Commercial Revolution in Medieval China*

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Abstract

We examine the origins of the Commercial Revolution in Song dynasty China—the world's first such revolution. By using a boundary created by an internal rebellion in the middle of the Tang dynasty, we find that, through the channels of migration and tax reform, counties that were politically stable and allowed a freer allocation of labor exhibited: 1) distinctly higher per capita commercial taxes, and 2) a larger number of market towns two centuries later. Further evidence suggests that in areas that remained effectively governed in the Tang dynasty after the rebellion these channels led to robust growth in agricultural productivity and improvements to river networks, paving the way for "Smithian growth".

Keywords: Commercial Revolution, An-Shi Rebellion, Migration, Tax Reform, Political Stability, Labor Allocation, Smithian Growth, China
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1 Introduction

The importance of institutions as crucial determinants of economic performance is well known (Acemoglu et al., 2001, 2005; Dell, 2011; Dell et al., 2018; North, 1990; Ogilvie and Carus, 2014). By enforcing contracts, the state reduces transaction costs (Barzel, 2002; North, 1990); by maintaining social order it provides political stability; together they facilitate growth (North et al., 2009). The importance of the state—as institutions—in promoting growth cannot be illustrated better than by Dell, Lane, and Querubin (2018). Using Vietnam as an example, they show how the two different regions of the same country have experienced radically different development trajectories as a consequence of the differences in historical institutions.[1] Over time, civic norms conducive to the provision of public goods and to overall economic development were found in the north but not in the south.

The "historical state", as alluded to above, also played a pivotal role in explaining the commercial revolution in Song dynasty China (c. 960-1278)—the world's first such revolution—by providing political stability and a well-developed tax system in a region where the dynastic regime was able to govern in contrast to one that was ruled by an extortionary warlord. The channels through which this commercial revolution came about were migration, as many fled from wars and extortion to areas free of them; and a tax regime that allowed individuals to reallocate their labor across sectors freely. The results were, first, robust growth of agricultural productivity, followed by regional specialization and trade and as a corollary, market expansion consequent on improvements in water transport. While not as fundamentally important as the Industrial Revolution, the Commercial Revolution brought a distinctly higher standard of living to the people affected by it; a back-of-the-envelope estimate of GDP growth finds that it was Song dynasty China rather than Middle Ages Europe that first achieved that watershed of economic development in the pre-industrial world.[2] Another indicator of Song's economic achievements is the size of its population—an indication of economic prosperity in the Malthusian world. For over a millennium and over several dynasties (200BC-900AD), China's population fluctuated but never exceeded 60 million. By

[1] The north, which geographically belongs to Northeast Asia, was heavily influenced by Chinese statecraft historically, and thus, following the traditions of the Sinitic state, had established well developed tax systems, bureaucracies and legal codes, and highly institutionalized village governance. By contrast, geographically a part of Southeast Asia, South Vietnam was highly influenced by Hindu-Buddhist statecraft, which followed a more decentralized patron-client model.

[2] With a *per capita* GDP estimated to be nearly 20% higher than Britain, China before 1400 was easily the richest country in the world (Broadberry, Guan, and Li, 2018). While Europe eventually also experienced the Commercial Revolution, it had to wait until European exploration and the discovery of the New World several centuries later. Even then, it was only that part of Europe "with access to the Atlantic Ocean and substantial trade with the New World, Africa, and Asia via the Atlantic" that could benefit from it (Acemoglu, Johnson, and Robinson, 2005: 546).

1110, the Chinese population had passed the 100 million mark for the first time (Figure 1), when the whole of Europe had only 70 million.

[Figure 1 about here]

The primary goal of this paper is to provide a detailed explanation of the origins of this commercial revolution. In an approach resembling that of Becker et al. (2016) and Dell et al. (2018), we use a plausibly exogenous boundary to demarcate the two regions of Tang dynasty China (c. 618-907) that were "split" by a major rebellion (the An-Shi Rebellion), resulting in radically different institutional characteristics and implications for economic growth. In what we call the "effectively governed area" (in the south of the country) where the Tang government remained in charge, taxes were regularized and levied moderately on its people. By contrast, where the military warlords were in charge (in the north), periodic conflicts occurred between them in what was basically an unstable institutional environment (Tackett, 2014), and irregular taxes and fees were extorted from residents.[3] Over time, the institutional differences between the two regions led to diverging development trajectories, to the point where the commercial revolution eventually took place in precisely the effectively governed area in the Song dynasty two centuries later, as evidenced by the larger *per capita* commercial taxes collected in 1077[4] and the greater number of market towns.[5]

Second, in addition to documenting the effects of a historical state on the commercial revolution, we provide evidence for two primary channels to account for them—migration in one instance and tax reform in another. Fuelled by the revolt and aggravated by the continuing instability of the warlords' rule, many fled from the afflicted north to the orderly south, providing a surplus of laborers to the region that subsequently became distinctly more commercialized. Similarly, the rebellion-induced migration rendered infeasible a tax system apportioned by headcount, i.e., a poll tax, and levied in kind—specifically on grain, cloth,

[3]Indeed, historian Nicolas Tackett (2014) argues that only the north was politically unstable in the aftermath of the An-Shi Rebellion.

[4]The dramatic increase in commercial taxes levied (modestly) on trade and consumption is one of the most prominent features of the commercial revolution. As Wheatley (1959) observes, at one-tenth ad valorem for goods of fine quality and one-fifteenth for goods of coarse quality, the tariff of the Song was quite moderate (p. 22). By 1077, about one hundred years after the dynasty was established, commercial taxes had grown so much that they accounted for two-thirds of the overall tax revenue (Bao, 2001). Liu (2015) thus remarks that Song was "the only fiscal state in China prior to 1880 to derive more than two-third of its tax revenues from indirect tax" (p. 94).

[5]Indeed, many eminent historians of Song dynasty China have attributed the flourishing of market towns to the increase in demand for market exchange (Elvin, 1973; Golas, 2015; Hartwell, 1982; Shiba, 1970). By contrast, Europe remained a largely feudal (and manorial) economy in which "exchange" rarely occurred; where it did, exchange was primarily determined by "custom, usage, and law" rather than by "negotiation between traders", who, on the whole, were few and far between (Rosenberg and Birdzell, 1986, p. 38; see also Greif, 1994; Lopez, 1976).

and corvée labor (known as *zhu-yong-diao* in Chinese)—forcing the emperor to change it to a land tax based on ownership, and allowing cash to substitute for both commodities and corvée labor. Known by historians as the "twice-a-year" tax reform or *liangshui zhi*, this reform was implemented more successfully in areas where the central government retained effective control over the social order than in areas dominated and controlled by regional warlords.[6] Indeed, using cross-sectional data on Song's household registration, we find that there were indeed more landless laborers in the EGA counties even after controlling for the effect of migration,[7] which facilitated the commercial revolution as measured by the same proxies of commercial taxes and market towns.

Third, we provide additional evidence showing that a politically stable environment and an institution that encouraged a freer allocation of labor in the EGA counties led to what economists called "Smithian growth" (Kelly, 1997), a third channel that led directly to the commercial revolution. Specifically, "Smithian growth" was indicated by the deepening of regional specialization and a geographic expansion of markets (e.g., Elvin, 1973; Shiba, 1970, among others). Occurring in goods regions were best suited to produce and linked by a highly sophisticated network of merchants, brokers, and other commercial agents, specialization was demonstrated by there being significantly more proto-industries in the EGA counties in the Song dynasty, while markets expansion was evident in the phenomenal growth of market towns.

Fourth, in addition to providing empirical evidence of this commercial revolution, we also provide evidence of the foundations of this Smithian growth; namely the rise in agricultural productivity and output as the basis for regional specialization and the concomitant rise in the shipbuilding industry[8] serving the need for distribution arising from the geographic expansion of markets, as well as substantial improvements in transportation—particularly waterway networks—all coalesced in the same EGA region.

Our empirical exercise may be vulnerable to a number of concerns, however. For instance,

[6]Indeed, historians see the Song dynasty as having witnessed power being transferred "from the political centers of northern China to the merchants of the south" (Morris, 2010, p. 359). In the process, it shifted the economy from a "bad" equilibrium of tying labor to the land (in a manner resembling that of the manorial system in tying serfs to the land of the vassals) to a "good" equilibrium of freeing up labor and allowing it to move across sectors, facilitating regional specialization and trade and the development of markets. We thank Noam Yuchtman for this insight.

[7]A historical data set allows us to differentiate the landowning from the tenant households. See Section 5.1.

[8]Based on the mariner's compass (one of Song's three "great inventions"), star charts, and so forth, the Song had made massive strides in seafaring. As Findlay and O'Rourke (2007) remark: "During the Tang it was the Arabs and Persians who came all the way to China in their own ships. Under the Sung (Song), however, the Chinese built their own oceangoing vessels, great junks with several masts, watertight compartments for their hulls, stern-post rudders, moveable sails, and other nautical innovations well in advance of the rest of the world" (p. 63).

the differences in the degree of commercial development between the two groups of counties may arguably be attributed to the direct effect of wars, as wars can decimate a population and destroy resources, and there were clearly more wars and conflicts in the ineffectively governed area. To alleviate concern about the direct effect of wars during the Tang dynasty in retarding growth in that area, we further controlled for: 1) whether a county was located in a region controlled by warlords, and 2) the number of battles fought during both the Tang dynasty and the transitional Five Dynasties and Ten Kingdoms (c. 908-959), respectively. Adding these controls does not change the significance of the EGA coefficients. Similarly, since there were just as many Sino-nomadic conflicts and potential threats of invasion during the Song dynasty, we thus also control for the direct effect of wars using the number of battles fought during this period, and the indirect effect of threats of invasion by controlling for a county's shortest distance to the nomadic frontier, respectively. Once again the significance of the pertinent coefficients holds up well in the presence of these additional controls. Finally, in order to ensure that commercialization was not already prominent in the Tang Dynasty, that we are not merely capturing a "pre-trend", we conduct a placebo test and find that: (1) the population density in 639 and 742 (both before the An-Shi Rebellion) was negatively associated with the EGA counties, and (2) there is no significant relationship between the EGA and both commercialization (as measured by a dummy variable indicating whether a prefecture had a commercial center) and proto-industries (as measured by the number of commodities produced in a prefecture) in the Tang dynasty. In short, the Tang dynasty was by no means a commercialized economy when judged by these markers.

Our story of the rise of a commercial revolution in Song China has a close affinity with several bodies of economics literature. Foremost is the more general importance of warfare and exogenous shocks in breaking down a tenacious equilibrium, with long-term consequences for economic development. In the "Three Horsemen of Riches", for example, Voigtländer and Voth (2013) show how, by decimating the population in Europe the Black Death and the warfare that spread the plague had the unwitting effect of substantially raising wages and contributing to urban economic growth. Our story of how fiscal pressure generated by exogenous war shocks led to tax reforms also finds parallels with the literature concerning how historical warfare was a major contributing factor to the formation of nation-states and economic growth in Europe (Bean, 1973; Tilly 1975, 1990; Besley and Persson 2009; Gennaioli and Voth 2014).

