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Demystifying growth and development in North Song China, 960–1127

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ABSTRACT

The Northern Song Period (960–1127) has been recognised as one of the most important eras in China’s economic and demographic history. This study investigates climatic and geopolitical conditions and factors that led to economic restructuring whereby intensive growth took place to generate more wealth to support a growing population. This paper reveals the unique nature and mechanisms behind the Song remarkable economic growth with quantitative evidence.

¹ I wish to thank Dr. Lucy Zheng who has helped with the quantitative part of this paper. My deep indebtedness goes to Professors Eric L. Jones, Patrick O’Brien, Stephen Broadberry, Janet Hunter, Mark Elvin, Bruce Campbell and Bozhong Li, who commented and advised on various drafts over the last three years.

The mainstream scholarship on Song China has regarded the Northern Song (960–1127) as a period of 'economic revolution' with which China demonstrated a clear tendency towards intensive growth.² Other opinions account for a small minority.³ There has been a range of influential works in Western literature by Robert Hartwell,⁴ Shiba Yoshinobu,⁵ Mark Elvin, Joel Mokyr and Kenneth Pomeranz.⁶ Eric Jones thus argued that Song China was the first credible candidate for a genuine industrial revolution centuries before any other civilisation.⁷ His provoking question 'why China was unable to repeat its Song success' has formulated an intriguing paradox.

Amongst Chinese academics, however, the Northern Song Period has not been celebrated quite the same way. In the Chinese collective memory, the Northern Song Period was marred by administrative weakness and military incompetence that led to repeated defeats with two emperors captured as prisoners of war and annual ransoms payable to nomads (Huizong, r. 1100–25; Qinzong, r. 1125–7), and then alien conquests of China. Even so, there has been a strong undercurrent in China to re-assess the Song economic performance.⁸ But the Song paradox of advanced industry and commerce coinciding with pathetic national defence has never failed to provoke debate.⁹

² On the Song industrial sector, see Hartwell, 'Iron and Coal Industries', 'Economic Change', *Iron and Early Industrialism* and 'Markets, Technology, and the Structure of Enterprise'. More recently, Wagner, 'Administration of the Iron Industry'. On Song commerce, see Shiba, *Commerce and Society*; Elvin, *Pattern of the Chinese Past*, Pt. 2. On Song technology, see Needham, *Science and Civilisation*; Deng, *Chinese Maritime Activities and Socioeconomic Development*; Mokyr, *Lever of Riches*, ch. 8; Von Glahn, *Fountain of Fortune*; Twitchett and Smith, *Cambridge History of China*, vol. 5, Part One; Qi, *Songdai Jingjishi*, vol. 2, chs 13, 18, 19, 28.

³ Some have questioned the existence of the Song growth; see e.g. Landes, *Wealth and Poverty*, ch. 21.

⁴ Hartwell, 'Iron and Coal Industries', 'Economic Change', *Iron and Early Industrialism* and 'Markets, Technology, and the Structure of Enterprise'. Noted here, most estimates have been based on 5.7 million piculs of iron (or 3,400 metric tons) received by the Song state in 1078; see Xu, *Song Huiyao Jigao*, 'Shihou 33/3–4, 33/27–9'. Hartwell's estimate of the Song annual iron output (114,000 metric tonnes) has not been short of debate; see e.g. Wagner 'Administration of the Iron Industry', p. 176 and his *Science and civilisation in China*, p. 300; Qi, *Songdai Jingjishi*, vol. 2, pp. 559–61; Liu, 'Songdaide Tiejian Yu Tie Chanliang'; Wang, *Songdai Kuangye Yanjiu*, pp. 159–74; Yoshida, *Chugoku Kagaku Gijutsu Shi Ronshu*, pp. 364–6. General speaking, Hartwell and Wagner operate on the supply side of the industry; Qi, Liu and Wang on the demand side. In his most recent re-assessment, Wagner concluded that Hartwell's figures were 'of the right general order of magnitude'; see his *Science and civilisation in China*, p. 280. Others believe that Hartwell overestimated the Song capacity. Liu's estimate is 10,000 metric tonnes; Qi-Wang's, about 70,000; Yoshida, somewhere in between.

⁵ Shiba, *Commerce and Society*.

⁶ Elvin called it 'the Medieval Revolution'; see his *Pattern of the Chinese Past*, Pt. 2; Mokyr, *Lever of Riches*; Pomeranz, *Great Divergence*.

⁷ Jones, *European Miracle*, p. 160; Jones, *Growth Recurring*, ch. 4; Jones, 'Real Question about China'. Also, Hobson, *Eastern Origins of Western Civilisation*, chs 1–4, 9.

⁸ E.g. Yuan, 'Local Government Schools'; Shi, *Beisong Shiqi Ziran Zaihai Yu Zhengfu Guanli Tixi Yanjiu*; Qi, *Songdai Jingjishi*; Wu, *Songdai Jingjishi Yanjiu*; Liu, *Songjin Zhibishi*; Cheng, *Songdai Wujia Yanjiu*; Gao, *Songdai Huobi Yu Houbi Liutong Yanjiu*. For a comprehensive review, see Zhu and Cheng, *Songshi Yanjiu*. Also, see *Songshi Yanjiu Ji*, a long-lasting research series published in Taiwan from 1958 to 1984 which contains short essays on all aspects of Song history.

⁹ Many civilisations were defeated by nomads from the Steppes around this time, China was no exception. But, Song China had serious internal defects. The Northern Song was established through a military *coup d'état* by Zhao Kuangyin (927–76) who later became paranoid about *coup* against himself.

Nevertheless, one view shared by both Western and Chinese literatures is that the Northern Song Period was marked by its rapid population growth.¹⁰ The main evidence comes from officially registered household numbers, which grew from 6.2 million households in 980 AD to 17.5 million households by 1101 AD, an increase of 280 per cent.¹¹ This was monitored by regular surveys (with 1–3 year intervals), including *dingzhang* (male poll), *dingchan bu* (household asset assessment), *shui zhang* (household tax accounts), *xiaqiu shui zhang* (two seasonal tax accounts), and *baojia bu* (neighbourhood watch enrolment).¹² During the previous Tang Period (618–907), nation-wide surveys were only conducted four times in total.¹³ This made the Song Period information-rich than any of its predecessors.

But so far, the actual population number of the Song (in persons) has remained unknown. Of 45 available observations from 960 to 1127, *kou* or *dingkuo* (meaning ‘male persons’ and ‘male poll-taxpayers’) varied from 1.42 to 2.57 per household, averaging 2.11.¹⁴ This male bias in population registration was deliberate. It all began in 963 when the newly crowned Emperor Taizhu (r. 960–76) decided to exclude the entire female population from the government taxation registrations.¹⁵ One therefore should not take these numbers as the actual sizes of Song households simply because such small family sizes would have made Song population unsustainable.

Sporadically, local family sizes were unveiled under certain extraordinary circumstances such as during famine when every soul was counted. Of over 400,000 locally registered relief beneficiary households, the average household had 5.3–5.5 persons.¹⁶ Or, one can use the Tang demography as a proxy, since the Tang Marriage Law was followed,¹⁷ and the geographic concentration of population remained more or less unchanged.¹⁸ However, scholars still have

He implemented a cluster of measures to separate military commanders from their troops and hence undermined the strength of the Song national defence which cancelled the Song advantages in military technology (including the world’s first compass and fire arms); see Deng, *Chinese Premodern Economy*, ch. 6. The system backfired after military leaders lost interest in the quality of troops. Army recruits were made of the ‘undesirable and untrustworthy’, i.e. beggars, ruffians, riffraff and bandits. Discipline was gone and mutinies were common; see Luo, *Songshi Pieshi*, pp. 3–58. As a result, of the 81 military clashes with the Khitans, the Songs triumphed only once; see Hua, *Songshi Luji*, p. 142. A lousy military was undoubtedly an Achilles’ heel of the Song Empire.

¹⁰ For Western works, see e.g. Durand, ‘Population Statistics of China, A.D. 2–1953’, pp. 227–8; Chao, *Man and Land in Chinese History*; Deng, ‘Unveiling China’s True Population Statistics’.

¹¹ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 164; Wu, *Zhongguo Renkoushi*, pp. 122–35.

¹² Liang, *Nansongde Nongcun Jingji*, p. 54; Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, pp. 229–30; Wu, *Zhongguo Renkoushi*, pp. 59–62.

¹³ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 78–114.

¹⁴ *Ibid.*, pp. 122–4. Similarly, see He, *Songdai Xiaofei Shi*, p. 308, where the average household size ‘declined’ from 2.2 to 1.7 persons. For the on-going debate, see Zhu and Cheng, *Songshi Yanjiu*, pp. 248–56.

¹⁵ The emperor instruction reads: ‘Local governments report the number of men from Age 20 until Age 60; women are excluded’, cited in Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, p. 255; see also Wu, *Zhongguo Renkoushi*, pp. 66–7.

¹⁶ Wu, *Zhongguo Renkoushi*, pp. 156, 159.

¹⁷ The legal ages for marriages were 15 for males and 13 for females during the Tang and the Northern Song; see Jiang, *Renkou Yu Lishi*, p. 272.

¹⁸ Population Census Office and the Institute of Geography, *Population Atlas*, pp. 70–1.

no agreed size for Song households.¹⁹ The variation may in fact reflect the Song regional demographic differences.²⁰ To avoid further controversy, the current study sticks to the official household numbers instead of making yet another set of population estimates (see Table 1).²¹

Given that difference in growth rates between households and male poll-taxpayers is negligible. For the purpose of this research, one per cent a year can be taken as a proxy for the population growth *per se*. An independent check is available to support this growth rate. According to the government record, from 995 to 1078 the Songs total marketed salt increase from 373,545 *xiaoxi* (small units) to 739,620 *daxi* (large units), or from 43.5 million to 103.5 million *catties*, with an annual growth rate of one per cent.²² Salt consumption is both price and income inelastic. It is a reliable barometer for population growth.

The question is what made a persistent increase in the Song population possible. One popular explanation is that the Song population grew on a cheaper food source known as the 'Champa Rice Hypothesis'. It asserts that a new rice species introduced from outside teleologically multiplied China's food stock on the one hand, and population, and industry and commerce on the other.²³ This is commonly associated with the 'surplus-pulled' model. The problem with this cheap food hypothesis is why a windfall of cheap food did so little for China's industry and commerce during the Ming-Qing Period later. Historically, more food often meant more pleasure instead of more work in industry. Also due to the price and income inelasticity in food consumption, more food does not create more market value or greater capital accumulation and capital formation. Quite the opposite: cheap food always harms farmers. Historically, therefore, a low market price itself was always sufficient to discourage excessive supply of food to last for too long. So, the 'Champa Rice Hypothesis' is self-defeating.

There is also a 'subsistence-pushed' model which operates differently: when *per capita* farmland shrinks too much to live on home-grown staple food, producers are forced to produce non-staple products in order to sell them in exchange for food to consume, often at the subsistence level. In doing so, population may still increase but per capita income often does not, called 'rural involution'.²⁴ In this context, much of the growth was fuelled by Chayanovian 'labour self-exploitation' within a frozen production possibility frontier.²⁵ To satisfy this 'subsistence-pushed' model however, the supply of arable land must be inelastic. This seems to be the case in later Qing but not during the Northern Song. If land supply was elastic, as in

¹⁹ The highest estimate is 7.5 people; the lowest, 5.0; the medium, 5.4–6.0. For a high estimate see Li, 'Songmo Zhi Mingchu Jiangnan Nongmin Jingyingde Bianhua', p. 33. For a low one, see Wu, *Zhongguo Renkoushi*, p. 580; Jiang, *Population and History*, p. 60; Duan, *Historical Demography*, p. 335. For the medium range; see Ge, *Zhongguo Renkou Fazhanshi*, p. 308; Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, pp. 253–63; Ma, 'Family Size'.

²⁰ Wang, *Jindai Zhongguo Wujia, Gongzi He Shenghuo Shuiping Yanjiu*, pp. 174–8.

²¹ We are fully aware of the story of lazy county magistrates forging local records in the late Qing; see Skinner, "Sichuan's Population in the Nineteenth Century". So far, there has been no similar complaint against the Song administration. The 'Skinnerian data problem' may have not been widespread during the Northern Song.