Second, economic historians and economists alike have identified a variety of favorable economic effects of migration including urbanization and growth, especially when migration was forced upon by the ravages of war (Dincecco and Onorato, 2018). Irrespective of whether it was in Europe before the Industrial Revolution, post-war Europe or the U.S., migrants

had supposedly brought with them their own human capital, knowledge, or valuable cultural traits to the host countries, generating growth in the long run (e.g. Abramitzky and Boustan, 2017; Bauer et al., 2013; Becker et al., 2020; Braun and Mahmoud, 2014; Hornung, 2014, among others).[9] For example, using the period following World War II as an example, Becker et al. (2020) show that forced migration of the Poles shifted their preferences away from material possessions towards investment in human capital. In the historical Chinese context, Bai (2021) similarly demonstrates that historical migration has had a persistent effect on contemporary economic growth as a result of competition between migrants and natives in China's millennium-old civil service exam. Following the essence of this rich literature, we show how migration triggered by warfare and political instability similarly contributed to commercial development in a period when China was ahead of Europe, by providing a surplus of laborers to an expanded market in a context where labor could be allocated efficiently across various economic sectors.

Third, our study is also related to the importance of property rights or more specifically political stability (or "institutional environment" in the words of North (1981)) in fostering economic exchange and growth in the long run (e.g., North, 1990; North et al., 2009; Ogilvie and Carus, 2014). Using dynastic China as example, we show how political stability is of first-order importance to its commercial efflorescence. Finally, we join the contributions of those who made creative use of historical natural experiments to provide causal explanations of European economic growth in the pre-industrial revolution period; examples include the birth of medieval universities (Cantoni and Yuchtman, 2014), the printing press (Dittmar, 2011), the Protestant Reformation (Becker and Woessmann, 2009), and so on.[10] Along this line of research, our paper may thus be regarded as representing the first empirical study of the origins of commercial revolution outside the European context using similarly novel data and empirical methods.

The remainder of the paper proceeds as follows. Section 2 provides the historical context necessary to understand the migratory and fiscal consequences of a military shock and the alternative development path that the effectively governed area experienced. Section 3 explains the empirical strategy and introduces the variables and data sources. We present the empirical results of the spatial RDD analysis in Section 4 and analyse the underlying channels, including the process of Smithian growth, in Section 5. Section 6 concludes.

[9]Historical examples include the Flemish and Dutch immigration in Tudor England, the Huguenot immigration during the religious upheavals of the Reformation in the 17th century, and so forth. Prompted by persecution and warfare in the source countries, these immigrants brought valuable skills and industries (for example tapestry weaving) to England.

[10]For a summary and overview of similar contributions see Cantoni and Yuchtman (2021).

2 Background

2.1 Commercial Revolution

For more than a millennium (counting from the Han dynasty to the Tang dynasty), the imperial Chinese economy was overwhelmingly agricultural and subsistence based. But it became highly commercialized by the time the Song dynasty came of age.[11] The highly commercialized nature of the Song economy was most evidently manifested in the formation of a nationwide market spurred by the phenomenal growth of regional specialization in the production of a wide gamut of commodities based on regional comparative advantage,[12] and in the growth of tax revenues that were increasingly drawn from commercial transactions—specifically from roughly one third in 997 to more than two-thirds, 67.76%, in 1077 (Bao, 2001). Importantly, an upsurge in agricultural productivity and surplus provided the important pre-conditions for the emergence of this commercial revolution, which according to Shiba (1970) was due to (1) a decisive shift from millet to rice cultivation, and (2) the adoption of a "package" of innovative farm practices.[13] While difficult to quantify the precise individual contributions of these various innovations, the adoption of fast-ripening rice varieties and the double cropping systems that accompanied it, were probably the two major factors contributing to growth in agricultural output.[14] Compared to millet, the crop most widely cultivated by farmers in the north in Tang times,[15] rice agriculture in South

[11]Both the Han and Tang dynasties were largely subsistence economies with little trade and hardly any use of money, with agricultural tax paid in kind being the primary source of fiscal revenue. Nonfarm (proto) industries were thus few and far between. But by the 11^{th} century, the Northern Song had reached a level of commercial and industrial development unsurpassed by any society until the last decades of the 18^{th} century, according to Hartwell (1982).

[12]The regional ceramics from Jingdezhen in the south central Jiangxi Province, the iron and coal industrial enterprises in the northeast, lacquer from the two southeast provinces of Jiangsu and Zhejiang, and a wide diversity of tea production across the entire country, etc., were prominent examples of regional specialization that collectively defined Song's commercial economy (Hartwell, 1966; Shiba, 1970; von Glahn, 2016, among others). Shiba (1970) provides a detailed description of the different regions specializing in the production of different products in Song (e.g., tea, timber, textiles, lacquer, paper, and pottery), including agricultural produce.

[13]These included improvements in, and greater dependence on, hydraulic control, a more productive complex of farm tools, land reclamation by means of terracing on hillsides, etc. (McDermott and Shiba, 2015; see also von Glahn, 2016 for a summary).

[14]The Song dynasty was certainly not the first time in the history of imperial China to experience the introduction of new types of rice. As early as the sixth century no fewer than 37 varieties of rice were introduced to the Yangtze River Delta region, according to *The Essential Methods of the Common People*. However, by 1100 all these previous varieties had been replaced by the even-higher yielding early-ripening varieties (Morris, 2010, p. 334 and 377). For example, the *Champa rice* that was introduced from South Vietnam by the late 10th century (early Song) effectively reduced the crop cycle from 150 to 120 days.

[15]That millet was the principal crop cultivated in North China in Tang times is evident in the fact that millet constituted the main agricultural tax back then; wheat was considered "mixed cereals" at best. See Kung et al. (2022) for the importance of millet in historical China.

China enjoyed a yield several times that of millet, contributing to rapid population growth. Indeed, between Tang (at its height) and the early 12th century (Song), the population in China doubled from the peak in the Tang dynasty of 60 million to well over the 100 million mark (McEvedy and Jones, 1978; Maddison, 1998; von Glahn, 2016),[16] comfortably surpassing Europe's population of 70 million around the same time (Morris, 2010; Rosenberg and Birdzell, 1986).

Additionally, historians have also emphasized the importance of the development of transport and communications—especially a revolution in water transport that began in the Sui-Tang dynasty and became well developed in Song times—in facilitating the "cheap long-distance carriage of everyday goods in large quantities" across regions for trade and marketing (Elvin, 1973, p. 135; Shiba, 1970). In particular, the network of water transport was distinctly better developed in south and central China, where "a number of hitherto separate waterway systems were now linked into an integrated whole, forming the foundation for the nationwide market", and where junks "had become very much more sophisticated" (Elvin, 1973, p. 139 and 137).[17]

2.2 An-Shi Rebellion, Tax Reform, and Long-distance Migration

From the Han dynasty (c. 206BCE-220CE) onwards imperial China was beset with unceasing threats of invasion from its nomadic neighbors (Bai and Kung, 2011; Lattimore, 1962). Although the Tang Empire reunified China after the Han dynasty fell prey to the nomads and the entire dynasty disintegrated for several hundred years, guarding its entire northern border from the threat of nomadic invasion remained a top priority for national security. Specifically, it was the Khitans to the northeast, Uyghurs to the north and northwest, and Tibetans to the west this time. To stabilize border relations, but more importantly to guard against unexpected attacks in a more responsive manner, Emperor *Xuanzhong* wittingly decentralized its military to as many as ten regions adjacent to nomadic neighbors (Figure A1 in the Appendix).

Designated as fence towns (*fanzhen*), the military commissioners or *jiedushi* were given enormous military power—many with substantial troops—over the territories they were appointed to guard. Clearly, the attachment of these commissioners to a specific region gave rise to *de facto* property rights over the region, creating the risk of autonomy and perhaps even independence. As shown in Figure A1, Emperor *Xuanzhong* appointed 10 *jiedushi* to

[16]The numbers are based on the two population censuses conducted in the Tang and Song dynasties, respectively.

[17]Allegedly it took a mere three days to sail from Ningbo on the southeastern coastal seaboard (of Zhejiang Province) to southern Shandong Province on the North China Plain (Elvin, 1973, p. 138).

various parts of the country, covering the north, northeast, northwest, and also the southwest and southeast. Ironically, it was not the breaking of the inherently tense relationship between the Tang Empire and its nomadic neighbors that led to conflict of epic proportions, but rather the unexpected upheaval of An Lushan, a military commissioner who revolted against the emperor as a result of the emperor vesting too much military power in him; being the only exception, An was given the authority to take charge of three fence towns and a quarter of the army that was placed in the hands of all military commissioners.[18] Although An was crushed and the rebellion was suppressed after eight years by the concerted effort of other regional commissioners in whom the emperor's son had vested extensive powers,[19] the fence towns essentially fell prey of "regional warlordism"; the number of autonomous warlords now increased from 48 before the An-Shi Rebellion to a staggering 64 afterwards, all of whom enjoyed the privilege of not remitting taxes to the emperor on a regular basis, forcing the succeeding emperor to change his tax policies (Guo, 2017). Indeed, evidence suggests that after the An-shi Rebellion stable tax revenues came primarily from the 49 prefectures in the eight south-eastern provinces (Chen, 1982; Twitchett, 1963). In the north, where the Tang emperor effectively lost authority over the provinces, various warlords "ruled their domains" and "fought among themselves", "with only occasional deference to the wishes of the emperors" (McNeil, 1963, p. 379).

Two major developments occurred as a consequence of the An-Shi Rebellion. First, the unstable institutional environment in the north led to a continuing process of mass migration to the Yangtze valley in the southeast and the south-central provinces—both being regions where the central government retained effective governance (Twitchett, 1979; Yang, 1957).[20] While internal migration that occurred as the rebellion unfolded was about 5%, the trend continued unabated as the north continued to be afflicted by political instability for about another two hundred years even after the fall of Tang, resulting in a migration rate of 25% by the time the Song dynasty was founded. For simplicity we refer to this broader region in the south as the "effectively governed area" or EGA. Figure A3 in the Appendix, which plots the

[18] An was allegedly a favorite of Emperor *Xuanzhong*'s concubine, Yang Guifei. Obsessed with Yang, the emperor ignored the "usual safeguards around military power" by allowing An to be in control of the north (Fanyang), northwest (Hedong) and northeast China (Pinglu)—respectively (Morris, 2010, p. 355). As Figure A2 (in the Appendix) shows, the key battles took place more or less in and around the regions where An was in control.

[19] The threat of invasion posed by the nomads on the frontier had not gone away, as the Turks (Uighurs) from the steppes were also invited to help out. Hence, while the Tang dynasty survived, it owed its preservation to the Turkish intervention, and the later Tang emperors remained politically dependent on Uighur goodwill (McNeill, 1963).

[20] Political stability in this region was also reinforced by the Tang deliberately staffing the region with civilian officials, who were more loyal to the emperor in part because of the Confucian education they received, but more importantly, perhaps, because they were not in the military (Cai, 2019).

destination prefectures based on Wu (1997), confirms that the south-central region and the Lower Yangtze River Delta region on China's eastern coastal seaboard received the largest inflow of migrants (see also Chen and Kung, 2021). Geographically, these two sub-regions coincide largely with the EGA.