²² Tuo, *Song Shi*, vol. 181, 'Shihuozi 134'. Note: *xiaoxi* = 116.5 *catties*; *daxi* = 140 *catties*.

²³ Ho, 'Early-Ripening Rice', p. 212.

²⁴ For Ming-Qing North China, see Huang, *Peasant Economy and Social Change in North China*. For medieval England, see Campbell, 'Agrarian Problem in the Early Fourteen Century'.

²⁵ Chayanov, *Theory of Peasant Economy*.

China from 1000 throughout 1750, home-grown food was able to feed the family; then, the majority farmers did not need to trade for food.

Among Song scholars, opinions have been divided. Followers of the 'surplus-pulled' hypothesis include Qi Xia who develops a long list of advancements in Song agriculture for cheap food.²⁶ Among the sceptics like Li Bozhong and Zeng Xiongsheng doubts are raised about a food windfall.²⁷ They tend to favour a subsistence-pushed explanation.

An alternative model is 'diversified income', meaning that there are opportunities to earn more income differently, something close to Arthur Lewis' dualism with which a higher income option available *ex ante* persuades people to change jobs across sectors voluntarily without the pain of the Enclosure Movement or class struggle.²⁸ It fits well with "Say's Law" of products being paid for by each other, and the market always clearing itself, an idea that has inspired many great works on modern growth.²⁹ Then, more incomes lead to a growth in population in a virtuous spiral. To achieve that, the economy needs to have a structure that is different from a traditional farming society. This study argues that during the Northern Song China was such an economy where economic restructuring occurred, offering diversified opportunities to make a living outside the farming sector. Diverse incomes in turn supported an increase in population. This paper has thus three objectives: first, to investigate the causes and mechanisms of the economic restructuring and development during the Northern Song; second, to measure the impact of such development on population growth; and third, to provide systematic empirical evidence generated from quantitative modelling.

This paper is organised as follows: in the wake of this current introduction section, Section I discusses historical information available in general. Section II analyses the causes and mechanisms of the economic restructuring and development during the Northern Song Period. Section III discusses data and variables, constructs a quantitative model for empirical analysis, and discusses the findings. Section IV draws the final conclusion.

I

Granted, all the data from historical sources are far from fool-proof due to human errors and the rep-tape. But modern estimates and 'guesstimates' are not fool-proof, either. The former deserve the benefit of the doubt, to say the least. Information-wise, this study thus depends on available Song official and private sources. Official sources available are predominantly *Song Shi* (*History of the Song Dynasty*) and *Song Huiyao Jigao* (*Edited Administrative Statutes of the Song Dynasty*). Modern compilations of historical accounts such as *Zhongguo Lidai Huko Tiandi Tianfu Tongji* (*Dynastic Data for China's Households, Cultivated Land and Land Taxation*) serve as a back-up since they include information extracted from other works such as state crafts like *Xu Zizhi Tongjian Changbian* (*Enlarged Comprehensive*

²⁶ See Qi, *Songdai Jingjishi*, vol. 1, chs 1–3.

²⁷ Li, Xuanjing, Jicui Yu Songdai Jiangnan Nongye Geming'; Zeng, 'Songdaide Shuangji Dao'.

²⁸ Lewis, 'Economic Development with Unlimited Supplies of Labour'.

²⁹ E.g. Braudel, *Wheels of Commerce*.

References for State Management) and *Wenxian Tongkao* (*Comprehensive Study of Historical Records*). Private accounts are also consulted such as *Qimin Yaoshu* (*Essential Techniques for the Peasantry*), *Chenfu Nongshu* (*Chen Fu's Treatise on Agriculture*), *Mengxi Bitan* (*Notes of Dreams*), and Song poems. These private sources are often pivotal for revealing farmland yield level, household commercial activities, and household consumption level at the micro-level.

However, these works have a common problem of small, often one-off, samples. There is no easy way out of it other than more textual research and archaeological findings to yield more information which is however not the purpose of this study. Farming yield level is a good example. Given the sheer complicity of local weather conditions, soil quality and moisture levels, and individual farmers' skills and working hours, it is impossible to know the real yield level within a county let alone the whole of China without a systematic survey. It is a common practice to pick up a figure for a region or for the country on an anecdotal basis. Such a figure should never be regarded as the 'gold standard' of farming practices. Rather, it is no more than a rough, plausible index when agricultural surveys on any scale were absent. Another example: the actual size of the population of Northern Song China is unknown. What accessible are numbers of households and male poll-taxpayers. Similarly, the real iron output during the Song is nonexistent. The only information is amount of the metal possessed by the government under the mandatory *erba choufen* scheme (20:80 output-sharing between the state and the producer).³⁰ The scale and scope of market activities are also elusive, apart from the stated commercial tax rates (2–5 per cent). So, just about all Song economic quantities are widely open for dispute. Therefore, in many cases, numbers used are merely proxies.

Likewise, due to the inherent problem of data unavailability, quantitative accuracy is a rare luxury for a study such as this. The best hope one can have is to establish a direction and trajectory of growth and development. With this in mind, if there is a range of quantities, this study takes the minimum.

II

Economic activities during the Northern Song was geographically uneven. To reflect that, the Song territory can be divided into five echo-economic zones (see Figure 1).

Zones A and E were old dry farming zones since the formation of the Chinese empire in 221 BC. Zone B (including B' and B" from now on) developed paddy rice-farming much later mainly during the Tang Period (618–907). At the beginning of the Northern Song, Zone C remained a peripheral region to farm,³¹ known for dangerous parasites, insects, animals, and diseases and short life expectancies. It was a region to exile common criminals and political dissidents.³² Zone D was even less inhabitable than Zone C during the Northern Song, with a

³⁰ Qi, *Songdai Jingjishi*, vol. 2, pp. 586–92; Hu, *Zhongguo Shouongye Jingji Tongshi*, pp. 149–50.

³¹ It was documented by an inspector that 'Rice fields are half tilled and half deserted with only 70 to 80 per cent of plants standing. Local farmers never fertilise or weed fields. After sowing, everything is up to the luck.' Cited in Gao, 'Zhongguo Chuantong Jingjide Fazhan Xulie', p. 73.

³² Zones C and D were stigmatised as *yuan-e* (faraway and nasty). During the Northern Song, criminals were routinely sent to Zones C and D with their faces tattooed to make their return to society impossible

nickname of *fachang* ('the killing field'), making it the ultimate dumping ground for criminals and dissidents.³³ This was an initial condition for the Song economy.

The regional demographic distribution was as follows (as in 1077/8): Zone A accounted for 24 per cent of all Northern Song households and 22 per cent of Northern Song China's farmland; Zone B (including B' and B"), 41 per cent households and 46 per cent of farmland; Zone C, 19 per cent of households and 21 per cent of farmland; Zones D and E, 8 per cent of households and 11 per cent of farmland.³⁴ Most economic activities took place in Zones A, B and C.

To understand how the Song economy evolved, one needs to retrospect to the environmental and geo-political factors that dictated Song society. The first-order factor, a *force majeure*, was a climate change, known as the 'Little Ice Age'. It caused the average temperature to drop 1–2° C on East Asian Mainland.³⁵ During 1000–1120 AD, the frequency of warm weather on record dropped 90 per cent compared a period either immediately before it or thereafter.³⁶ On record, this climate change was severe enough to delay the harvest season for about a month,³⁷ push China's rice-growing belt 2–4° latitudes southwards, and move its economic centre 500 km to the Yangzi River (i.e. from Kaifeng to Wuhan, see Figure 2).³⁸

In addition, there was an odd phenomenon of drought-flood double disasters. The Northern Song period experienced the most serious droughts since 500 AD,³⁹ which devastated the flora over a vast area in North China and caused unprecedented soil erosion which in turn silted up the Yellow River bed and forced the river to burst its banks frequently, and even changed its course permanently. In 1108, the city of Julu (Hebei) was completely buried by silt of several meters deep; later in 1117, one million lives were lost to another flood in the same region.⁴⁰ According to Ouyang Xiu (1007–72), floods attacked Hebei Province, wiped out 30 to 90 per cent of farmland in 20 counties at one go.⁴¹ The Huai and Yangzi rivers also behaved

(*cipei*); see Xu, *Song Huiyao Jigao*, vol. 168, 'Xingfa, 4/1–4/4, 4/15, 4/25, 4/68', 'Xingfa 169, 5/12, 5/25', 'Xingfa 170, 6/34'.

³³ Liang, *Nansongde Nongcun Jingji*, p. 63.

³⁴ For households, see Geelan and Twitchett, *Atlas of China* p. 13; Needham, *Science and Civilisation*, 1961, ch. 4; 1984, pp. 3–46; 1986, pp. 23–181; Chen, *Regional Economies*, pp. 87, 96; also see Qi, 'Productivity Increase', pp. 43–5; Wu, *Zhongguo Renkoushi*, pp. 122–35. For data for 1102; see Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 164. For farmland, see Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 290–1; Cheng, *Songdai Diyu Jingji*, p. 87. See also Perkins, *Agricultural Development in China*, p. 342.

³⁵ Zhu, 'Woguo Jinwuqiannianlai Qihou Bianqiande Chubu Yanjiu', p. 36. There was a cycle of Little Ice Ages in the last two millennia: 1 AD, 536, 1000, 1350, 1650, 1750, 1800; see Flohn, *World Survey of Climatology*, p. 236; Schneider and Mass, 'Volcanic Dust, Sunspots, and Temperature Trends', pp. 741–6. For the global temperature decline, see Loehle, 'A 2000-Year Global Temperature Reconstruction'.

³⁶ Song et al. *Zhongguo Gudai Ziran Zaiyi Dongtao Fenxi*, p. 343.

³⁷ Tuo, *Song Shi*, vol. 174, 'Shihuozi 127'.

³⁸ Zhao and Yin, 'Gongyuan 11 Shijihoude Qihou Bianleng Dui Songyihou Jingji Fazhande Dongtai Yingxiang', p. 71; Cheng, *Songdai Diyu Jingji*, pp. 13–14.

³⁹ Song et al. *Zhongguo Gudai Ziran Zaiyi Dongtao Fenxi*, p. 123.

⁴⁰ Kang, *Beisong Wenhua Zhongxin Yanjiu*, p. 117.

⁴¹ Ouyang, *Ouyang Xiu Quanji*, vol. 2, p. 965.

erratically due to the environmental disequilibrium caused by the same climate change.⁴²

The compounded impact was a 10–20 per cent decline in farming yield in a vast region north to the Yangzi River.⁴³ There was an official complaint in around 1007 that, although the total farmland increased by 417,000 *qing*, government land tax revenue declined by 718,000 *shi*.⁴⁴ Vast farming areas were simply deserted (*feitian*) despite government persistent promotion of agriculture. In 996, the court official Chen Jing (948–1026) filed a chilling report that ‘Across 30 prefectures of 1,000 *li* surrounding the capital, only 20–30 per cent arable land is actually cultivated. Only 50–60 taxpayers pay taxes. ... People abandon farming and become idle.’⁴⁵ Over time, it went from bad to worse: Hou Shuxian, an official in charge of farming in the north, reported in 1069 that

‘In the capital region, over 10,000 *qing*, or half the total arable land, is not farmed. ... The capital region could produce several million *shi* of rice to feed the army. To cultivate idle land will reduce the cost of shipping stipend rice, save the military budget, enrich the country, and strengthen the army [*fuguo qiāngbing*].’⁴⁶

All this means that in North China farming was crippled. In this context, population grew in Zone A at the lowest rate, even lower than Zone D where migrants (criminals and dissidents) were sent (in households):⁴⁷

		980	1101	Annual %
Old zones				
	A	1,680,755 (100)	3,750,266 (223)	0.67
	B	2,536,634 (100)	7,262,900 (286)	0.87 ⁴⁸
	E	436,964 (100)	1,349,072 (309)	0.94
New zones				
	C	879,117 (100)	3,677,907 (418)	1.19
	D	636,297 (100)	1,474,484 (232)	0.68

⁴² Song *et al.*, *Zhongguo Gudai Ziran Zaiyi Dongtao Fenxi*, pp. 120, 176, 226–7, 261, 281, 297, 317, 340–1, 369–70.