The long-term effect of migration is evident in the reversal of the geographic distribution of the population—from less than 45% of the Tang's population residing in the south in 756 to 66% by 1080 (McDermott and Shiba, 2005).[21] Second, migration meant that the emperor had to seek solutions to collect the tax revenue that was lost as the migrants abandoned their homes and land. Not only did tax revenues from the northern country shrivel, but the original poll tax that each household was made to pay in kind—grain, cloth, and corvée labor (known as *zu-yong-diao* in Chinese)—also became uncollectable as many went south. As a remedial measure, the emperor who succeeded *Xuanzhong*, Emperor *Dezong* (r. 779-805) replaced *zu-yong-diao* with a tax levied progressively on land assets, effectively changing a poll tax levied in kind to a land tax that allowed farm households to pay cash in lieu of grain and cloth twice a year coinciding with the sowing seasons—hence the term "twice-a-year" tax reform or *liangshui zhi* (Qian, 1937; von Glahn, 2016). The most important implication of this change for the Song commercial revolution was that the abolition of corvée labor and the possible payment of a tax in cash effectively eliminated key constraints on the allocation of household labor.[22]

As a "surplus" labor emerged in the EGA counties, the greater population pressure in turn induced a series of innovative practices in agriculture (via population pressure), the higher productivity that resulted from such innovations provided a labor force that could be tapped for specialization. As agricultural productivity and output rose, and labor was freed to work in sectors of their own choice, specialization deepened and markets expanded, as borne out by the phenomenal increase in the market towns. Aided by an efficient network of waterways, regional specialization, and market expansion were especially strong in the south (Elvin, 1973; Shiba, 1970), producing what Kelly (1997) defines as Smithian growth. Figure 2 sketches the elements of this great transformation refer to by historians as the "Tang-Song Transformation".[23]

[21]This was especially the case for the Yangtze River valley. Located in the southeast of the delta region (the lower reach), it supplanted the traditional heartland of the North China Plain and became the new center of gravity of the imperial Chinese economy. This remains the case to the present day (Chen and Kung, 2021).

[22]In regions where *liangshui zhi* was effectively implemented (most notably the lower Yangtze River Delta region), the reform was deemed "an instant success"; as "it generated greater income than the central government's revenue from all sources, including the salt monopoly, in the previous year" (von Glahn, 2016, p. 213; Kegasawa, 2005; Twitchett, 1963, 1979).

[23]The "Tang-Song Transformation" is a term pioneered by the Japanese historian Naitō Konan. For details see Miyakawa Hisayaki (1955).

[Figure 2 about here]

3 Empirical Strategy

3.1 Variables and Data Sources

3.1.1 Commercial Revolution

We employ two measures as proxies for the regional variation in the commercial revolution across the Song counties. They are commercial taxes for the year 1077 and the average number of market towns in Northern Song—both normalized by the county population.

Commercial Taxes. According to China's first Commercial Tax Law (*Shangshui Zeli*) published in 960 AD, commercial taxes were of two types: a tariff levied on goods transported—*guosui*, and a consumption tax imposed on the sale of a wide array of goods and services—*zhusui*.[24] To facilitate tariff collection, more than 2,000 (2,060) tax stations were erected at major nodes of the official trade routes.[25] The fact that both tariffs and consumption tax were set at the relatively low standard rate of respectively 2% and 3% suggests that the Song administration was careful to attempt to strike a balance between milking the commercial taxes on the one hand and providing optimal incentives to the merchants on the other hand so that overall specialization and trade would not be compromised as a result of maximizing the tax revenue.

Cross-sectional data are available for commercial taxes from 1,186 Song counties for the year 1077, which is the only year for which such data are available. The data were originally collected in the Song government archival records entitled *Song Huiyao Jigao*; the ones that we use were subsequently reconstructed by a group of Qing-dynasty scholars led by Xu Song (1781-1848). Given that the Song's population data are only available at the prefectural level, to normalize commercial tax by a county's population it is necessary that we first derive the counties' population figures using the prefectural data available in *Yuanfeng Jiuyuzhi* (1078) or the *Yuanfeng Geographic Gazetteer* compiled by the Song scholar *Wang Cun* (1023-1101) during 1075-1080. To obtain a county's share of the prefecture's population, we multiply its share of the prefecture's land area by the prefecture's population.[26] Panel A of Figure

[24]The latter included not only major commodities of the time such as cloth, silk, liquor, tea, salt, livestock (horses, cows, mules, camels, etc.), and grain, but also *ad valorem* taxes on transactions of arable land, shops, houses, and so forth.

[25]To facilitate long-distance trade, merchants were allowed to pay the consumption tax either at the point of origin or at the destination and obtain a certificate (*gongyin*) that spared them the inconvenience of paying the tariff along the way (Liu, 2013).

[26]Given that it is highly unlikely that counties within a single prefecture have had a homogeneous distribution of population, we aggregated our data to the prefectural level and ran the regressions again and

3 shows the geographic distribution of the *per capita* commercial tax for 1077. In terms of spatial distribution, it clearly shows that counties in the southeast region (with a few scattered ones in the southwest) were paying the bulk of these taxes—counties that coincide spatially with Tang's EGA. The GIS shapefile of Song's county boundaries (compiled as of 1080) was obtained from the Hartwell's China Historical GIS maintained by the Harvard Fairbank Center for Chinese Studies.

[Figure 3 about here]

Market Towns. Song witnessed the flourishing of market towns set up for trade. There were only a few dozen of these towns in the Tang, but the period of the Northern Song alone (c. 960-1127) saw a total of 3,422 market towns springing up, many of which arose in the countryside alongside the walled cities, which now "became thriving hubs of commercial activity in addition to their traditional administrative and military functions" (von Glahn, 2016, p. 242).[27] Moreover, the importance of the growth of market towns in Song went beyond the boundaries of trade; it also called for a new mandate that entailed the management of an increasing number of territories with dense populations (Golas, 2015; Hartwell, 1982). Thus, unlike towns in Medieval Europe, which remained small in scale and heavily regulated in nature, those of the Song encountered a brave new world, stimulating a gradual process of urbanization as well as commercial efflorescence.[28] We employ the total number of market towns in a county in Northern Song as our second measure to capture the effect of both migration and Tang's tax reform on the resulting growth in specialization and trade. As with commercial taxes, we normalize this variable by the estimated county population in 1078 following the procedure just described. Panel B of Figure 3 geo-references the spatial distribution of market towns at the county level. As with the commercial tax, market towns were mostly concentrated in the southeast where the majority of Tang's EGA counties were located. Data on market towns were obtained from *Fu Zongwen*'s (1989) *A Study of Song's Market Towns* (*Songdai Caoshizhen Yanjiu*).

Table 1 provides summary statistics of the variables introduced above.

obtained similar results (and hence not separately reported).

[27]We choose Northern Song simply because the northern half was ceded to the Jurchen-led Jin dynasty at the end of this period (c. 1127), thus ruling out comparison of the effect of Tang's tax reform on commercial development between the effectively (primarily the southeast) and ineffectively governed areas (primarily the north).

[28]Defense against warfare was a constant requirement for Medieval European towns, at least until the 15^{th} or 16^{th} century. This implies that enough funds had to be raised to maintain defensive structures and that they did not grow beyond the capacity of walls. Rosenberg and Birdzell's (1986, p. 51) remark about the growing power of Guilds in managing towns in Medieval Europe is indicative of that constraint, "most lines of industry and trade were the exclusive monopolies of the guilds", and the "holding of markets and fairs was permissible only under license, and their conduct was as rigidly regulated as the trade of the guilds themselves".

[Table 1 about here]

3.2 Spatial Regression Discontinuity Design (SRDD)

Our empirical strategy is to estimate the possible effects of political stability and labor reallocation combined with commercial development using a spatial regression discontinuity design (SRDD). Specifically, we compare counties located in those prefectures (*fu* as they were known then) where the leaders would still pay tax to the Tang Empire on a regular basis during the remainder of the Tang dynasty (i.e., 780-907), with those which continued to be ruled by the semi-autonomous military commissioners who enjoyed the privilege of paying taxes to the central government at their discretion (Kaisaburō, 1942, 1980). The spatial delineation between the two is shown in Figure 4, where the thick red line marks the boundary between these two types of county, while the dashed lines depict spatial radius thresholds 400, 300, 200, and 100 kilometres from the boundary of the EGA. Information about Tang's fiscal administration was obtained from Chen (1982) and Twitchett (1963). Our spatial RDD assumes the following specification:

$$Outcome_c = \alpha + \beta EGA_C + f(GeographicLocation_c) + \sum_{i=1}^{n} Seg_c^i + \varepsilon_c \tag{1}$$

where $Outcome_c$ represents the three outcome variables of interest as they pertain to commercial revolution across county c. Our key explanatory variable, EGA_c, is an indicator variable set to 1 if county c fell within Tang's EGA, and 0 if it did not. $f(GeographicLocation_c)$ is the RD polynomial controlling for smooth functions of the geographic location. Given that the tax boundary forms a multi-dimensional discontinuity in longitude-latitude space, we employ polynomials of a county's centroid in latitude and longitude to control for unobserved confounding variables, in a manner analogous to the spatial RD design of Becker et al. (2016), Dell (2010), Dell et al. (2017) and Dell and Querubin (2018). To ensure robustness, we also control for polynomials of the distance to the boundary following Becker et al. (2016). As in Dell and Querubin (2018), we split the boundary into 10 segments of equal-length, with Seg_c^i equal to 1 if a county is closest to segment i, and 0 otherwise.

[Figure 4 about here]

To exploit the advantages of the spatial RD design fully, we employ: 1) a full sample of all counties, 2) a subsample of counties located respectively within 400, 300, 200, and 100 kilometres of the spatial threshold from the boundary of the Tang's EGA (graphically shown in the dotted lines of Figure 4), and 3) a subsample of counties within the optimal bandwidth

from the same boundary estimated according to Calonico et al. (2014, 2017, 2022). As is standard practice, we employ a local linear RD polynomial for all baseline specifications and document robustness for a wide range of bandwidths and RD polynomials.

3.3 Validity of the Spatial RD Design

Identification of the spatial RD relies on three assumptions: 1) the formation of the boundary is exogenous to commercial development in the Song dynasty; 2) except for the treated variable, all other confounding factors vary smoothly at the boundary (balance checks); and 3) the outcome variables vary discontinuously across the boundary as a result of the greater political stability and freer allocation of labor within the EGA counties.

3.3.1 Exogeneity of the EGA Boundary

We begin with assumption (1). Because the boundary that separates the two types of county is an outcome of a military conflict waged by a rebellious military commissioner, concerns arise that there might be unobserved heterogeneities associated with the counties on either side of the boundary—heterogeneities that may have affected commercial development directly in late Tang on through to Song. For example, it is arguable that the EGA boundary might capture the effect of omitted factors such as the political instability caused by warlords in the north, even retarding its development long after the An-Shi Rebellion was quelled. Similarly, the north seems to have been more disrupted by the internal warfare that occurred after the An-Shi Rebellion until the collapse of the Five Dynasties and Ten Kingdoms period (c. 907-979), spanning at least two centuries. By escaping the destruction caused by the ravages of war, the EGA counties would thus be more prosperous even in the absence of a tax reform that worked in their favor. Thus, despite the fact that the fence towns were completely abolished by the Song's founding emperor,[29] to check robustness we deal with this possible omission by controlling for whether a Song county was once a part of a fence town, and also the variation in the incidence of battles fought across the counties during the aforementioned period. But we find no significant difference between the baseline and controlled estimates (refer to Section 4.2.1 for details).

[29]Realizing that army commanders had brought down most dynasties, and specifically that the autonomous warlords were the primary cause of the fall of the Tang, Emperor *Taizu* effectively "dissolved the militarists' power with a cup of wine" by toasting the generals for having reached retirement (Morris, 2010, p. 373; Kuhn, 2011; Qian, 1937; Tanner, 2010). In particular, to prevent regional governors from cultivating and consolidating their power base in a specific locale, *Taizu* made them rotate from one outpost to another periodically. Moreover, regional officials were also stripped of the power to command the military within their jurisdictions. This alleviates the concern that the boundary drawn on the basis of the effectiveness of the tax reform two centuries ago would be unlikely to affect commercial development through unobserved dimensions.

By the same token, concerns may also be raised with regard to the comparability of EGA and non-EGA counties in Song times, given that the distance of these two sets of counties from the northern frontier and the corresponding likelihood of them being subject to nomadic invasions was probably different. To alleviate this concern we therefore control for a county's distance (measured from its centroid) to the nearest nomadic frontier and the actual variations in conflict as it occurred across the counties. As reported in Section 4.2.1, the robustness check does not result in estimates that differ from those of the baseline.

Finally, the continuing warfare during the Five Dynasties and Ten Kingdoms altered the Song's boundary (Li, 2017) so much that during the first 20 years of his rule the founding Song emperor had to merge as many as 299 or 22% (out of 1,388) underpopulated counties. This resulted in a demarcation radically different from that of the Tang (Li, 2017). As shown in Figure A4 in the Appendix, the Tang's boundary (the green shaded area) differs (for the most part) from the Song's provincial boundary (the dark grey lines), providing evidence that further ensures that our outcome variables of interest would be unlikely to be affected by the boundary drawn some 200 years ago. All of these combine to satisfy assumption (1).

3.3.2 Balance Check

To verify assumption (2) we make use of a balance check, which requires that all relevant variables other than migration and tax reform vary smoothly at the boundary. Table 2 examines a variety of geographic, social and political characteristics associated with counties on either side of the boundary by performing the regressions specified in equation (1). For instance, columns (1) and (2) of Table 2 examine various geographic characteristics such as elevation and slope,[30] and find that the point estimate of these variables is small relative to the mean and is statistically insignificant. Columns (3) and (4) show that the treatment and control areas are similarly balanced in terms of their suitability for planting China's two main staple crops—rice and wheat.[31] To check for robustness, we also use the caloric suitability index developed by Galor and Özak (2016)[32] to account for the effect of various other crops cultivated before 1500, and find no significant difference in that respect between the counties on either side of the boundary (column (5)). In columns (6) and (7) we further test the differences in the average terrain ruggedness[33] and a county's distance to the nearest

[30]The average elevation and slope of each county in the Song dynasty are calculated by the authors using 90 square-meter gridded data of a Digital Elevation Model (DEM) map provided by the United States Geographic Service (USGS).

[31]The crop-specific suitability data is obtained from the Global Agro-Ecological Zones (GAEZ) v4 database maintained by the Food and Agriculture Organization of the United Nations (FAO).

[32]Obtained from `https://ozak.github.io/Caloric-Suitability-Index/`.

[33]An index of terrain ruggedness is constructed by calculating the difference in elevation between adjacent grid cells using the DEM data acquired from the USGS.

river,[34] and similarly find no significant difference between counties across the boundary.

Finally, we examine whether there is any difference in the administrative status of the counties lying across the boundary, in that the Song dynasty classified them under a three-tier ranking system based mainly on military importance. Using information in the *Yuanfeng Geographic Gazetteer* (1078), we assign a unique rank to each of the 1,197 counties and confirm that there is also no significant difference in administrative status (column (8)). Together, the results of our balance check suggest that it is highly likely that the EGA boundary affects the outcome variables of interest only through the commercial revolution.

[Table 2 about here]

We leave the test of assumption (3), i.e., that our two dependent variables that measure commercial development vary discontinuously at the boundary, to Section 4.

4 Tang's Effectively Governed Area (EGA) and Song's Commercial Revolution

4.1 Baseline Estimates of the Effect of Political Stability and Tax Reform

We begin our analysis by first showing graphically the relationship between distance to the boundary of Tang's EGA and our two dependent variables of commercial revolution, i.e., commercial tax and number of market towns, in Figure 5, restricting the sample counties to those within the 400-kilometer radius. Panel A plots the shortest distance between the sample counties (measured from its centroid) and the boundary with respect to the size of *per capita* commercial tax, with dashed lines marking the 95% confidence intervals. The discontinuity between the counties on either side of the boundary in terms of *per capita* commercial tax is sharp and clear, suggesting that Tang's EGA had a lasting impact on commercial development during Song. In panel B, we repeat the same exercise but for market towns, and find a similar result—the number of market towns in a county changes discontinuously at the boundary. This satisfies assumption (3).

[Figure 5 about here]

[34] Distance to the nearest river is measured as the distance between a county's centroid (generated from the 1080 county boundary map) to the closest point on the nearest navigable river. The geographic information for Song's navigable rivers is obtained from *The Making of a Fiscal State in Song China, 960-1279* (Liu, 2015).

The results of our spatial RDD analysis that uses whether a Song county falls within the Tang's EGA boundary as predictor are reported in panel A (*per capita* commercial tax) and panel B (the number of market towns) of Table 3, respectively, employing bandwidths of 400, 300, to 200 and 100-kilometer radii, as well as the optimal bandwidth selector proposed by Calonico et al. (2014) and detailed in Calonico et al. (2017, 2022). In addition, we control for the cubic polynomials of latitude and longitude and the segment fixed effects following Dell et al. (2018). Irrespective of the choice of the polynomial and bandwidth, the Song counties that fall within the Tang's EGA have significantly higher per capita commercial tax as well as number of market towns. Taking the optimal bandwidth estimate as an example, counties within the EGA yield an average of 14.1% more *per capita* commercial tax and have 81.5% more market towns. In addition, to check for robustness we report the coefficients of both the linear regression and those for other polynomial regressions (ranging from quadratic to quartic) in latitude and longitude or in distance to the EGA boundary in Tables A1 and A2 of the Appendix, and confirm that the results are similar.

[Table 3 about here]

Additionally, to ensure that the results of our outcome variables are not driven by the estimated county population, we re-estimated the regressions in Tables A3 and A4 using prefectural-level data and confirm that they do not differ from the county-level estimates.

4.2 Robustness Checks

4.2.1 Direct Effects of Wars and Nomadic Threats

As mentioned in Section 3.3.1, here we deal with the concern that the EGA boundary might also capture the direct effect of political instability caused by warlords in the north, and the internal warfare that occurred following the An-shi Rebellion until the collapse of the transitional Five Dynasties (c. 763-960), respectively. If the effect of these omitted factors is significant, they might contaminate our baseline estimates in that the EGA counties would be more economically prosperous anyway because they avoided the adverse consequences of war. To ensure that our results are robust to the inclusion of these direct conflicts, we construct three dummy variables with each indicating (1) whether a Song county coincided geographically with a fence town in the Tang dynasty; and (2) two count variables enumerating the battles that occurred in the Tang dynasty and the Five Dynasties and Ten Kingdoms, respectively. The GIS data for fence towns was constructed by matching the locations of all fence towns as they existed in the Tang dynasty from the *History of China's Administrative Boundary volume 5 on Tang* (Guo, 2017) with the GIS map of the Song counties, while

the number of battles were obtained from the *Chronological Records of Natural Disasters and Conflicts in China's History* (Chen, 1939). Table 4A reports the results of the EGA estimates after controlling for these three measures based on the specification in Table 3. As with the baseline estimates, the estimated effect of the EGA with these additional controls remains robustly significant across various bandwidth estimates, suggesting that the beneficial effect of the EGA counties on commercialization was indeed due to the effects of a freer labor reallocation regime and a surplus of laborers resulting from both the post-rebellion tax reform and southward migration.

[Table 4A about here]

By the same token, given that the Tang's EGA counties coincided geographically with the southeastern region of the Song dynasty, which was further from the northern nomadic frontier than the non-EGA counties, a concern may be raised that the EGA counties benefitted from a considerably smaller incidence of nomadic threats than did their northern neighbors.[35] To verify whether the EGA counties might also capture this omitted benefit, we constructed two measures as proxies for its possible omission. First, we control for a county's distance (measured from its centroid) to its nearest nomadic frontier. Second, we control for the number of battles fought between Song and its nomadic neighbors in the northeast, Liao (c. 916-1125) and Jin (c. 1115-1235), and Western Xia (1038-1127) in the northwest, respectively. These data were also obtained from Chen (1939). Table 4B reports the results of adding these two controls based on the specification in Table 3. As shown, while both additional control variables have a significant effect on both measures of commercial development, they do not affect the effects of the EGA in terms of both level of significance and magnitude of the estimated coefficients. Together, these findings help to alleviate the concern that counties in the EGA region might differ from those outside it in terms of sensitivity to nomadic threats.

[Table 4B about here]

4.2.2 Placebo Tests on the Commercial Development in Tang

To verify the proposition that political stability in the EGA was an important precondition for the emergence of a commercial revolution in Song, we conduct a placebo test to verify that this transition had not already occurred in the Tang dynasty, using: 1) the population

[35]Recall from Section 2, however, that two of the ten fence towns were located in the south—one in the southwest and the other in southeast. In fact, military conflicts did occur in the southwest during the mid-Tang

density in 639 and 742 (i.e., both before the An-Shi Rebellion of 755-763), 2) a dummy variable indicating whether a Tang county had a well-recognized commercial center, and 3) the overall number of proto-industries as measured by the number of commodities produced in the Tang dynasty. The data on population density is obtained from *The Population History in Sui-Tang Dynasties* (*Zhongguo Renkoushi Sui-Tang Juan*), while the data on the locations of commercial centers and various proto-industries are taken from *Tang's Regional Economy* (*Tangdai Quyu Jingji*) (Weng, 2001) and *Tang's Proto-industries* (*Tangdai Gongshangye*) (Zhang, 1995), respectively. Weng (2002) considered a county as having a commercial center if that county was active in producing and selling handicrafts items in Tang times. In the case of proto-industry, Zhang's (1995) estimates suggest that there were roughly nine proto-industries in Tang times, including ceramics, silk, tea, iron, copper, silver and gold, shipbuilding, lacquerware, paper and printing. Together, we code the Tang counties according to whether they were a commercial center and, depending on whether a county had a proto-industry, the total number it had as a proxy for its degree of proto-industrialization. As reported in panels A and B of Table 5, population density in both periods of early Tang is significantly negatively correlated with counties inside the EGA boundary across various bandwidth specifications (columns (1) - (5)) but insignificant in the optimal bandwidth regression (columns (6)), suggesting that counties inside the EGA were no different—if not poorer—to those outside it before the An-Shi Rebellion. And there is plainly the EGA boundary makes no significant difference in terms of either being a commercial center or having a proto-industry as indicated by the results in panels C and D of Table 5. Together, these indicators combine to suggest that, as compared with the Song the Tang economy was far from commercialized.

[Table 5 about here]

5 Channels of EGA

Based on the stylized historical facts rehearsed earlier, we propose three primary channels through which the respective effects of migration, tax reform, and processes of a Smithian growth induced by the first two impacted the Song Commercial Revolution.