⁴³ Zheng, *Zhongguo Gudai Jingji Zhongxin Nanyi He Tangsong Jiangnan Jingji Yanjiu*, pp. 39–43; Song *et al.* *Zhongguo Gudai Ziran Zaiyi Dongtao Fenxi*, p. 187; Zhang, *Qihou Yu Renlei*, pp. 123–4.

⁴⁴ Tuo, *Song Shi*, vol. 174, ‘Shihuozi 127’. Note: One *qing* = 100 *mu*; 1 Song *qing* = 6 ha. One Song *shi* = 46.2 kg.

⁴⁵ *Ibid.*, vol. 173, ‘Shihuozi 126’. Note: the term *li* was elastic. Historically it meant consistently ‘300 paces long’. A modern observation makes it 500 metres. Hence, 1,000 Song *li* ≈ 500 km.

⁴⁶ Xu, *Song Huiyao Jigao*, ‘Shihuo 7/19’.

⁴⁷ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 164; Wu, *Zhongguo Renkoushi*, pp. 122–35. See also Shiba, *Songdai Jiangnan Jingjishi Yanjiu*, p. 148.

⁴⁸ For an estimate at one per cent *per annum*, see Shiba, *Songdai Jiangnan Jingjishi Yanjiu*, p. 148.

However, it will be wrong to assume the supply of arable land during the Northern Song was inelastic. Firstly, the registered farmland was not necessarily all in good use. It was documented in 1067 that of all the registered farmland (4.4 million *qing*), 11 per cent was *feitian* ('wasted land').⁴⁹ In another account, 70 per cent of farming households did not farm all their registered land; they did not paid their expected taxes, either.⁵⁰ Secondly, new land was plentiful in all southern zones (B, C and D). In 979, Emperor Taizong (r. 976–97) allowed people to self-declare private ownership over unclaimed land in Zone B.⁵¹ People did move to Zone B which explains why the immigrant/tenancy rates were so high there.⁵² Even so, according to Shen Kuo (1031–95), the best known proto-scientific writer in Chinese history,⁵³ in 1074 'I witnessed in Liangzhe Province [at the heart of Zone B] lots of idle and unreported lands yet to be utilised in vast seashore in Wenzhou, Mingzhou and Taizhou.'⁵⁴ By this time, Zones C and D were also fairly empty. This was disappointing after decades of government promotion of peasant landownership in the region. Now, if the supply of arable land was so elastic, there should have no involution in the rural sector. The 'subsistence-pushed' hypothesis for the Northern Song can be ruled out.

Clearly, something made the Song farmers half-hearted in their profession. The Song state was worried. Farming as well as food supply was on the agenda of the Song government all the time. Farming was consistently linked to the state's goal of *fuguo qiangbing* ('enriching the country and strengthening the military').⁵⁵ To bring more land to cultivation, an array of institutions was deployed by the state, including landownership, tax holidays and, to less extent, technical assistance. After self-declared ownership over unclaimed land, the offer was extended to all state-owned land in the Empire in 980.⁵⁶ In 1082, army soldiers were allocated 200 *mu* each in military colonies.⁵⁷ In the process of privatisation, state ownership dropped to merely 1.4 per cent of China's total farmland, much lower than the previous Tang.⁵⁸ Other measures included tax deduction and exemption. Although the Land Tax rate was set at 10 per cent of a farm's output,⁵⁹ farmers were granted 50 per cent tax reduction if they brought idle land back to cultivation.⁶⁰ Taxes on newly reclaimed land went well below 10 per cent, too.⁶¹ Land under rice was once completely tax-free.⁶² Tax holidays and government loans were used to persuade farmers to stay in Zone A (Hebei) or to settle in Zone C (Jingxi).⁶³ So much so, according to one

⁴⁹ Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'. Note: 4.4 million Song *qing* = 26.4 million ha.

⁵⁰ *Ibid.*, vol. 7, p. 5712.

⁵¹ Xu, *Song Huiyao Jigao*, 'Shihuo 69/36'.

⁵² Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 126–9.

⁵³ His *Mengxi Bitan* provides valuable information about the Song scientific achievements across a wide spectrum.

⁵⁴ Xu, *Song Huiyao Jigao*, 'Shihuo 7/28'.

⁵⁵ *Ibid.*, 'Shihuo 61/97'.

⁵⁶ Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'.

⁵⁷ Xu, *Song Huiyao Jigao*, 'Bing 4/11'. Note: 200 *mu* = 12 ha.

⁵⁸ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 290; Qi, *Songdai Jingjishi*, p. 299.

⁵⁹ Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'.

⁶⁰ Xu, *Song Huiyao Jigao*, 'Shihuo 63/195'.

⁶¹ *Ibid.*, 'Shihuo 63/162'.

⁶² Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'.

⁶³ Xu, *Song Huiyao Jigao*, 'Shihuo 63/182', 'Shihuo 69/38'.

source, only 30 per cent of land under cultivation actually bore tax before 1069.⁶⁴ Government technical provision was also well documented.⁶⁵ If this was not enough, during 1023 to 1063, with the mounting ransoms to the northern nomads and the military spending on the northern front, the emperor decided not to increase land taxes.⁶⁶

From the Malthusian point of view, one thinks of more aggressive rice-farming outside the disaster-stricken Zones A and E as a way out the Song agrarian crisis. However, irrigation was the *sine qua non* for rice-farming across all regions under the Song rule, not to mention the frost-free season as another prerequisite, a factor that separates China from Southeast and South Asia where rain-fed rice-farming has been more common. Only about 5 per cent of rice paddies are rain-fed in China, compared with 40 per cent in South and Southeast Asia and 29 per cent on the world average.⁶⁷ China's low annual precipitation is a huge constraint. In contemporary China, for argument's sake, Zone A has 500–1,000 millimetres; Zone B, 1,000–1,500 millimetres; Zones C and D, above 2,000 millimetres; and Zone E, 100–500 millimetres.⁶⁸ No single zone in modern China is able to grow rice without artificial irrigation (in millimetres of water/day):⁶⁹

Zone	Seepage loss	Plant evaporation	Water deficit for rice
A and E	360–1,560	480–840	840–2,280
B	30–1,120	280–800	350–1,800
C and D	30–160	270–540	300–700

In Zones B and C, for example, the annual rainfall (1,000–2,000 millimetres) supports rice-growing for merely a week.

The Northern Song state did promote irrigation very ostentatiously. In 973, for example, it amassed 200,000 workers to build an irrigation system in Hangzhou.⁷⁰ But the effectiveness of such projects is questionable. Of the state-owned land merely 0.5 per cent was irrigated.⁷¹ In 1011–69, six irrigation works were carried out across Zones A and B, creating only 42,800 *qing* irrigated land, barely one per cent of the Song total of 4.4 million *qing* (as in 1065).⁷² By the end of the Northern Song, the scale of irrigation remained 7–8 per cent of all farmland within

⁶⁴ Zhou, *Zhongguo Caizhengshi*, p. 249.

⁶⁵ Xu, *Song Huiyao Jigao*, 'Shihuo 6/11 – 7/57'.

⁶⁶ Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'.

⁶⁷ Neue, 'Methane Emission from Rice Fields', p. 467, Table 4.

⁶⁸ Based on www.britannica.com/EBchecked/topic/11803/China/70982/Precipitation.

⁶⁹ Zhao *et al.*, *Zhongguo Tezhong Dao*, p. 100.

⁷⁰ Tuo, *Song Shi*, vol. 97, 'Hequzhi 49'.

⁷¹ See Shiba, *Songdai Jiangnan Jingjishi Yanjiu*, p. 203.

⁷² Tou, *Song Shi*, vol. 173, 'Shihuozi 126'. In fact, one cannot assume *shili* (water projects) were all for irrigation. Many large Song *shuili* projects were in fact devoted to canal construction and river flood control, not to rice-farming; see Fang, 'Songdai Heliu Qianxi Yu Shuili Gongcheng'. In Hangzhou, the state employed several million worker-days to build a dyke along the sea front against tidal waves in 1012; see Tuo, *Song Shi*, vol. 97, 'Hequzhi 49'.

the Song territory.⁷³ This comes as no surprise because the irrigation rate of China's all farmland was only 24 per cent in as late as 1919.⁷⁴ With such a low irrigation rate, rice-farming had to be limited despite the government propaganda.

Moreover, even if irrigation was available universally, considering a shortened growth season at the mercy of the Little Ice Age, double-cropping of rice across Zones B and C (where 67 per cent of Song China's farmland lay) was not performed according to all the known Northern Song sources. It was well documented that a single rice crop a year was the norm in Zones B, C and D where rice-farming was well suited.⁷⁵ The earliest known experiment with double-cropping of rice took place in 1178 when the Northern Song was over.⁷⁶ Champa Rice promoted by Emperor Zhenzong in 1012 across Zone B has been a supply-side of story. The actual demand for the new rice strain has been poorly justified,⁷⁷ not to mention that the Chinese knew about this rice long before the Song.⁷⁸ Double-cropping of rice became common much later during the Ming Period (1368–1644).⁷⁹ Even so, in the 1930s, only four per cent of China's farmland was double-cropped with rice.⁸⁰ This is what the 'Champa Rice Hypothesis' completely overlooks. The widely quoted 'second harvest of rice' during the Song (zaishu dao, or daosun, meaning "rice's offspring") came in fact from re-tiller of old stems. The output from such re-growth was neither predictable nor guaranteed.⁸¹ So it cannot be justified as a crop. Rather, it is a weed.

The alleged double-cropping of rice during the Song has so far been based on the dubious notion that 'early-ripening rice' equates with 'fast-ripening rice' and then with 'rice double cropping'.⁸²

⁷³ A total of 30,794,365–36,117,800 Song *mu* was recorded under irrigated rice vis-à-vis 443,792,405 Song *mu* farmland in total; based on Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 290–1; Cheng, *Songdai Diyu Jingji*, p. 87. See also Perkins, *Agricultural Development in China*, p. 342. A higher figure of 36,117,800 comes from Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'.

⁷⁴ Perkins, *Agricultural Development in China*, pp. 16, 64.

⁷⁵ Geelan and Twitchett, *Atlas of China*, p. 13; Needham, *Science and Civilisation*, 1961, ch. 4; 1984, pp. 3–46; 1986, pp. 23–181; Cheng, *Songdai Diyu Jingji*, pp. 87, 96; also see Qi, 'Songdai Shehui Shengchanlide Fazhan Jiqizai Zhongguo Gudai Jingji Fazhan Guochengzhongde Diwei', pp. 43–5; Wu, *Zhongguo Renkoushi*, pp. 122–35; Liang, *Nansongde Nongcun Jingji*, p. 117. For the geographic distribution of rice cultivation during the Northern Song, see Song Xi, 'Beisong Daomide Chandi Fenbu'.

⁷⁶ For the first recorded double-cropping of rice in Guangnan Xi, see Zhou, *Lingwai Daida*, vol. 8.

⁷⁷ Tuo, *Song Shi*, vol. 8, 'Benjin 8'; and vol. 173, 'Shihuozi 126'.

⁷⁸ Wang, *Tang Huiyao*, vol. 98 'Linyi Kingdom'; Zhou, *Lingwai Daida*, vol. 2 'Annan' and vol. 3 'Duonong'.

⁷⁹ Li, *Tangdai Jiangnan Nongyede Fazhan*, pp. 119–20; and his 'Songmo Zhi Mingchu Jiangnan Nongmin Jingyingde Bianhua'; Liang, *Nansongde Nongcun Jingji*, p. 117; Cheng, *Songdai Diyu Jingji*, pp. 98–101; Chao, *Man and Land in Chinese History*, p. 199. See also Chen and Zheng, 'Daozuo Qiyuande Kaogu Tansuo'; Ting, 'Zhongguo Zaipei Daozhongde Qiyuan Jiqi Yanbian'; Yan, 'Zhongguo Daozuo Nongyede Qiyuan'; Lin, 'Changjiang Qiantanjiang Zhongxiayou Diqu Xinshiqi Shidai Dili Yu Daozuode Qiyuan He Fenbu'; Cao, 'Jiangxi Wannian Xianrendong Yicun Zaiyanjiu Ji Zhongguo Daozuo Nongye Qiyuan Xin Renshi'; Fan, 'Jiangnan Diqude Shiqian Nongye'.