5.1 Migration

The An-Shi Rebellion sparked off a large-scale wave of migration that eventually changed the center of gravity of economic activity in imperial China from north to south (Chen and Kung, 2021). As mentioned earlier, over a period of eight years, an estimated 2.5 million

or 5% of the total population left the war-afflicted north for the peaceful south during the rebellion (Wu, 1997). But that only marked the beginning of what was to become a secular trend of southward migration over the next two hundred years or so, as Tang continued to suffer from periodic conflicts staged by the military warlords who occupied the north, so much so that by the time the Song dynasty was founded South China was already home to nearly 15 million migrants, accounting for 25% of the prevailing population. Specifically, migration captures two effects; one relates to social and political stability, while the other to the availability of a surplus of labor in the destinations for migration.

To verify the channel of migration, we collected data on the major origins and destinations of migration after the An-Shi Rebellion, which are contained in two atlases in *A Migration History of China, Volume 3 on Tang and Song Dynasties* (*Zhongguo Yiminshi III Sui-Tang Juan*) compiled by Wu (1997). Specifically, these atlases contain detailed categorical information on the location and ranking of all migration origins and destinations; e.g., from none to minor, semi-major (or median) and major. Reported in panels A and B of Table 6, the results clearly show that the EGA counties were a major destination for migration and, conversely, an unlikely origin of migration, respectively. Given the ordered nature of the dependent variable, we use an ordered probit model in columns (1) through (5). The results are robust across estimates for all bandwidths. In column (6), which we estimate using the optimal bandwidth, we find that the EGA counties were 27.3% more likely to be a major destination for migrants compared to non-EGA counties, and 23.2% less likely to be origins of migration. To the extent that migration may have a spillover effect on the neighbouring counties, the coefficients are probably underestimated because of this downward bias. Our findings are thus likely to represent a lower-bound estimate of the actual effect of migration. In addition, as more people flowed into the EGA counties, the destination region will have enjoyed a surplus of laborers over the source region. While data on labor supply by regions are not available, data on population density are available for several times before Tang (639 and 742) and during Song (980, 1978, and 1102), which we can use as a proxy for the available labor pool. As reported in Figure 6, we find that the EGA boundary has no significant effect on population density before the fiscal reform of 780 (the vertical red line), but a significantly positive effect began to emerge after the first millennium (roughly before the year 1000 and 1100) for counties located within the EGA boundary. This estimate agrees well with the census finding that by 1110 the Chinese population passed the 100 million mark for the first time.

[Table 6 and Figure 6 about here]

5.2 Tax Reform

In addition to migration, we expect the fiscal reform or twice-a-year tax reform to also have the hypothesized effect of facilitating commercial development by freeing up laborers and capital from land or agriculture to many businesses in the non-farm sector. As in the case of overall labor supply, we do not have fine-grained data for the allocation of labor by sector, but we do have data on the distribution of households registered as either having land (*zhihu*) or not having land (*kehu*) in the total population according to the survey of 980 as a proxy. While crude, this measure allows us to construct a variable to account for the proportion of population that was landless in 980, against which we hypothesize that a rise in the number of landless laborers tends to facilitate specialization. The pertinent data are obtained from the *Universal Geography of the Taiping Era* (*Taiping Huanyuji*), compiled by *Shi Le* for the period 976-983. By regressing the proportion of landless households in the overall population on the EGA boundary across a number of bandwidths, and controlling for the cubic polynomial in longitude and latitude and segment fixed effects (panel C of Table 6), we find that the proportion of landless population was significantly higher in the EGA counties, by 14%, providing an important precondition for the emergence of a commercial revolution.

To further separate the respective effect of migration and tax reform on commercialization, we regress the same two dependent variables (of commercial tax and market towns) against the interaction terms of EGA with migration destinations designated by historians as representing their varying degrees of popularity (major, median, and minor, respectively) and that with the share of landless households, and confirm that the positive effect of EGA was driven by those counties that were either more popular destinations of migration or with higher share of landless households within the EGA, regardless of the choice of bandwidth.

[Table 7 about here]

5.3 Smithian Growth

5.3.1 Proto-industries as Regional Specialization

With mass migration and tax reform underway, the economy of the late Tang slowly but gradually changed as capital and labor were redistributed from the farm sector to the non-farm sector, culminated in a commercial revolution that became evident in the Song dynasty. Based on observations by historians of Song China (Shiba, 1970; von Glahn, 2016;, among others), this commercialization process was characterized by two distinct processes—regional

specialization and the geographic expansion of markets—processes an economist conceives as "Smithian growth" (Kelly, 1997).

Measured by the number of commodities produced in a county, we use the number of proto-industries—defined essentially as artisanal, home-based non-assembly-line operations—as a proxy for regional specialization.[36] In the Chinese context, where agriculture had long been the mainstay of the economy, proto-industries testified to the wide array of specialization highlighted by Song historians (e.g., Shiba, 1970). Information on proto-industries in Song China was documented in two compendia of geographic gazetteers for this dynasty; one is the aforementioned *Universal Geography of the Taiping Era* (*Taiping Huanyuji*), the other is the *Yuanfeng [1078] Geographic Gazetteer* (*Yuanfeng Jiuyuzhi*). According to these compendia, there were as many as 10 proto-industries in the Song, including: ceramics, silk, tea, iron, shipbuilding, timber, cotton, silver, coal, ink, paper and calligraphy brushes. Lacking information on the particulars of these industries such as size and complexity, we simply count the type of proto-industries in each county as a measure of its specialization, for which the maximum was four in our sample counties. The geographic distribution of proto-industries is shown in Figure A5 in the Appendix and the results of the relevant estimates are reported in panel A of Table 8. Except for the 100km bandwidth estimate (column (5)), which is insignificant, there were significantly more proto-industries in the EGA counties. In terms of magnitude, the result from column (6) indicates that the EGA counties had an average of 17% more proto-industries, suggesting that there was already a non-trivial amount of labor being reallocated from the farm to nonfarm sectors in Northern Song.

[Table 8 about here]

5.3.2 Rise of Waterway Network and the National Market

The other salient feature of Smithian growth pertains to the geographic expansion of markets, which according to historians was aided by an effective national waterway network (Elvin, 1973; Kelly, 1997; Shiba, 1970). Before examining the effect of improvements to the waterway network, we first examine the development of shipbuilding which, according to Shiba (1970), complemented the increased use of waterways to expand regional trade and development. Based on the data Shiba (1970) provided in *Commerce and Society in Sung China*, a county is set to 1 if it had developed a shipbuilding industry, and 0 otherwise. We report the estimated effects of the EGA boundary on the geographic distribution of shipbuilding industry in panel B of Table 8, and confirm that counties within the EGA were significantly more likely to have developed a shipbuilding industry during the Song dynasty.

[36] For example, prominent examples of proto-industry that emerged in the European countryside before the industrial revolution were spinning and weaving (see, e.g., Ogilvie, 1993).

We then examine Elvin's (1973) proposition that the Smithian growth in Song was substantially facilitated by improvements made to the network of waterways and transport before and during Song times. In particular, an obvious advantage with which south-eastern China enjoyed in respect of commercialization was its dense and well-connected river networks, a feature on which China's "transport revolution" depended crucially (Elvin, 1973). The importance of river transport in trade and development in Song China is well borne out by a historian's estimates (Liu, 2015). Of all the commercial taxes collected, those collected along the 12 major river tributaries accounted for half. To assess whether river networks indeed conferred a significant effect on commercial development, we construct a dummy variable to indicate whether a county falls within a 50km radius of the network of navigable rivers in the Song dynasty.[37] As a placebo test, we also construct another dummy variable, namely whether a county falls within a 50km radius of postal road, on the assumption that the effect of postal roads on regional development and market expansion was less than that of the river network. The data for postal roads are obtained from *The Transportation Network in Tang-Song Dynasties* (Aoyama, 1963), while those for navigable rivers are from *The Making of a Fiscal State in Song China, 960-1279* (Liu, 2015), respectively.

We regress the proxies for commercial revolution on these two dummy variables of respectively river and road transport infrastructure in columns (1)-(2) and (7)-(8) of Table 9, and their interactions with the EGA boundary in columns (3)-(6) and (9)-(12), respectively. Panel A is estimated using the amount of commercial tax, while panel B uses the number of market towns, both normalized by the county population, respectively, as dependent variables. The first striking observation arising from Table 9 is that, by itself proximity to postal road has a significantly positive effect on a county's commercial development, but proximity to river networks does not. However, once we interact river networks with EGA, counties closer to the river networks (defined as 50km or less in distance to these networks) inside the EGA experienced a significantly faster growth in commercial development, relative to those further away from it (columns (3)-(4) and (9)-(10)). But the same does not apply to postal roads (columns (5)-(6) and (11)-(12)). These findings thus importantly substantiate Elvin's (1973) thesis regarding just how crucial a "transport revolution" premised on the dense and widespread river network in south-eastern China was for commercial development.

[Table 9 about here]

[37] We choose a radius of 50 km because the average diameter of a county was 47 km.

5.3.3 Agricultural Innovations and Productivity Growth

An important pre-condition for deeper market expansion and specialization was the growth in agricultural productivity and farm surpluses, which was in turn attributed to the adoption of a package of new agricultural innovations. Recall earlier our hypothesis that the mass migration induced by the An-Shi Rebellion had the effect of increasing population pressure in the south, thus providing the region with a strong impetus to adopt new agricultural technologies such as improved fertilizing practices, the adoption of a double-cropping system, planting early-ripening rice varieties, and so forth (see, e.g., von Glahn, 2016). To test this hypothesis empirically, we constructed three measures as proxies for agricultural innovation; they include: 1) the number of agricultural treatises (*nongshu*), measured by the book titles written by authors of different counties; 2) a dummy variable indicating whether a county practiced double cropping (either both cycles of rice or one cycle of rice followed by another of wheat, see Shiba, 1992); and 3) a dummy variable indicating whether a county had adopted the new, early-ripening rice varieties. The data on the titles of agricultural treatises are obtained from Amano's (1989) *Zhongguo Gunongshukao* (*A Study on Imperial Chinese Book on Agricultural Knowledge*), *Zhongguo Gu Nonglin Shuili Shumu* (*A Catalogue of Chinese Book Titles on Agricultural and irrigation Knowledge*) (Nanjing Library, 1956), and Wang's (2006) *Zhongguo Nongxue Shulu* (*A Catalogue of Chinese Book Titles on Agricultural Knowledge*). We combined the three sources to create a complete catalogue of books on agricultural technology and practice published in the Song dynasty. Altogether there were 214 such titles. Data on the adoption of the double cropping systems and new seed varieties respectively are obtained from Han's (1993) *Song's Agricultural Economy*.

Table 10 reports the results of regressing the number of book titles of agricultural treatises against the EGA, using the same spatial RD specifications as previously. The results clearly show that, first, significantly more agricultural treaties were written by authors within the EGA. Second, double-cropping was also practiced significantly more in the EGA. Third, early-ripening seed varieties were adopted significantly more within the EGA. Together, these findings coalesce in confirming that it was the EGA counties that experienced what von Glahn (2016) describes a "great leap forward" in agricultural productivity, forming an important pre-condition for specialization both within and beyond agriculture, with the expansion of regional markets as a corollary.