⁸⁰ Perkins, *Agricultural Development in China*, pp. 16, 44.

⁸¹ Cheng, *Songdai Diyu Jingji*, p. 97.

⁸² In ancient China, 'early-ripening' (measured by crop harvest time) and 'fast-ripening' (measured by the duration needed for crops to mature) were not identical. In *Shi Jing (Book of Odes)* of the eleventh to sixth centuries BC, crops were already categorised as 'early-sowing', 'late-sowing', 'early-ripening' and

The question is whether the Song population could live on a single crop a year, something that needs to be investigated. There are three facts here. First, according to the Song official famine relief standards, an adult needed two *sheng* of grain (or 924 grams, presumably husked) to maintain subsistence.⁸³ This is reasonable *per diem*, as according to John Buck's survey in the 1920s–30s, 924 grams of traditionally produced rice, wheat and millet provided 2,270, 2,220, and 2,320 kilocalories of energy, respectively.⁸⁴ A family of, say generously, six (three adults and three children) would need 4,240 grams per day or 1,550 kilograms a year, if weighting each child as half an adult in food consumption. To take into account wastage during milling,⁸⁵ the gross amount of food should be around 2,060 kilograms. Second, it has been generally agreed that the average yield of the main crop from farmland of the medium fertility was roughly one Song *shi* per Song *mu* in the north and about twice as much per *mu* in the south.⁸⁶ Third, the Song total registered farmland was 3.1 million *qing* in 996 AD.⁸⁷ With these stylised facts, the Song farming regions would look like the following (with the aforementioned geographical distribution of farmland in 1077 as a proxy):⁸⁸

'late-ripening'; see Xia, *Cihai*, p. 97. In Ho's work, however, 'early-ripening' and 'fast-ripening' are worryingly interchangeable. For critique, see Seng, 'Songdaide Wandao He Zaodao'.

⁸³ Tuo, *Song Shi*, vol. 175, 'Shihuozi 128', and vol. 191, 'Bingzhi 144'. One Song *sheng* = 1/100 Song *shi* = 462 grams. Two Song *sheng* = 924 grams.

⁸⁴ Buck, *Land Utilization in China*, p. 66.

⁸⁵ Rice-milling usually causes 20 per cent loss in weight to husks and another 8–12 per cent to bran; see <http://www.knowledgebank.irri.org/rkb/index.php/rice-milling>. Wheat loses 20–22 per cent to bran in the milling process; see <http://www.apgoe.com/wheat.htm>.

⁸⁶ Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, p. 115; Ge and Gu, 'Songdai Jiangnan Diqude Liangshi Muchan Jiqi Gusuan Fangfa Bianxi' pp. 78–9; Hua, *Shongshi Lunji*, pp. 4–5; Qi, 'Songdai Shehui Shengchanlide Fazhan Jiqizai Zhongguo Gudai Jingji Fazhan Guochengzhongde Diwei', pp. 38–9; Li, *Tangdai Jiangnan Nongyede Fazhan*, p. 148. Noted, the Song *shi* and *mu* were lighter and smaller than their modern counterparts: one Song *shi* = 0.66 modern *shi*, and one Song *mu* = 0.9 modern *mu*; see Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 545; Wu, 'Lishishang Liangshi Shangpinliang Cegu', p. 19. One Song *shi* per Song *mu* = 46.2 kg.

⁸⁷ Tou, *Song Shi*, vol. 173, 'Shihuozi 126'. Note: It is agreed that only 70–80 per cent of farmland ever got registered; see Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, p. 172. However, if this margin of error persisted, official figures still serve as minimum proxies after a 'hair cut'. More headaches come from the common practice of *zhemu* (land unit conversion): A Song cadastral *mu* was not in a fixed physical size. Often, the average output from one *mu* of the medium fertility in a region was picked as a common denominator to convert outputs from plots in different fertilities. After that, farmers were taxed according to annual outputs not the actual acreage. The conversion rate was as high as 10:1; see Xu, *Song Huiyao Jigao*, 'Shihuo 70/120'. In this context, although the official *mu* was always 240 paces in perimeter, the actual *mu* upon which the land tax was levied varied from 360 to 1,200 paces. For the Qing case, see Zhao, 'Jishu Wucha, Zhemu Jiqi Juli Shuaijian Guilü Yanjiu'. That should not deter anyone to use the Song cadastral records so long as one knows the complexity behind those them. Note: one *qing* = 100 *mu*.

⁸⁸ Geelan and Twitchett, *Atlas of China* p. 13; Cheng, *Songdai Diyu Jingji*, pp. 87, 96; also see Qi, 'Songdai Shehui Shengchanlide Fazhan Jiqizai Zhongguo Gudai Jingji Fazhan Guochengzhongde Diwei', pp. 43–5. Note: here, the shares of Zones A and E were almost larger than in 1077 because of a decline in farming there. But we stick to the 1077 shares because there is no other reliable information for 996.

Zone	Million Song <i>mu</i>	Main grain type	Per <i>mu</i> yield
A	68.8	Millet/wheat	1 Song <i>shi</i>
B	142.6	Rice	2 Song <i>shi</i>
C	66.0	Rice	2 Song <i>shi</i>
D	1.3	Rice	2 Song <i>shi</i>
E	31.3	Millet/wheat	1 Song <i>shi</i>
Total farmland	310.0		
China-wide average per Song <i>mu</i>			1.7 Song <i>shi</i>
Total food stock			520 million <i>shi</i>

The total food stock would be in the region of 520 million *shi* (24 million metric tons) and provide for 11.7 million households.⁸⁹ But in the same year (i.e. 996), Song China had only 4.6 million households.⁹⁰

Now, considering the impact of the climate change, Zone A could even be a write-off from farming. Then, the food stock would be 451 million *shi* (20.8 million tons) enough to sustain 10.1 million households. Song agriculture had at least an overcapacity of 120 per cent. Champa Rice is not needed in the equation.

But the Little Ice Age did create a niche for a winter crop in Zones A and B in the following pattern: a summer crop in Year One (including rice, a 145–175 day growing season) → a winter crop (a \pm 175 day growing season) → another summer crop in Year Two (a 145–175 day growing season).⁹¹ Winter-wheat (*sumai*, or ‘over-year wheat’) fills the bill very well when a combination of a low temperature and minimum irradiance was lethal for the vast majority of annuals.⁹² After the initial two-year cycle, farmers sowed and harvested twice in the same plot each calendar year. This was a different type of double cropping. This cropping pattern was confirmed in 1037 that ‘the Lower Yangzi is fertile with many products. ... In farming, the region has rice after harvesting [winter] wheat which makes two crops a year.’⁹³ The yield of winter-wheat from land of medium fertility was about 0.8 Song *shi* per Song *mu*.⁹⁴

To add winter-wheat to the farming cycle began in Tang China around the eighth

⁸⁹ Note: one Song *shi* = 46.2 kg.

⁹⁰ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 122; Wu, *Zhongguo Renkoushi*, p. 346. Note: Liangs’ figure is 4,574,257; Wu’s is 3,574,257, one million apart. To play safe, the former is chosen.

⁹¹ Numerous references; e.g. Ge, *Song Liao Xia Jin Jingji Yanxi*, pp. 103–13; Li, ‘Changjiang Xiayou Daomai Fuzhongzhide Xingcheng He Fazhang’, p. 7; Kong, ‘Jianlun Zhongtang Yilai Chuantong Nongyede Yaosu Shengchanlü’.

⁹² See Cheng, *Songdai Diyu Jingji*, pp. 98–100.

⁹³ Zhu, *Wujun Tujing Xuji*, vol. 1, ‘Wuchan’.

⁹⁴ Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, p. 115; Ge and Gu, ‘Songdai Jiangnan Diqude Liangshi Muchan Jiqi Gusuan Fangfa Bianxi’ pp. 78–9; Qi, ‘Songdai Shehui Shengchanlide Fazhan Jiqizai Zhongguo Gudai Jingji Fazhan Guochengzhongde Diwei’, pp. 38–9.

century.⁹⁵ The Tang tax system, the *liangshui zhi* ('Two Seasonal Taxes'), was synchronised with one crop harvest in spring (winter-wheat) and the other in autumn (the main crop).⁹⁶ However, winter-wheat gained wide popularity only during the Northern Song thanks to two specific reasons. First, the Little Ice Age climate change prolonged the winter season which made winter-wheat a sound insurance policy, described by the Song official Ouyang Xiu (1007–1072) as 'people raise debts in winter and repay their debts with their winter-wheat harvest in early summer; they raise debts in summer-autumn and repay their debts with their main harvest before winter.'⁹⁷ In fact, the Song low-interest *qingmiao fa* ('Green-shoots Loan Scheme') issued in 1069 was designed to help those whose winter-wheat crop failed.⁹⁸ Second, the Song tenancy rate was high, affecting 30–50 per cent of all farmland.⁹⁹ Winter crop was extra-attractive to tenants because the second crop was customarily rent-free.¹⁰⁰ Evidence indicates that winter cropping was carried out on a large scale and remained the norm in regions like the Lower Yangzi until the early twentieth century.¹⁰¹

Assuming that winter-wheat was adopted where it was suited, the Song staple food production would look as follows when China's farmland reached 4.4 million *qing* (as in 1065):¹⁰²

⁹⁵ Li, *Tangdai Jiangnan Nongyede Fazhan*, p. 116; Li, 'Changjiang Xiayou Daomai Fuzhongzhide Xingcheng He Fazhang', pp. 16–17. The Tang poet Bai Juyi (772–846) described it as:

*When it is rainless and windy in the Third Month
Wheat ears wither and die,
When it is frosty and cold in the Ninth Month
Rice ears go empty and dry.*

Cited in Tang, *Tangsong Shici Jianshang Zidian*, p. 863.

⁹⁶ Likewise, it was recorded during the Northern Song that in Zone B the *xiashui* (Summer Tax) was paid in wheat, textiles, and cash. No rice was involved. See Wu, *Tangsong Zhiji Tianshui Zhidu Bianqian Yanjiu*, p. 111. In another account, 'The Summer Tax payment in grain is always made of wheat; the Autumn Tax payment in grain is always made of millet, rice, legume and so on.' Cited in Song, *Songshi Yanjiu Luncong*, p. 90.

⁹⁷ Cited in Hua, *Songshi Lunji*, p. 23.

⁹⁸ Tuo, *Song Shi*, vol. 176, 'Shihuozi 129'.

⁹⁹ Qi, *Songdai Jingjishi*, vol. 1, p. 269. For the *kehu* category (guest households), see Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 126–9.

¹⁰⁰ Li, 'Changjiang Xiayou Daomai Fuzhongzhide Xingcheng He Fazhang', p. 9; Ge and Gu, 'Songdai Jiangnan Diqude Liangshi Muchan Jiqi Gusuan Fangfa Bianxi', p. 82. The Song sharecropping practised a 40:60 split in favour of the landlord if he provided draught animals or in favour of the tenant if the landlord had no input other than land. See Yang, 'Songdai Mintian Chuzude Dizu Xingtai Yanjiu', p. 139; Liang, *Nansongde Nongcun Jingji*, p. 108; Ge and Gu, 'Songdai Jiangnan Diqude Liangshi Muchan Jiqi Gusuan Fangfa Bianxi', pp. 80–2.

¹⁰¹ E.g. Li, 'Rengen Shimu Yu Mingqing Jiangnan Nongminde Jingying Guimo'. According to the British East India Company's Hamilton H. Lindsay who travelled in 1832 to Shanghai on the *Amherst*, 'Upon our arrival, wheat was just harvested in. That was immediately followed by ploughing, sowing and irrigation for growing rice. Rice ripens in the Ninth Month.' See Hu, 'A-meishide Hao 1832 Nian Shanghai Zhixin Jishi', p. 277. In the 1930s, 18.6 per cent of China's farmland was subject to the 'winter-wheat plus rice regime'; see Perkins, *Agricultural Development in China*, pp. 16, 46.

¹⁰² Tou, *Song Shi*, vol. 173, 'Shihuozi 126'.