[Table 10 about here]

6 Conclusion

Although second in importance to the Industrial Revolution, the Commercial Revolution is an epochal event in world economic history and it was in Song dynasty China that a commercial flowering occurred several centuries before Europe. While China remained pre-industrial, this revolution nonetheless transformed an overwhelmingly agricultural or subsistence economy which had lasted for at least a millennium, to one where commerce and trade thrived on the basis of agricultural productivity and output growth. By constructing a novel data set from a variety of rich historical data sources, we have explained the origins of this commercial revolution, accounted for its primary channels, and provided evidence of the dynamics of this Smithian growth process. Specifically, we made use of the An-Shi Rebellion, which triggered massive population movements, and reallocations of labor made possible by a tax reform to examine how institutional differences between the two regions led to long-term economic growth in one instance but not the other. Additionally, we have brought empirical evidence to bear on the claim that the commercial revolution that eventually transpired from this institutional change arose foremost from the remarkable growth in agricultural productivity and output and improvements to a network of waterways, which, together, laid the foundations required for generating the regional specialization and markets expansion that defined Smithian growth.

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Figure 1. Population Growth between 200 BC and 1400 AD

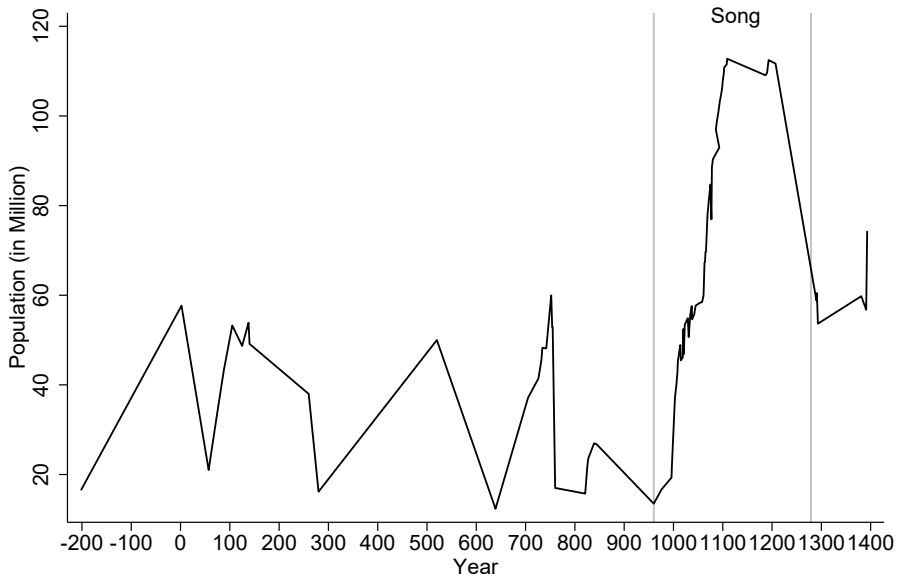


Figure 2. Conceptual Framework: Anshi Rebellion and the Rise of Commercial Revolution

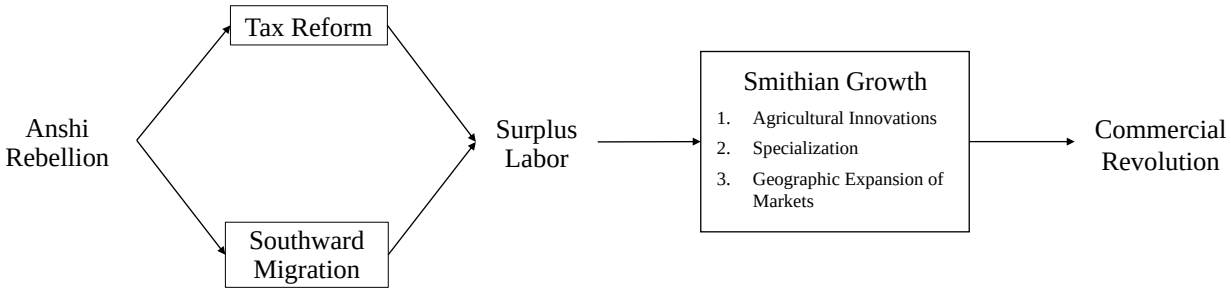
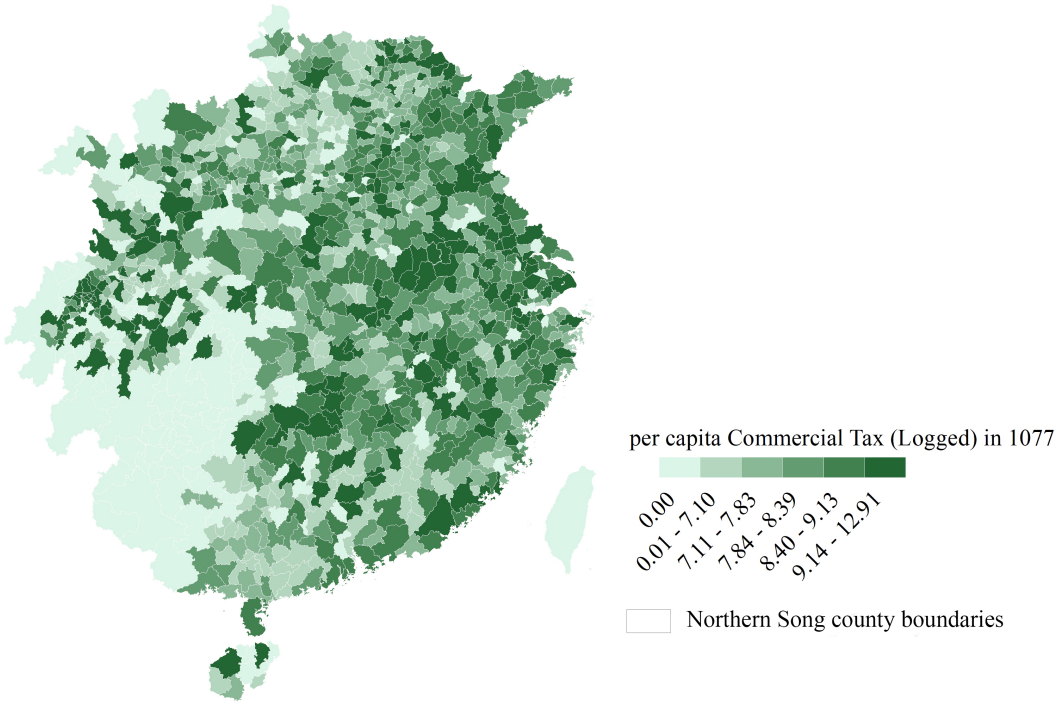
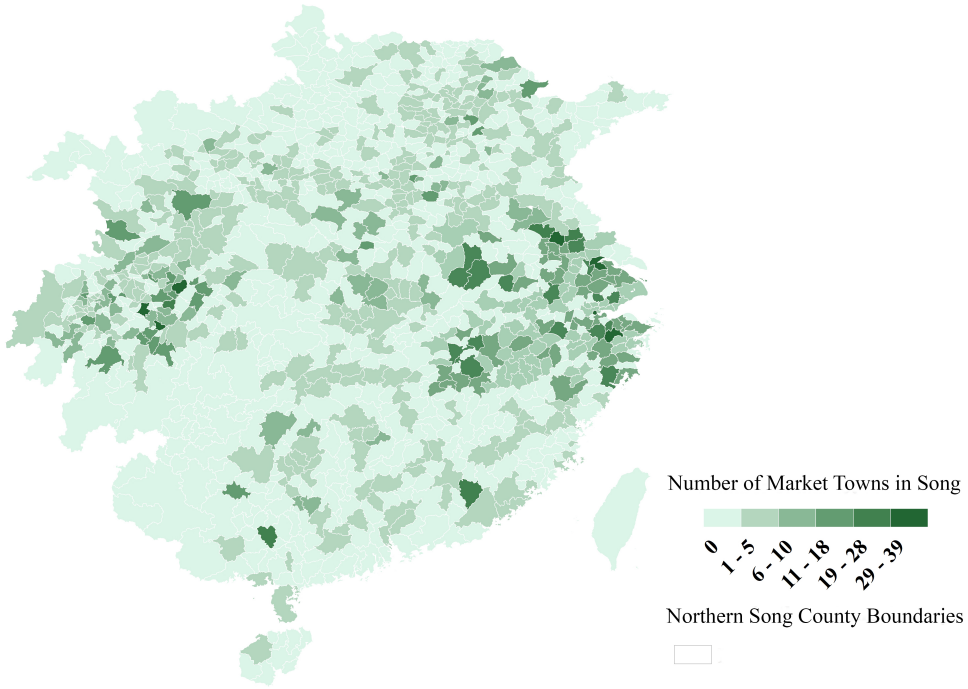


Figure 3. Geographic Distribution of Proxies of Commercial Revolution in Song



Panel A. Commercial Tax (Logged) in 1077



Panel B. Market Towns in Song Dynasty

Figure 4. The Boundary of the Effectively Governed Area in Late Tang (c. 780 and Beyond)

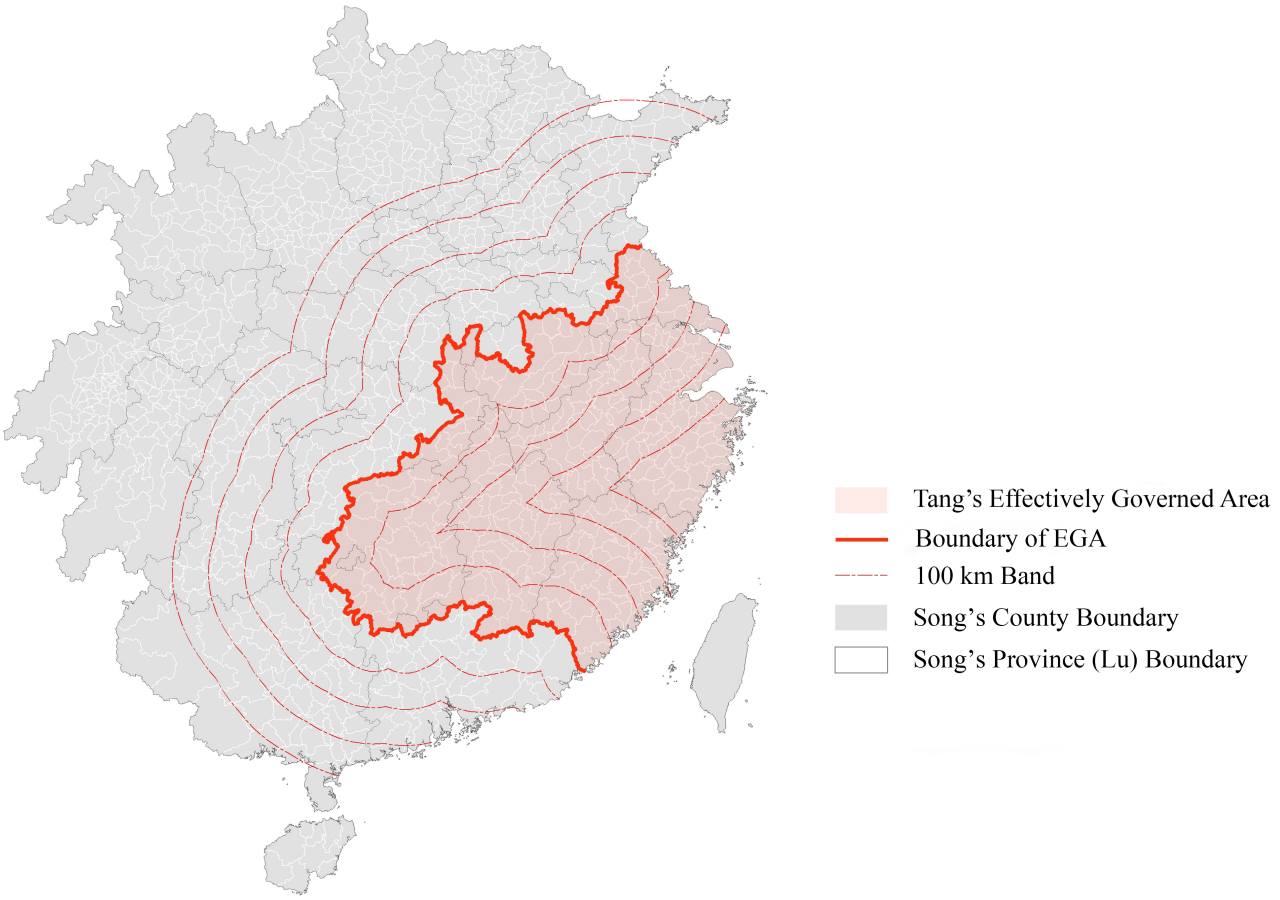


Figure 5. Fitted Values from a Local Linear Regression of the Three Commercial Measures in the Song Dynasty