Zone	Million Song <i>mu</i>	Main grain type	Per <i>mu</i> yield
A	97.7	Winter-wheat + millet	1.8 Song <i>shi</i>
B	202.4	Winter-wheat + rice	2.8 Song <i>shi</i>
C	93.7	Rice	2 Song <i>shi</i>
D	1.8	Rice	2 Song <i>shi</i>
E	44.4	Millet/wheat	1 Song <i>shi</i>
Total	440.0		
China-wide average per Song <i>mu</i>			2.2 Song <i>shi</i>
Total food stock			978 million Song <i>shi</i>

The gain from the winter crop was likely to be 240 million Song *shi*, or one quarter extra, to make an aggregate food stock of 978 million Song *shi* (45.2 million tons). It was documented that the payment ratio between the Summer Tax and the Autumn Tax 1:4 in loose grain (as in 1077),¹⁰³ matching rather neatly our calculation. So, the climate change did make the Song farming more efficient.

To take away afore-mentioned 11 per cent lying idle, the Song food stock would be 870 million Song *shi* (40.2 million tons), able to feed 19.5 million households. In the same year, China only had 12.9 million households.¹⁰⁴ Song agriculture thus still ran 50 per cent overcapacity. If farming in Zone A was again omitted, the amount of 32.9 million tons would support 16.0 million households. To push it further, without a winter crop at all, China would still produce 738 million Song *shi* (34.1 million tons) to maintain 16.6 million households. This is 25–30 per cent overcapacity.¹⁰⁵ So, strictly speaking, winter-wheat helped but was not imperative.

The overcapacity of Song agriculture, which has not been recognised before, explains why the Song farmland acreage moved up and down like a yoyo when the population kept growing, which has puzzled many (Table 2).¹⁰⁶ If the population lived a hand-to-mouth life, China would have had seen one-third of the Song households facing starvation in 1085. But from the average point of view, the overcapacity was still 40 per cent over time. So, the periodical reduction of farmland could well be deliberate.

The acid test comes from food prices. Had the Song population growth been driven by surplus yield, food must have become cheaper. But that was not the case. Cash prices of rice increased about 500 per cent in densely populated regions (capital city, lower Yellow and lower

¹⁰³ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 289.

¹⁰⁴ *Ibid.*, p. 124; Wu, *Zhongguo Renkoushi*, pp. 347.

¹⁰⁵ This approach differs from that of Perkins who worked out China's national average yield per *mu* from a total food bill divided by the total farmland; see his *Agricultural Development in China*, pp. 14, 17.

¹⁰⁶ It is worth noting that the Song Period was not unique regarding a decline in farmland coinciding with a rise in population. During the Ming Period (1368–1644), China's farmland contracted by 27 per cent from 1393 to 1502; see Perkins, *Agricultural Development in China*, p. 223.

Yangzi):¹⁰⁷

Kaifeng (A)¹⁰⁸		Hedong (A)		Liangzhe (B)	
AD	wen/one dou rice	AD	wen/one dou rice	AD	wen/one dou rice
989	30	979	10	970	20
1074	150	1086	50	1098	100
Annual %	1.9		1.5		1.3

As these prices were likely to be distorted by rampant inflation, currency heterogeneity, and multiple exchange rates of the time,¹⁰⁹ a better gauge is rice prices relative to iron and silk (i.e. terms of trade). They all moved in the same direction as the cash prices:¹¹⁰

AD	Amount iron/shi rice	AD	Bolts silk cloth/shi rice
997	16	997	0.24
1080	56	1108	0.95
Annual %	1.5		1.2

The point is that these prices all grew faster than the Song households. The notion ‘cheaper food feeding the Northern Song population’ was a red herring. This phenomenon dismisses the afore-mentioned ‘surplus-driven’ hypothesis. Meanwhile, there was no widespread famine or a large quantity of food imports. Sufficient food had to be produced to meet the aggregate demand. It means that the Song production overcapacity was not exploited.

Buy why did the Song population not maximise food output? The explanation leads to the geopolitical factor of external threat. To begin with, the Northern Song Empire was only about 40 per cent of the size of the Tang (Tang: 618–907).¹¹¹ This territorial contraction was a result of three militarily powerful nomadic groups living side by side with the Chinese: the Khitans (Liao Kingdom: 916–1125), the Tanguts (Xixia Kingdom: 1038–1227) and then the Jurchens (Jin Kingdom: 1115–1234). Despite their small population sizes compared with the

¹⁰⁷ Cheng, *Songdai Wujia Yanjiu*, pp. 125, 132–4, 139–41. Noted, these figures only serve as rough indications.

¹⁰⁸ Kaifeng was the capital city where food was persistently more expensive. Hedong was one of the oldest northern farming provinces; Liangzhe was a new farming province at the time.

¹⁰⁹ For the Northern Song inflation, see Peng, *Zhongguo Huobi Shi*, p. 505; Guo, ‘Songchaode Wujia Biantong Yu Jizang Lunzui’, p. 72; Qi, *Songdai Jingjishi*, vol. 2, pp. 1104–7. For multiple currencies and exchange rates, see Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 287–321, 331.

¹¹⁰ Iron-rice prices, cited in Hartwell, ‘Markets, Technology, and the Structure’, p. 33; silk-rice prices, based on Yu, *Zhongguo Jiage Shi*, pp. 602, 610.

¹¹¹ Tan, *Jiangming Zhongguo Lishi Ditu Ji*, pp. 41–2, 51–2; Fu et al., *Zhongguo Junshi Shi, Lidai Zhanzheng Nianbiao*, Xia, pp. 1–13.

Song,¹¹² these groups firmly controlled the areas where the old Great Wall and the Silk Road were located. China's old farming and industrial core along the Yellow River was eventually lost to the Jurchens in 1127, which ended the Northern Song (Figure 2). Arguably, the scale, scope and persistence of the southward expansion by the nomads, who were specialised with violence to prey on farming communities, were dictated by the very same climate change that made the livelihood in the Steppes far less sustainable.¹¹³ So, the origin of the problem was the same. But the similarity ended there.

The pressure from external invasion formed yet another *force majeure* to Northern Song China. Unlike the climate change which only tested China's farming and administrative capacities to maintain food security, the threat from the nomads tested China's capacity to generate non-food wealth. In other words, the climate change only made the Song farming more efficient farming but did not alter China's growth trajectory. The external threat of invasion however forced the Song mindset, behaviour and growth trajectory to embark on some drastic changes.

Most puzzlingly, the response of the Song state to the external threat was not to fight but to appease and compromise.¹¹⁴ China's military vulnerability and diplomatic weakness were exploited to the full by nomads who demanded annual ransoms as a precondition for peace. In accordance with the humiliating '1004 Chanyuan Treaty', the Khitans received annually 200,000 bolts of silk cloth and 100,000 taels of silver (3.7 metric tons). As the Song economy grew fast, the sums increased accordingly to 300,000 bolts of silk cloth and 200,000 taels of silver (7.4 metric tons) in the '1042 Guannan Treaty'.¹¹⁵ The Tanguts along another stretch of the Song border followed the suit, demanding 130,000 bolts of silk cloth, 500,000 taels of silver, and 200,000 *catties* of tea a year as their price for peace with China.¹¹⁶ More wealth was forcefully transferred to the coffers of the greedier Jurchens, a third group who joined the kill. In 1126, the Song state shipped to the Jurchen Jin 5 million taels of gold, 50 million taels of silver, 2 million bolts of silk cloth, and 11,000 draft animals. Another 378,000 taels of gold, 7,140,000 taels silver, and 1,040,000 bolts of silk went to the Jurchens a year later.¹¹⁷ These were heavy fiscal burden on the Song state finance. Meanwhile, to secure their prey, the Khitan-Song treaties stipulated that the Song side was not allowed to build walls or dig moats along the border to obstruct the Khitan cavalry.¹¹⁸ Song China lived on borrowed time; and the stake was high.

Considering that the Song state collected about two million bolts of silk cloth a year as taxes, the silk ransom was easy to fulfil domestically. But the Song economy produced only 200,000 taels of silver a year (as in 1078),¹¹⁹ not enough for the ransom of over one million taels a year. Some silver had to come from outside and through voluntary and peaceful

¹¹² E.g. in 938 AD, the total household number of the Khitan Liao was 127,200; see Tuo, *Liao Shi*, 'Dilizghi 1'.

¹¹³ For the Mongol case, see Gumilev, *Searches for an Imaginary Kingdom*.

¹¹⁴ Cheng, 'Songchu Mibinglunde Jiantao'.

¹¹⁵ Mao, *Songchaode Duiwai Jiaowang Geju*, pp. 166, 176.

¹¹⁶ *Ibid.*, p. 177.

¹¹⁷ *Ibid.*, pp. 50, 227.

¹¹⁸ *Ibid.*, pp. 167, 176.

¹¹⁹ Tuo, *Song Shi*, vol. 185, 'Shihuozi 138'. Note: a tael = 37.5 grams.

exchange given the weakness of the Song military. Moreover, to maintain a rapport with its nomadic neighbours, the Song state made sure a continuous supply of luxuries to the northern borders.¹²⁰ Such luxuries only came by sea routes thanks to the loss of the Silk Road.

Facing its draconian hard-budget *diktat*, more non-food production and more trade were the only option in a perfect sample of Toynbee's challenge-response theory.¹²¹ To survive, the Song state turned quickly to clear-cut mercantilism, no more ambivalence towards trade and merchants. This was a *volte-face* from China's long-entrenched norm of *yishang* (confining trade).¹²² A preferential tax rate was set at half the rate imposed on agriculture.¹²³ There were marked regional differences in freedom and tax burden. Cities in the north bore more commercial taxes in both the total and per household terms (Table 3).

Zones B, C and D were corvée-tax havens, 'Special Economic Zones' of the time:

- Zone A Very strong government/military presence; taxes paid mainly in kind; heavy in corvée services.¹²⁴
- Zone B Some government presence; taxes paid mainly in cash; hardly any corvée imposed.¹²⁵
- Zone C Weak government presence; taxes paid mainly in cash; no corvée services recorded.¹²⁶
- Zone D The weakest government presence; hardly any tax or corvée.¹²⁷
- Zone E The same as Zone A

So, predictably, the market found it cosy in the south where more industrial and commercial growth was generated. Also, it was no accident that paper currency and business credit were invented there.

The state priority was given to overseas trade. Large sea-worthy ships were designed and

¹²⁰ In an official account, the Jurchen Jin imported from its 'belligerent', meaning the Northern Song, lychees, longans, mandarins, olives, bananas, sugar, sapanwood, rhinoceros horns, elephant tusks, and cinnabar – items native to China and beyond; see Tuo, *Jin Shi*, 'Shihuo 5'; see also Qi, *Songdai Jingjishi*, vol. 2, pp. 1030–41.

¹²¹ See Somervell, *A Study of History*; Kearny, 'Arnold Toynbee; Challenge and Response'.

¹²² Tian, *Zhongguo Gudai Xingzheng Shilue*, p. 228.

¹²³ Tuo, *Song Shi*, vol. 173, 'Shihuo 126' and vol. 186, 'Shihuo 139'. For the debate, see Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 238–41.

¹²⁴ For geographic deployment of officials, see Cheng, *Songdai Diyu Jingji*, pp. 132–4. For regional taxes, see Xu, *Song Huiyao Jigao*, 'Shihou 15/1–20'; Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 223–8.

¹²⁵ Cheng, *Songdai Diyu Jingji*, pp. 132–4; Xu, *Song Huiyao Jigao*, 'Shihuo 7/13–14'.

¹²⁶ Cheng, *Songdai Diyu Jingji*, pp. 132–4.

¹²⁷ *Ibid.*, pp. 132–4, 263–4.

built; new sea routes opened; and new trading destinations explored,¹²⁸ new policies and institutions created and implemented.¹²⁹ In the official account, 33 foreign countries were on the trading list. Apart from those in nearby Southeast Asia and the India Subcontinent, there were new ones in the remote Arabian Peninsular (Tazi) and East African coast (Zanj).¹³⁰ The scale was more or less the same as Zheng He's voyages in the early fifteenth century. Ports along China's southeast coast were free from nomad-raiders and geographical handy for this new development (see Figure 1).

To yield overseas trade returns, a network of customs offices of two tiers (*wu* and *chang*) were set up and officials were given performance quotas to fulfil.¹³¹ Imported materials, predominately *xiang yao* (spices, perfumes and pharmaceuticals), were subject to state monopoly for revenue. Pharmaceuticals were controlled by the *shibo si* (Bureau for Maritime Trade). The bureau then distributed the imports through the *taiyiju maiyaosuo* (Pharmacy of the Imperial Medical Bureau) via a chain of 1,800–2,000 *wu* (bureaus) and *chang* (fairs) whose tentacles reached each of the 1,235 counties across the Empire to sell goods and collect commercial taxes on them at the same time.¹³² Between 1076 and 1078, an amount of frankincense worth 1.5 billion bronze coins was sold that way.¹³³ This makes on average 60 coins per household, not trivial. In the end, pharmaceutical imports altered China's pharmacopoeia. According to the Song pharmacopoeia published in 1080, 33 per cent of animal ingredients, 53 per cent of plant ingredients and 13 per cent of mineral ingredients came from overseas.¹³⁴ Similarly, spices were monopolised by the same bureau and re-sold to the domestic consumers through another network of the *shiyiwu* (Market Trading Office) for a profit margin of 20–100 per cent.¹³⁵

It worked. A strong growth in maritime tax revenues confirms this success:¹³⁶

AD	Annual maritime tax (10 ⁶ coins)	Index	1087 prices ¹³⁷
1087	416	100	100
1106	1,110	267	134
Annual growth %	5.3	1.6	

¹²⁸ Zhou, *Lingwai Daida*; Gong, *Xiyang Fanguo Zhi*; Ma, *Yingya Shenglan*; Shen, 'Zhenghe Baochuanduide Dongfei Hangcheng'; H and D, *Xinbian Zhenghe Hanghai Tuji*, pp. 84–98.

¹²⁹ For a survey of studies of the Northern Song trade policy; see Li, *Songchao Zhengfu Guomai Zhidu Yanjiu*, pp. 10–25.

¹³⁰ Lin, *Songdai Xiangyao Maoyi Shi*, pp. 162–5.

¹³¹ Deng, *Chinese Premodern Economy*, p. 268; Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, p. 233; Liu 'Song China's Water Transport Revolution Revisited'.

¹³² Lin, *Songdai Xiangyao Maoyi Shi*, pp. 270–93; Song, 'Songdaide Shangshui Wang'.

¹³³ Deng, *Port Guangzhou*, p. 100.

¹³⁴ Deng, *Maritime Sector*, p. 85.

¹³⁵ Tuo, *Song Shi*, vol. 184, 'Shihuozi 137'.

¹³⁶ Wang, *Liangsong Caizheng Shi*, pp. 723–4.

¹³⁷ Calculation is based on 238 per cent inflation of food prices from 1101 to 1125; see Long, 'Songdai Liangjia Fenxi', p. 159.

As a result, the maritime duties accounted for 15 per cent of the government total revenue.¹³⁸

On the domestic front, government procurement-marketing schemes involved anything that the state was able to lay its hands on: metals, silk textiles, tea, salt, wine and so forth. Tea, wine, salt and silk were monopolised.¹³⁹ Tea was controlled by 6 government bureaus and 13 centres. They routinely handled some 23 million *catties* a year, earning the government between 100 and 300 million coins.¹⁴⁰ Over 100 million decilitres of wine and 400 million *catties* of salt were handled under the government procurement schemes on a yearly basis.¹⁴¹ The amount of silk cloth bought by the government increased five-fold from 600,000 bolts (in 1004) to 3,000,000 bolts (in 1041), with an annual growth rate of 4.5 per cent.¹⁴² All this sped up commercialisation of the economy.

The government also collected revenue disproportionately more in cash than goods, called *zhebian*.¹⁴³ From 1021 to 1065, the cash component in the tax revenue grew 226 per cent and the cash share in the total revenue jumped from 18 per cent to 52 per cent.¹⁴⁴ On the other hand, Poll Tax payments collected in home-made cloth decline in relative terms in relation to a continuous increase in poll-taxpayers:¹⁴⁵

AD	Tax payments in home-made cloth (bolts)
997	2,180,000 (100)
1077	2,672,323 (123)
Annual growth %	0.2

Similarly, the Land Tax collected in grain stagnated first and then declined in absolute terms:¹⁴⁶

¹³⁸ Chen and Wu, *China's Maritime Trade*, pp. 180–2. For the debate, see Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 390–405.

¹³⁹ Tuo, *Song Shi*, vols 180–6, 'Shihuozi 134, 135'.

¹⁴⁰ Hua, *Songshi Lunji*, pp. 76, 109. The amount of 23 million *catties* of tea required about 5.1 million working days; based on Hua, *Songshi Lunji*, p. 58.

¹⁴¹ Hu, *Zhongguo Shougongye Jingji Tongshi*, *Song Yuan Juan*, pp. 353, 402. Official involvement in market deals and profiteering became epidemic and corruption was widespread. But that was a separate issue.

¹⁴² Li, *Songchao Zhengfu Guomai Zhidu Yanjiu*, p. 466.

¹⁴³ Zhang, 'Songdai Zhebianzhi Tanxi'.

¹⁴⁴ Quan, 'Tang Song Zhengfu Suiru Yu Hubi Jingjide Guanxi', p. 202.

¹⁴⁵ Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 288–9.

¹⁴⁶ *Ibid.*, pp. 288–9; also Bao, *Songdai Difang Caizhengshi Yanjiu*, pp. 282, 316–9.

AD	Land Tax payments in food (shi)
997	31,707,000 (97)
1021	32,782,000 (100)
Annual growth %	0.1
1021	32,782,000 (100)
1077	17,887,257 (55)
Annual growth %	-1.1

From 1021 to 1086, the cash component amounted for about a quarter to a third of all Land Tax payments,¹⁴⁷ meaning that farming households now paid cash for their dues. Tenants' rent payment had the same trend because their landlords needed cash.¹⁴⁸

Overall, the fiscal importance of the agricultural sector became marginalised while the share of the non-agricultural sector doubled.¹⁴⁹

AD	Total (10⁹ coins)	Agricultural share	Non-agricultural share
997	35.6	65%	35%
1077	70.7	30%	70%

In addition, the state issued negotiable securities such as yanyin (Salt Permits), chayin (Tea Permits) and dudie (Certificates for Monks and Nuns) for investors.¹⁵⁰ All these securities were part of the public debts raised by the Song state to ease its budget deficits in the absence of foreign borrowings of the time (10⁶ coins):¹⁵¹

AD	Revenues	Expenditures	Balance
997	70,893	86,950	-16,057
1021	140,298	168,044	-27,746
1049	126,252	126,252	0
1065	116,138	120,343	-4,205
1086	82,491	91,910	-9,419

¹⁴⁷ For tax components, see Wang, *Liangsong Caizheng Shi*, pp. 688–92; for prices, see Peng, *Zhongguo Huobi Shi*, pp. 487, 507.

¹⁴⁸ Qi, *Songdai Jingjishi*, vol. 1, ch. 9. The reform was called *zhebian*; see Zhang, 'Songdai Zhebianzhi Tanxi'.

¹⁴⁹ Ye, 'Songdai Gongshangye Fazhangde Lishi', p. 108; Bao, *Songdai Difang Caizhengshi Yanjiu*, pp. 282, 316–9.

¹⁵⁰ In 1078, salt permits sold by the government were worth 23 billion coins; see Li, *Songchao Zhengfu Guomai Zhidu Yanjiu*, p. 222. Regarding Certificates for Monks and Nuns, a total of 20,5918 such certificates were sold for 32.2 billion coins in 1068–1109; see Qi, *Songdai Jingjishi*, vol. 2, chs 22, 23, 25, 29; Guo, *Liangsong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 259–68. Wang, *Liangsong Caizheng Shi*, pp. 741–3.

¹⁵¹ Wang, *Liangsong Caizheng Shi*, pp. 678–86; Cheng, 'Songdaide Gongzhai'.

All this indicates substantial reshaping and restructuring in the economy. The most significant development occurred in heavy industry. Metal production grew exponentially. It is documented in 1040 that it took 700 industrial households in Shaanxi to produce 100,000 *catties* of iron (60 metric tons) each year.¹⁵² It was a minor production centre;¹⁵³ but there was no evidence to suggest its technical inferiority. If Shaanxi is used as a benchmark, the annual output of 28.5 million *catties* of the metal would need some 200,000 industrial households, excluding iron mining, coal mining, charcoal marking (hence lumbering) and transportation.¹⁵⁴

Although the north (mainly Zone A for iron production) has so far received most attention and publicity,¹⁵⁵ it was the south (Zones B, C and D) that experienced a real take-off in metal production. From 727/836 to 1077/8, iron (dominated by the north) grew 14-fold; but copper increased 39-fold; tin, 54-fold; and lead, whopping 467-fold. Copper, tin and lead mainly came from the south.¹⁵⁶ At its peak, each household in Zones C and D shouldered an output of 12.3 *catties* of metals a year (government procurements only, as in 1077).¹⁵⁷ Table 4 shows the growth momentum.

The metal sector underpinned an array of other pursuits. Copper, tin and lead played a key role in facilitating monetisation of the economy with 1–5 billion new bronze coins per year (as in 1021–80).¹⁵⁸ This was a 37-fold increase from the Tang level (820 AD).¹⁵⁹ To produce 1–5 billion bronze coins a year required another 5–15 million worker-days,¹⁶⁰ or 70,000–210,000 households (counting one adult per household) working in the industry.¹⁶¹ The lion's share of iron was used in shipbuilding and coin-minting (as a currency, *tie qian*). During the Northern Song, a cheap way to construct large sea-going ships, known as the 'clinker method', was developed which required a huge input of iron nails and rivets of high quality to hold planks together to make a hull.¹⁶² The Northern Song sea-going fleet maintained about 3,000 large cargo ships of 500–1,000 ton loading capacity each.¹⁶³ These ships were vital for China's foreign trade capacity. The Song river fleet boasted to own another 3,000 ships of 200-ton

¹⁵² Wagner, 'Administration of the Iron Industry', pp. 181–3.

¹⁵³ A larger centre rolled out over one million *catties* a year; see Wagner, *Science and civilisation in China*, pp. 295–8.

¹⁵⁴ Modern chemical analysis has revealed a high sulphur content in Song iron products as the evidence for the use of coal in smelting; see Hu, *Zhongguo Shouongye Jingji Tongshi, Song Yuan Juan*, p. 191.

¹⁵⁵ The Song administrative network for iron production covered 35 key locations across the Empire; see Xu, *Song Huiyao Jigao*, 'Shihou 33/3–4'; Wagner, *Science and civilisation in China*, pp. 295–8.

¹⁵⁶ It has been estimated that the north-south output ratio was 1:6; see Qi, *Songdai Jingjishi*, vol. 2, p. 610.

¹⁵⁷ For regional household numbers, see Wu, *Zhongguo Renkoushi*, pp. 129–35.

¹⁵⁸ Qi, *Songdai Jingjishi*, vol. 2, p. 609.

¹⁵⁹ Hu, *Zhongguo Shouongye Jingji Tongshi, Song Yuan Juan*, p. 236.

¹⁶⁰ Qi, *Songdai Jingjishi*, vol. 2, pp. 608–9.

¹⁶¹ Based on 300–1,000 coins per worker per day; see Qi, *Songdai Jingjishi*, p. 615.

¹⁶² Regarding iron nails and rivets for shipbuilding, see Deng, *Chinese Maritime Sector*, pp. 47–8; Qi, *Songdai Jingjishi*, vol. 2, pp. 681–8. Note: ship nails and rivets have to be made of pure iron to avoid erosion in sea water.