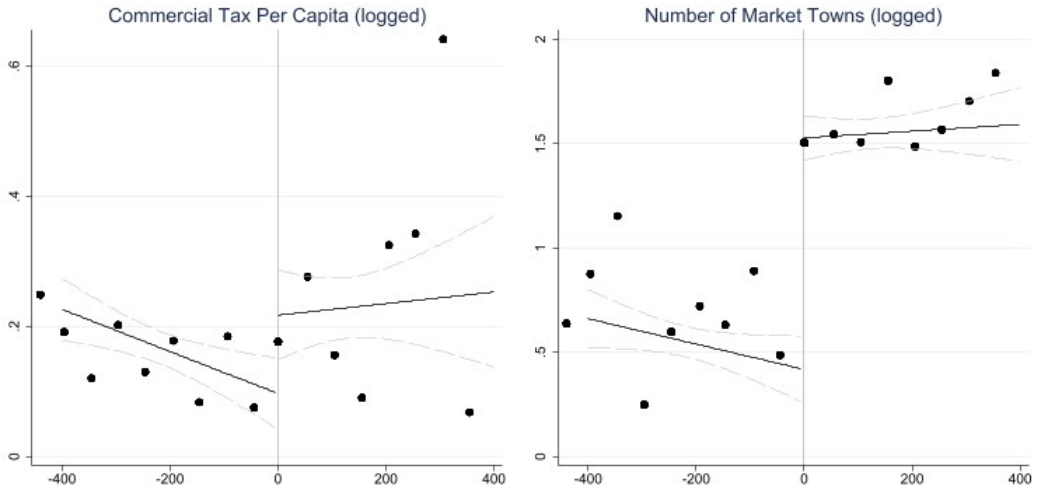


Figure 6. RD Estimates of the Effectively Governed Area on Population Density between 680 and 1776

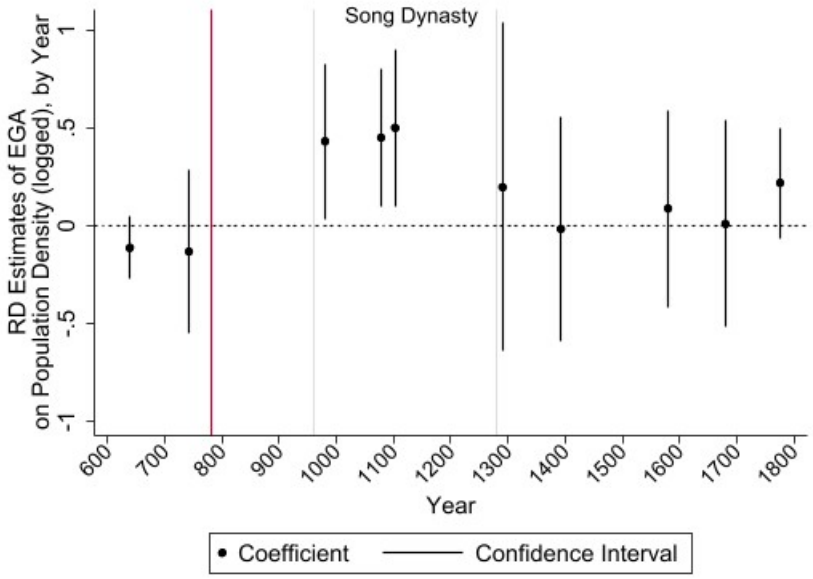


Table 1. Summary Statistics of the Variables Employed in the Analysis

Variables	# of Obs.	Mean	Std. Dev.	Min	Max
Commercial Tax per capita (Logged)	1197	0.053	0.115	0	1.179
Number of Market Towns (Logged)	1197	0.029	0.100	0	2.791
Effectively Governed Area (=1)	1197	0.302	0.459	0	1
Major Migration Inflow Destination	1197	0.688	0.745	0	3
Major Migration Outflow Origin	1197	0.493	0.761	0	3
Ratio of Landless Population (c. 980)	1185	0.418	0.280	0.494	1.507
Number of Agricultural Treatise Titles in Song	1197	0.134	0.215	0	7
Adoption of Double Cropping (=1)	1197	0.071	0.096	0	1
Adoption of Early-Ripening Rice Varieties (=1)	1197	0.097	0.112	0	1
Number of Proto-industries (logged)	1197	0.668	0.450	0	1.792
Locations of Shipbuilding Industry in Song (=1)	1197	0.041	0.175	0	1
Near River (<=50km)	1197	0.607	0.489	0	1
Near Road (<=50km)	1197	0.191	0.393	0	1
Elevation	1197	472.810	507.645	0.842	3755.941
Slope	1197	9.954	7.577	0.494	37.669
Rice Suitability	1197	1124.134	1135.700	0	5535
Wheat Suitability	1197	2739.371	1136.972	61	7431
Caloric Suitability	1197	1994.197	427.652	261.157	2960.697
Distance to River	1197	10.453	1.259	3.007	13.362
Terrain Ruggedness Index	1197	179.486	146.274	0	972.474
Number of Battlefields	1197	24.595	10.714	0	53.648
Administrative Ranking	1197	1.196	0.481	1	3

Table 2. Balance Check

	Optimal Bandwidth							
	Elevation	Slope	Rice Suitability	Wheat Suitability	Caloric Suitability	Terrain Ruggedness Index	Distance to Navigable River	Administrative Ranking
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Effectively Governed Area	40.486	0.435	-16.576	152.728	-21.350	-1.522	-0.335	0.098
	(30.898)	(0.926)	(264.076)	(134.566)	(34.292)	(14.990)	(0.281)	(0.102)
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1198	1198	1198	1198	1198	1198	1198	1198

Notes: The average elevation, slope, and terrain ruggedness index for each Song's county are calculated by authors using the 90 square-meter grid-level data of a Digital Elevation Model (DEM) map provided by the United States Geographic Service (USGS). The rice and wheat suitability data is obtained from the GAEZ v4 database provided by FAO, while the caloric suitability is provided by Galor and Ozak (2016). The distance to the navigable river is calculated by authors using the GIS map of Song's county boundaries from the Hartwell China Historical GIS and the navigable river GIS information in Song from *The Making of a Fiscal State in Song China, 960–1279* (Liu, 2015). Finally, the administrative rank of each Song county is constructed from the *Yuanfeng Geographic Gazetteer*. * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 3. Effectively Governed Area and Commercial Revolution:
A Spatial Regression Discontinuity Analysis

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
Panel A	Commercial Tax Per Capita (logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.174***	0.245***	0.269***	0.283***	0.220***	0.141**
	(0.058)	(0.060)	(0.064)	(0.073)	(0.077)	(0.063)
Observations	1198	733	578	406	240	1198
Panel B	Number of Market Towns (logged)					
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	1.027***	1.028***	0.948***	0.957***	0.763***	0.815***
	(0.109)	(0.128)	(0.136)	(0.160)	(0.209)	(0.191)
Observations	1198	734	579	406	240	1198
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The data of Song's commercial tax is obtained from the Song government archival records entitled *Song Huiyao Jigao*, while the number of market towns is from Fu Zongwen's (1989) A Study of Song's Market Towns (Songdai Caoshizhen Yanjiu). * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 4A. Robustness Check II: Controlling the Direct Effects of War before Song

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
	Commercial Tax Per Capita (logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.175***	0.244***	0.279***	0.303***	0.225***	0.235***
	(0.061)	(0.062)	(0.068)	(0.081)	(0.084)	(0.071)
A fence town in Tang (=1)	0.030	0.070*	0.087*	0.125**	0.084	
	(0.036)	(0.040)	(0.050)	(0.062)	(0.095)	
# Battles in Tang	0.027	0.046**	0.065*	0.081	0.103	
(618-907)	(0.019)	(0.023)	(0.039)	(0.050)	(0.076)	
# Battles in Five Dynasties	0.077***	0.102***	0.155**	0.146*	0.183	
(908-959)	(0.024)	(0.039)	(0.063)	(0.087)	(0.111)	
Observations	1198	733	578	406	240	1198
	Number of Market Towns (logged)					
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	1.044***	1.031***	0.964***	0.956***	0.765***	0.803***
	(0.110)	(0.129)	(0.136)	(0.162)	(0.212)	(0.207)
Warlord County in Tang	0.065	0.037	0.085	0.038	0.098	
	(0.057)	(0.070)	(0.074)	(0.101)	(0.151)	
# Battles in Tang	0.068**	0.131**	0.131	0.075	0.042	
(618-907)	(0.032)	(0.051)	(0.082)	(0.096)	(0.118)	
# Battles in Five Dynasties	0.076*	0.063	0.129	0.151	0.138	
(908-959)	(0.041)	(0.066)	(0.089)	(0.124)	(0.153)	
Observations	1198	734	579	406	240	1198
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The GIS data of fence towns is constructed by matching the location information of all fence towns existed in Tang from the History of China's Administrative Boundary volume 5 on Tang (Guo, 2017) and Song's county GIS map, while the number of battles from the Chronological Records of Natural Disasters and Conflicts in China's History (Chen, 1939). * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 4B. Robustness Check II: Controlling the Threats from Nomadic Invasion in Song

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
	Commercial Tax Per Capita (logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.192***	0.211***	0.259***	0.282***	0.202**	0.262***
	(0.055)	(0.054)	(0.057)	(0.071)	(0.084)	(0.079)
Distance to Nomadic Frontier	-0.027**	0.030***	0.434***	0.566**	0.417	
	(0.010)	(0.009)	(0.162)	(0.281)	(0.466)	
# Battles in Song	0.070***	0.127***	0.130***	0.135***	0.150***	
(960-1279)	(0.018)	(0.031)	(0.034)	(0.039)	(0.043)	
Observations	1198	733	578	406	240	1198
	Number of Market Towns (logged)					
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	1.016***	1.002***	0.900***	0.867***	0.690***	0.777***
	(0.109)	(0.129)	(0.139)	(0.169)	(0.215)	(0.186)
Distance to Nomadic Frontier	0.023*	0.045**	-0.441	-1.049*	-1.207	
	(0.012)	(0.022)	(0.363)	(0.583)	(0.944)	
# Battles in Song	0.059***	0.102***	0.106***	0.104***	0.093**	
(960-1279)	(0.020)	(0.028)	(0.031)	(0.035)	(0.042)	
Observations	1198	734	579	406	240	1198
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: the distance to nomadic frontier is calculated by authors using the Song's county boundary map, while the number of battles is constructed from Chen (1939). * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 5. Placebo Test of Effectively Governed Area on Tang's Commercial Development