¹⁶³ Deng, *Chinese Maritime Activities and Socioeconomic Development*, pp. 68, 80; Deng, *Maritime Sector, Institutions, and Sea Power*, p. 12.

displacement to handle 300,000 tons of cargo each year along inland waterways.¹⁶⁴ The river fleet was imperative for the Song market function and food supply to the north. Given that a traditional ship of the medium size (a 70-tonner) needed 100 m³ of wood planks and 5 metric tons of iron nails and rivets to build,¹⁶⁵ the aggregate inputs in the Song shipbuilding were in the region of 5 million m³ of planks and a quarter of million tons of nails and rivets.¹⁶⁶ Regarding money supply, from *circa* 970 AD onwards, iron coins were mass-produced in the region of 400 million pieces (*wen*) a year, the largest amount made of iron in Chinese history hitherto, to maintain a dual track system together with bronze coins to tackle the growing hunger for liquidity in a commercial boom.¹⁶⁷ Other common objects made of iron included weapons, statues, bridge-building (iron chains), musical instruments (e.g. gongs and cymbals), farming and handicraft tools (spades, ploughs, saws, chisels), and kitchen utensils (knives, pots and woks).¹⁶⁸ Steel was produced from iron during the Northern Song, although its quantity is known.¹⁶⁹ Iron sheets were also used to produce copper with an input-output ratio at 2.4:1 called *dantong fa*, a novel method of extracting copper cheaply through a chemical agent (i.e. CuSO₄·5H₂O).¹⁷⁰

During the Northern Song, China's ceramic production came a long way from the earthenware *tang sancai* type (Tang three-coloured earthenware) to the genuine water-proof porcelain made of the 'kaolin clay' (powder from rocks), baked for weeks on end at a temperature above 1200° C in kilns of a house size. Unlike the cottage-based earthenware-making potteries, the new porcelain industry was a heavy industry which needed a minimum output to justify the investment sum. Northern Song had 28 porcelain production centres, although the size of the workforce has remained unknown.¹⁷¹

There was a strong growth in construction. In Quanzhou (Zone B"), the main trading port for the Song Empire, about 290 bridges were constructed during the Northern Song.¹⁷² They cost a total of one billion Song coins, coming mainly from the private sector.¹⁷³ To build these bridges needed a minimum of 890,000 tons of granite slabs,¹⁷⁴ or 4.4 tons of slabs per household in the prefecture of the time (as in 1078).¹⁷⁵ To achieve that, sizeable quarrying, masonry and overland transport industries were vital.¹⁷⁶

¹⁶⁴ Deng, *Chinese Maritime Activities and Socioeconomic Development*, pp. 62, 66, 82.

¹⁶⁵ Deng, *Maritime Sector, Institutions, and Sea Power*, pp. 29, 31.

¹⁶⁶ *Ibid.*, p. 27.

¹⁶⁷ Yan, *Liangsong Tieqian*, p. 403; for the historical context, see von Glahn, *Fortune*.

¹⁶⁸ Ebrey, *Illustrated History*, p. 144.

¹⁶⁹ There were three documented ways to make steel out of iron at the time; see Hu, *Zhongguo Shougongye Jingji Tongshi*, pp. 205–7.

¹⁷⁰ The annual copper production this way reached 380,000 *catties* a year. The iron input required was one million *catties*; see Qi, *Songdai Jingjishi*, vol. 2, pp. 567–8.

¹⁷¹ Li, *Zhongguo Gudai Jingjishi Gao*, vol. 3, pp. 48–55; Qi, *Songdai Jingjishi*, vol. 2, pp. 690–700.

¹⁷² Deng, *Maritime Sector, Maritime Sector, Institutions, and Sea Power*, p. 27.

¹⁷³ *Ibid.*, p. 39. Buddhists played a highly visible role in bridge construction as good deeds; see Fang, 'Songdai Sengtu Dui Zaoqiaode Gongxian'.

¹⁷⁴ Deng, *Maritime Sector, Maritime Sector, Institutions, and Sea Power*, p. 38.

¹⁷⁵ Wu, *Zhongguo Renkoushi*, p. 131.

¹⁷⁶ Deng, *Maritime Sector, Maritime Sector, Institutions, and Sea Power*, p. 39.

Regarding light industry, a boom appeared in paper manufacturing. In Zone B, eight prefectures were specialised in paper-making.¹⁷⁷ Huizhou Prefecture (Zone B) and Xinan Prefecture (Zone A) alone were able to roll out annually 1.4 and 1.5 million sheets, respectively.¹⁷⁸ Such a quantity was achieved by an organised workforce. A recent archeological discovery made in Fuyang (Zone B) reveals a sizeable paper workshop built in 1009 AD with a floor area of 22,000 m² with a daily pulp output capacity of 10 tons.¹⁷⁹ Much of the paper outputs fuelled the growth in the printing industry for which the Northern Song was prominent in Chinese history.¹⁸⁰ Large numbers of books were produced for prestige, profit, and bureaucrat recruitment *via* the Imperial Examinations.¹⁸¹ From 1080 to 1113, a total of 300 million characters were carved on 400,000 printing blocks in Fujian for the circulation of a Chinese translation of the *Tripitaka*.¹⁸² On the whole, 6,705 new book titles with 73,877 volumes were registered as newly acquired items in the Song imperial collections.¹⁸³ There was also regular circulation of official and semi-official newspapers (*chaobao*, *dibao*, and *xiaobao*).¹⁸⁴

There was the repertoire of household-based textile production to meet tax obligations, a tradition going back to the Tang.¹⁸⁵ There was also an urban arm of the industry to produce mainly for the upper end of the market with an elaborate putting-out system. Urban professional weavers amounted for about 100,000 households, each producing 30 bolts a year, or three million bolts in total.¹⁸⁶

A growth also infected the service sector (including commerce) which was well documented. The evidence of fast commercialisation came from money supply. Bronze coins issued increased over six times:¹⁸⁷

AD	Output (10⁶ coins)	Metal inputs (10⁶ catties)
995	800	4 (2,400 tons)
1080	5,060	25.3 (15,180 tons)
Annual growth %	2.2	2.2

¹⁷⁷ Zheng, *Tang Wudai Jiangnan Gongshangye Buju Yanjiu*, pp. 206–7.

¹⁷⁸ Needham, *Science and Civilisation*, vol. 5, pt 1, p. 47; Hu, *Zhongguo Shouongye Jingji Tongshi, Song Yuan Juan*, p. 51.

¹⁷⁹ See <http://xbh.zjol.com.cn/05xbh/system/2010/01/20>.

¹⁸⁰ Qi, *Songdai Jingjishi*, vol. 2, pp. 715–22.

¹⁸¹ During the Song Period, the numbers of candidates received their Imperial Degrees a year was 5 times of the previous Tang and 3.4 times of the Qing half a millennium later; see Yang, *Songdai Chuban Wenhua*, p. 47.

¹⁸² Kang, *Beisong Wenhua Zhongxin Yanjiu*, p. 157.

¹⁸³ Tuo, *Song Shi*, vol. 202, 'Yiwenzhi 155'.

¹⁸⁴ Kang, *Beisong Wenhua Zhongxin Yanjiu*, pp. 108–31.

¹⁸⁵ In theory, there were some 20 million households producing home-made textiles to pay their taxes; in reality only a tenth of them actually did it. See Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 288–9.

¹⁸⁶ Hu, *Zhongguo Shouongye Jingji Tongshi, Song Yuan Juan*, p. 118.

¹⁸⁷ Qi, *Songdai Jingjishi*, vol. 2, pp. 608–9.

From 1023 to 1107, the amount of paper currency issued increased 40 times, annually growing 4.5 per cent.¹⁸⁸ A range of novel devices were first invented during the Northern Song, too, including written business contracts for risk reduction, *jiaozi* (bills of exchange) for business credit, *huizi* and *qianyi* (paper currency) for liquidity, not to mention the securities.

In this context, it is easy to envisage the full force of the change encountered by the farming sector in a quasi-dualistic way. Staple food production now faced unprecedented competition from high value-adding cash crops (Table 5).

Cash cropping and non-farming employment seemed winning the competition.¹⁸⁹ Anecdotaly, in the Kaifeng region, the income generated from 10 *mu* of vegetable garden matched the income from 100 *mu* under food crops.¹⁹⁰ According to a contemporary observation, 70 per cent of farms in parts of Zone C involved in sugarcane-growing and sugar-processing, at the expense of rice.¹⁹¹ Tea was produced in 374 districts, across 15 provinces in Zones B and C. The annual output was 23–29 million catties (13,730–17,300 metric tons),¹⁹² also at the expense of rice. Large tea plantations were reported in Chengdu Fu (Sichuan) with an annual output up to 50,000 catties each; in Fujian Lu, there were over 1,300 private workshops, specialised in tea-processing.¹⁹³ Silk was produced in 123 districts in 21 provinces (in Zones A, B and C). Over 60 per cent raw silk and silk textiles came from Zone B, again at the expense of rice.¹⁹⁴ The trade-off between silkworm-raising and rice-farming was well-documented as follows:¹⁹⁵

In Ji-an [Zone B], many people live exclusively on raising silkworms. A household of 10 people is able to raise 10 trays [*bo*] of worms. Each tray yields 12 *catties* of cocoons. Each *catty* of cocoons produces 1.3 *liang* of raw silk. Each 5 *liang* of such silk produce a bolt of plain cloth, worth 1.4 *shi* of rice. In doing so, both ends of the household are guaranteed to be met.

Finally and inevitably, urban centres emerged. The capital city Kaifeng is believed to have had 1.5 million residents,¹⁹⁶ while the urban proportion of the population has been estimated as between 12 and 20 per cent of the Song total.¹⁹⁷ Although these figures are subject to

¹⁸⁸ *Ibid.*, vol. 2, p. 1087. This caused, as expected, a severe inflation. But this was a different matter.

¹⁸⁹ Cheng, *Songdi Diyu Jingji*, pp. 118–54; also Li, *Tangdai Jiangnan Nongyede Fazhan*, ch. 5; Qi, *Songdai Jingjishi*, vol. 1, ch. 4; Ji, *Zhetang Shi*, ch. 6.

¹⁹⁰ Cited in Qi, *Songdai Jingjishi*, vol. 1, p. 162.

¹⁹¹ Wang, *Tangshuang Pu*.

¹⁹² Zhu, 'Songdai Chazhi Chanqu Jiqi Zhonglei Yu Chanliang'.

¹⁹³ Hau, *Songshi Lunji*, pp. 56, 58.

¹⁹⁴ Zhao, 'Songdai Cansiyede Dili Fenbu', pp. 587, 595.

¹⁹⁵ Chen, *Chenfu Nongshu*. One Song *liang* = 37.3 grams.

¹⁹⁶ Wu, *Zhongguo Renkoushi*, p. 574; Hu and Zhang, *Zhongguo Renkou Dili*, vol. 1, p. 249.

¹⁹⁷ Qi, *Songdai Jingjishi*, vol. 2, pp. 933, 948; Zhao, *Zhongguo Chengshi Fazhanshi Lunj*, p. 76. Wu, *Zhongguo Renkoushi*, p. 681. To feed urban people, 43 million *shi* of food (20 million metric tons) were

debate, by the end of the Northern Song, a dozen cities seemed to have had over 100,000 households each.¹⁹⁸ The growth was particularly strong in the south where Jizhou and Tanzhou surpassed Kaifeng (Table 6). This is not surprising given the political and economic freedom in Zone C.

A general pattern emerges from the Northern Song changes and growth. Firstly, the economy experienced major restructuring and leaned more towards industry and services. Secondly, industry and commerce grew fast and the south performed better than the north due to climatic, geopolitical and institutional reasons. Thirdly, the farming sector did not aim to make food cheaper despite its spare capacity. Only a high market price for food, together with the availability of arable land and tax cuts, was able to persuade and compensate those who kept on farming. Fourthly, in the process, resources were allocated by and through the market. The Song households now optimised incomes across different sectors instead of maximising their food output. Finally, the population grew continuously through these changes. Only an established market economy behaves this way. The Song Chinese could well be short-listed for the first group of *Homo economicus* in the world history.