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
Panel A			Population Density in 639			
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	-0.597***	-0.237***	-0.236***	-0.262***	-0.172***	-0.136
	(0.120)	(0.079)	(0.073)	(0.066)	(0.056)	(0.093)
Observations	1198	734	579	406	240	1198
Panel B			Population Density in 742			
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	-0.022	-0.586***	-0.515***	-0.438***	-0.419***	-0.100
	(0.122)	(0.088)	(0.085)	(0.093)	(0.110)	(0.229)
Observations	1198	734	579	406	240	1198
Panel C			Commercial Center in Tang (=1)			
	(13)	(14)	(15)	(16)	(17)	(18)
Effectively Governed Area	-0.012	-0.032	0.012	-0.002	0.060	0.074
	(0.047)	(0.051)	(0.049)	(0.052)	(0.051)	(0.046)
Observations	1198	734	579	406	240	1198
Panel D			Number of Proto-industries in Tang (logged)			
	(19)	(20)	(21)	(22)	(23)	(24)
Effectively Governed Area	0.038	0.020	0.016	-0.026	-0.010	0.021
	(0.023)	(0.061)	(0.083)	(0.025)	(0.022)	(0.014)
Observations	1195	733	578	405	240	1195
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The data on population density is obtained from *The Population History in Sui-Tang Dynasties* (*Zhongguo Renkoushi Sui-Tang Juan*), while the data on the locations of commercial centers and various proto-industries are taken from *Tang's Regional Economy* (*Tangdai Quyu Jingji*) (Weng, 2001) and *Tang's Proto-industries* (*Tangdai Gongshangye*) (Zhang, 1995), respectively. * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 6. Effectively Governed Area, the Channels of Mass Migration, and Tax Reform after An-Shi Rebellion

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
Panel A			Major Migration Inflow Destination			
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.984***	0.968***	0.911***	0.802**	0.884**	0.273*
	(0.202)	(0.235)	(0.267)	(0.326)	(0.413)	(0.140)
Observations	1198	734	579	406	240	1198
Panel B			Major Migration Outflow Origin			
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	-0.044	-0.199**	-0.195**	-0.289***	-0.184*	-0.232**
	(0.076)	(0.083)	(0.089)	(0.098)	(0.101)	(0.109)
Observations	1198	734	579	406	240	1198
Panel C			Ratio of Landless Population (c. 980)			
	(13)	(14)	(15)	(16)	(17)	(18)
Effectively Governed Area	0.183***	0.267***	0.255***	0.282***	0.221**	0.140**
	(0.045)	(0.053)	(0.057)	(0.067)	(0.090)	(0.063)
Observations	1185	726	572	402	239	1185
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Data on the major origins and destinations of migration after the An-Shi Rebellion are constructed from two atlases in *A Migration History of China, Volume 3 on Tang and Song Dynasties* (*Zhongguo Yiminshi III Sui-Tang Juan*) compiled by Wu (1997). And the variable of the ratio of the landless population (c.980) is constructed using information from the *Universal Geography of the Taiping Era* (*Taiping Huanyuji*). * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 7. Heterogeneity Tests on the Effects of Mass Migration, and Tax Reform on Commercial Development

	Commercial Tax per capita (logged)				Number of Market per capita (logged)			
	<=400km	<=300km	<=200km	<=100km	<=400km	<=300km	<=200km	<=100km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Effective Governed Area (EGA)	-0.112	-0.537***	-0.541***	-0.700***	1.011	-0.131	-0.223	-0.516**
	(0.216)	(0.080)	(0.095)	(0.147)	(0.635)	(0.108)	(0.139)	(0.237)
Reference Group: No inflow counties								
Minor Migration Inflow Destination	0.080**	0.101***	0.127***	0.183***	0.273***	0.292***	0.459***	0.676***
	(0.031)	(0.036)	(0.039)	(0.064)	(0.102)	(0.108)	(0.137)	(0.179)
Median Migration Inflow Destination	0.069	0.129*	0.176*	0.084	0.285	0.335	0.471*	-0.071
	(0.058)	(0.074)	(0.093)	(0.187)	(0.193)	(0.223)	(0.283)	(0.314)
Major Migration Inflow Destination	0.033	0.067	0.109	0.157*	0.401	0.497	0.650	0.907
	(0.093)	(0.084)	(0.086)	(0.087)	(0.631)	(0.657)	(0.647)	(0.636)
EGA*Minor Migration Inflow Destination	0.017	0.428***	0.452***	0.634***	-0.414	0.761***	0.709***	0.719***
	(0.218)	(0.068)	(0.089)	(0.134)	(0.641)	(0.128)	(0.163)	(0.251)
EGA*Medium Migration Inflow Destination	0.088	0.455***	0.462***	0.760***	-0.314	0.870***	0.828***	1.451***
	(0.235)	(0.116)	(0.145)	(0.255)	(0.663)	(0.240)	(0.301)	(0.349)
EGA*Median Migration Inflow Destination	0.302	0.413***	0.398*	0.591***	0.791	2.269***	2.820***	2.620***
	(0.385)	(0.152)	(0.205)	(0.110)	(0.924)	(0.715)	(0.648)	(0.637)
Share of Landless Labor	-0.010	-0.024	-0.002	0.022	-0.200	-0.352*	-0.465*	-0.893**
	(0.045)	(0.055)	(0.057)	(0.089)	(0.164)	(0.194)	(0.240)	(0.371)
EGA*Share of Landless Labor	0.290***	0.309***	0.282***	0.245*	0.371**	0.515**	0.609**	1.086***
	(0.084)	(0.091)	(0.096)	(0.128)	(0.171)	(0.201)	(0.246)	(0.373)
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	726	572	402	239	726	572	402	239

* p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 8. Song's Commercial Revolution as Smithian Growth

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
Panel A	Number of Proto-industries in Song					
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.222***	0.178***	0.205***	0.132*	0.021	0.173**
	(0.055)	(0.066)	(0.069)	(0.075)	(0.081)	(0.072)
Observations	1197	733	578	406	240	580
Panel B	Locations of Shipbuilding Industry in Song (=1)					
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	0.290***	0.138***	0.114***	0.115***	0.121**	0.267**
	(0.083)	(0.027)	(0.043)	(0.024)	(0.050)	(0.122)
Observations	1197	733	578	406	240	745
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Information on proto-industries in Song China was documented in two compendia of geographic gazetteers for this dynasty; one is the aforementioned *Universal Geography of the Taiping Era* (*Taiping Huanyuji*, the other is the *Yuanfeng [1078] Geographic Gazetteer* (*Yuanfeng Jiuyuzhi*), while the locations information for the shipbuilding industry is from *Commerce and Society in Sung China* (Shiba, 1970). * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 9. Waterway Network and Commercial Revolution

	<=400km	<=200km	<=400km	<=200km	<=400km	<=200km
Panel A	Commercial Tax per capita (logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area (EGA)	0.111**	0.142**	0.067	0.088*	0.081*	0.100*
	(0.048)	(0.057)	(0.048)	(0.052)	(0.043)	(0.054)
Near River (<=50km)	0.068**	0.048	0.003	-0.06	0.066*	0.05
	(0.034)	(0.042)	(0.030)	(0.037)	(0.034)	(0.042)
Near Roads (<=50km)	0.107***	0.131***	0.106***	0.132***	0.064**	0.075**
	(0.029)	(0.044)	(0.029)	(0.044)	(0.026)	(0.036)
EGA * Near River			0.121**	0.181***		
			(0.061)	(0.063)		
EGA * Near Roads					0.073	0.082
					(0.048)	(0.057)
Observations	733	406	733	406	733	406
Panel B	Number of Market (logged)					
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area (EGA)	0.167***	0.199***	0.167***	0.163**	0.110	0.156*
	(0.055)	(0.074)	(0.053)	(0.069)	(0.078)	(0.080)
Near River (<=50km)	0.056	0.008	-0.003	-0.078	0.056	0.01
	(0.037)	(0.028)	(0.035)	(0.052)	(0.036)	(0.029)
Near Roads (<=50km)	0.068*	0.125***	0.067*	0.126***	0.067**	0.076
	(0.035)	(0.046)	(0.035)	(0.046)	(0.033)	(0.053)
EGA * Near River			0.128*	0.144**		
			(0.070)	(0.066)		
EGA * Near Roads					0.002	0.072
					(0.050)	(0.056)
Observations	733	406	733	406	733	406
Cubic Polynomial	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The data for postal roads are obtained from *The Transportation Network in Tang-Song Dynasties* (Aoyama, 1963), while those for navigable rivers are from *The Making of a Fiscal State in Song China, 960–1279* (Liu, 2015), respectively. * p<0.10; ** p<0.05; *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.

Table 10. Effectively Governed Area and Agricultural Innovations

	All	<=400km	<=300km	<=200km	<=100km	Optimal Bandwidth
Panel A		Number of Agricultural Treatise Titles in Song				
	(1)	(2)	(3)	(4)	(5)	(6)
Effectively Governed Area	0.433***	0.551***	0.683***	0.652***	0.487***	0.524***
	(0.060)	(0.050)	(0.048)	(0.062)	(0.047)	(0.049)
Observations	1197	733	578	406	240	766
Panel B		Adoption of Double Cropping (=1)				
	(7)	(8)	(9)	(10)	(11)	(12)
Effectively Governed Area	0.298*	0.277***	0.242**	0.206***	0.111***	0.139***
	(0.142)	(0.055)	(0.082)	(0.061)	(0.025)	(0.027)
Observations	1197	733	578	406	240	670
Panel C		Adoption of Early-Ripening Rice Varieties (=1)				
	(13)	(14)	(15)	(16)	(17)	(18)
Effectively Governed Area	1.158*	1.423*	1.195**	1.142*	1.059*	1.364**
	(0.484)	(0.615)	(0.433)	(0.511)	(0.477)	(0.480)
Observations	1197	733	578	406	240	645
Cubic Polynomial of XY	Yes	Yes	Yes	Yes	Yes	Yes
Segment Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The data on the titles of agricultural treatises are constructed by combining information from Amano's (1989) *Zhongguo Gunongshukao* (*A Study on Imperial Chinese Book on Agricultural Knowledge*), *Zhongguo Gu Nonglin Shuili Shumu* (*A Catalogue of Chinese Book Titles on Agricultural and irrigation Knowledge*) (Nanjing Library, 1956), and Wang's (2006) *Zhongguo Nongxue Shulu* (*A Catalogue of Chinese Book Titles on Agricultural Knowledge*), while data on the adoption of the double cropping systems and new seed varieties are obtained from Han's (1993) Song's Agricultural Economy. * p<0.10, ** p<0.05, *** p<0.01. Robust standard error in parentheses. A constant is added but not reported.