This pattern was most obvious in the south where the local population did not plump for a mono-product of grain despite the absolute advantages in doing so (including more suited climate, more arable land and a long way from external threat). Rather, metal production, trade and urbanisation flourished there. The local population grew, too. Such a change is compatible with the on-going 'real wage debate' in global history.¹⁹⁹

The findings of the causes, mechanisms and stance of the Song growth and development suggests that Eric Jones is right: 'China came within a hair's breath of industrialising'.²⁰⁰

III

This study argues that the unprecedented Song population spurt was fuelled by an economic restructuring-cum-growth. It is already clear from the *prime facie evidence* that annual growth rates of industry and services increased faster than that of the population. To test that further, this paper employs the Ordinary Least Squares (OLS) to regress a set of time series data to examine the impact of economic growth on the Song population (for data sources, see Appendix). The model in the log-linear version is structured as follows:

sold to cities and towns every year, enough to sustain one million households at the subsistence level. See Gao, 'Lun Songdai Huobi Liutongzhongde Jige Guanxi', p. 96.

¹⁹⁸ Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 79–80.

¹⁹⁹ The debate is all about differences in monetary costs for the same 'utility function' across different economies. Consumers pay more for the same level of consumption in a more advanced economy where wages are higher than a less advanced economy where wages are lower. Or, wages in a more advanced economy have less purchasing power than their counterpart in a less advanced economy in possessing the same basket of consumer goods. This is the basic principle of utilitarianism. It has been argued that such a divergence in wages leads to different investment strategies which in turn determine different growth trajectories. See e.g. Allen *et al.*, *Living Standards*; Broadberry and Burhop, 'Real Wages and Labor Productivity'.

²⁰⁰ Jones, *European Miracle*, p. 160.

$$LHH = \alpha + \beta_1 LAOUTPUT + \beta_2 LINCOME + \beta_3 LTAX + \beta_4 LRICEP + \beta_5 LSILKP + \beta_6 LWARDI + \text{error} \quad (1)$$

Where the dependent variable is the total number of households (HH), serving as a proxy for the Song population. Three predictor variables are (1) total farming output to feed the population (AOUTPUT), (2) total non-agricultural incomes to maintain the population (INCOME), and (3) tax burden per household as an income reducer (TAX). In addition, three control variables are included for estimation. Rice and silk cloth were two common and relatively homogenous consumer items during the Northern Song. Their prices (RICEP and SILKP) are used as control variables to represent costs of living. The third control variable is disasters (WARDI), combining wars and natural calamities, to estimate shocks on population growth.

It is expected that AOUTPUT and LINCOME are positively, and TAX, RICEP, SILKP and WARDI negatively, related to the growth in HH, *ceteris paribus*. The results generated from the Ordinary Least Squares (OLS) are listed in Table 7. The high values of adjusted R-squared imply that the independent variables in Equation (1) explain well and capture most of the variation in the dependent variable.

The empirical results generated from Model 1 (Column 1) indicate that all the three predictor variables are important for the Song population growth (HH). The total farming output (AOUTPUT) and the total non-agricultural incomes (INCOME) both have positive and significant impact at a high level on the growth in household numbers. With one per cent increase in agricultural output and in non-agricultural incomes, households increase by 0.42 per cent and 0.39 per cent, respectively. This result supports our hypothesis that with economic restructuring agriculture and non-agriculture simultaneously supported the Song population growth like twine engines. As expected, tax burden per household (TAX) has negative impact on the population growth. One per cent deduction of tax burden increases households by 0.12 per cent. It makes sense as the Song taxation burden was low from the beginning.

The three control variables, living costs (LRICEP and LSILKP) and disasters (LWARDI) also have negative but weak influence on the population growth. The reason was that as economic prosperity increased population's tolerance towards income deductions caused by living costs and disasters increased, too. This is not to say that disasters and wars were not important. The Little Ice Age was vital for the performance of the farming sector in the north (Zones A and E). But it directly affected only a third of the farmland of the Empire. Farmers could take up jobs in local non-farming sectors or move to the south. The nomad threat was vital for sharp changes in behaviour and policies of the state. But the policy of paying ransoms worked. More wars were avoided in a fragile geopolitical equilibrium, although the ransoms did not solve the problem of national security in the long run.

Considering a potential bi-directional relationship from households to agricultural output and to non-agricultural income, more dynamic models are added to check robustness, i.e. the lagged LAOUTPUTlag1 (Model 2), lagged LINCOMElag1 (Model 3), lagged LAOUTPUTlag1 and LINCOMElag1 (Model 3). The results (Columns 2, 3, and 4) show high similarities to Model 1 (Column 1), testifying a low risk of bi-directional causality in Model 1.

What this paper has achieved is to demystify the intricacies of the Song growth and development. It has revealed that the unprecedented population spurt during the Northern Song Period was not a result of a purposely introduced new rice species. Rather, it was a complicated story of shocks, economic restructuring and development, and subsequent population growth. In the process, industry and commerce grew faster than the one per cent population growth rate; farming for staple food matched the population growth, but only just. So, the Northern Song growth was neither 'surplus-pulled' nor 'subsistence-pushed' as commonly believed. Rather, this is predominantly a story of 'demand-driven backward linkages'.

The Northern Song paradox is all about spectacular incompetence in national security leading to epic economic prosperity. The prime mover for the Song growth and development was the mounting geopolitical pressure from nomads who decided to exert their military supremacy to milk cash and luxuries from the Northern Song economy. Such specific demand did two things to Song China. First, it created a pressing fiscal emergency for the Song state to amass the cash and luxuries. Second, to get cash and luxuries activated a dormant market economy as well as Chinese creativity. A chain reaction of backwards linkages soon began, leading to economic re-structuring. Here, the role of the state and the market orientation of the Song economy were both decided by the quality and quantity of the ransoms. There could be three other realistic scenarios: the nomads could have demanded, say, staple food and slaves instead; the Song state could have surrendered to the nomads at the beginning; and the Song military could have been overhauled and defeated the enemy. Any of them would have made the Song economic landscape look very different.

All the time, the economic restructuring was a freestanding factor independent from the population increase.²⁰¹ The Little Ice Age did little to transform the Song economic structure. At best, the climate change helped Song China reach an existing production possibility frontier with the diffusion of winter-wheat at the time when the Song farmers were fully able to produce enough food during the climate change without Champa Rice or even without winter-wheat. Of course, the climate change caused the life in the Steppes to deteriorate. But it did not automatically justify nomads' wars against China. During the Northern Song Period, arable land was abundant in all zones; and the monad population small. If enough nomads had had decided to be 'sinicised', immigrate, settle in and become farmers, as a great many Khitans did after 1127,²⁰² the Song economic landscape would have looked very different, too.

Consequently, with the economic restructuring, China's production possibility frontier shifted outwards, exuberant non-farming sectors became increasingly significant in the economy, and individuals' incomes increased and diversified. So, after deductions (e.g. taxation and securities), enough was left to be funnelled to support one per cent growth in population. This virtuous growth spiral was not intended when the Northern Song began in 960 AD.

²⁰¹ This fundamentally contracts North and Thomas' view on how better institutions were created under population pressure; see North and Thomas, *Rise of the Western World*, ch. 3.

²⁰² The Khitan Jin boasted to have 6.15 million households and 1.69 million *qing* of farmland (as in 1183); and its official policy of the Khitan Jin was stated as 'tilling and weaving as the foundation of the economy' (in 1189); see Tuo, *Jin Shi*, 'Shihuo 1'. The Jin official land allocation was 100 *mu* for each poll-taxpayer in a land abundant region, and 10 *mu* for each poll-taxpayer in a land scarce region; see Tuo, *Jin Shi*, 'Shihuo 2'. Also see Deng, *Chinese Premodern Economy*, ch. 6.

Ideally, after demystifying the Song growth and development, this study should consider China's national income, sectorial GDP growth,²⁰³ real wages and living standards.²⁰⁴ This requires a great deal of more statistical information that Song China does not offer.²⁰⁵ This sets the limits for this study. Clearly also, more in-depth research is still needed in regard to how the Song elite and general public managed to overcome the stubborn resistance to changes. Such resistance usually came from indoctrinated physiocracy, entrenched private property rights for the peasantry, deeply rooted discrimination against the artisan and merchant classes, and relative high costs of capital and labour-saving machines.

In addition, we still do not know enough about how capital investment and re-investment was made in industry and commerce especially by the private sector; nor do we have a clear idea of how a new cluster of useful and reliable knowledge/technology was patronised and diffused in society rapidly; nor do we understand how transaction costs were lowered for ordinary peasants to switch to different labour markets for industry and commerce.

Moreover, although Song China responded successfully to exogenous shocks, the very fact that it took three demanding nomad groups to cause the economic restructuring to occur implies a lack of internal impetus in Chinese society in its 'natural self'. Equally, the fact that the Song state was in the end unable to safe-guard China's remarkable economic achievements points to the same problem. More work is needed in this area.

Finally, more comparison will be very useful between Northern Song and other commercial economies in world history to see their differences and similarities. For example, how similar was the Song maritime expansion to the Indian Ocean as a response to the control of the Silk Road by nomads, compared with Western European maritime endeavour during the fifteenth to sixteenth centuries to outflank the Ottoman monopoly of oriental trade and reach the Asian market directly?

If one really wishes to push the debate further, was Song China marked a 'proto-Great Divergence' by generating entirely independently advanced industry and commerce ahead of anyone else in the Old World of the time? Counterfactually, could it be possible for the Song growth to lead China to a fully fledged industrial revolution if the Mongol conquest had been absent? Or, why did the Northern Song saga end in the fashion of 'killing the goose that lay golden eggs'? Why could the Mongols not be bribed like the Khitans, Tanguts and Jurchens by the richest economy in the Old World? And, could the Song success be passed on to the Mongols and then propagated itself across the rest of Eurasia?

Now, the door for the study of the Northern Song case has opened even wider than ever before.

²⁰³ For some pioneer works on China's national income, see Ou, *National income of China* and Liu and Yeh, *Economy of the Chinese Mainland, National Income and Economic Development*, vol. 1, pp. 39, 94, 207–8, 215, 250. For an earlier period, see Guan and Li, 'Mingdai GDP Ji Jieguo Shitan'. Regarding incomes of the elite, see Chang, *Income of the Chinese Gentry*, p. 193. Chang, and Guan and Li followed Liu and Yeh in methodology. Regarding the agricultural income, Perkins used *per capita* food consumption, population size and farmland acreage; see his *Agricultural Development in China*. Perkins' method was followed by Angus Maddison, see his *Chinese Economic Performance in the Long Run*.

²⁰⁴ For recent attempts, see Broadberry *et al.*, 'China, Europe and the Great Divergence'; Edwards, 'Redefining Industrial Revolution: Song China and England', pp. 20–3.

²⁰⁵ For the recent debate, see Du and Li, 'Zhongguo Jingjishi GDP Yanjiuzhi Wuqu'.

Appendix

The time series examined cover the period from 997 to 1111 due to data availability. The time series has 38/39 observation points with intervals of three years apart. All the prices are converted to a 997 constant price when applicable.²⁰⁶ The original data are often patchy, but well spread out across the 997–1111 period. The missing data are linearly interpolated and, only occasionally, extrapolated.

Regarding the dependent variable (HH), there are 18 entries directly from historical sources. We use two compilations of historical records: Liang's *Zhongguo Lidai Huko Tiandi Tianfu Tongji* and Wu's *Zhongguo Renkoushi*. The value of the total farming output (AOUTPUT) is obtained from the total farmland multiplied by the average yield level per *mu*. The data for farmland come from the Song cadastral surveys in 996, 1021, 1067 and 1083, cited in Tuo's *Song Shi* (vol. 173, 'Shihuozi 126'), Liang's *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, Qi's *Songdai Jingjishi* and Cheng's *Songdai Diyu Jingji*. The yield level is region-weighted as discussed earlier (i.e. 1.7 *Song shi* per *Song mu* before circa 1000 AD and 2.2 *Song shi* per *Song mu* after 1000 AD). This range is very modest.²⁰⁷ Modern estimates of Song farmland are not used due to their tendency to assume that the Song acreage went up all the time, simply untrue in reality. Moreover, those estimates are overwhelmingly derived from the Song population *per se*,²⁰⁸ an approach that is highly vulnerable to endogeneity.

The value of non-agricultural incomes (INCOME) is derived from the commercial tax rate (5 per cent) and the government non-agricultural tax revenues. Eight government fiscal reports are available (for 996, 1021, 1058, 1063, 1065, 1069, 1078, and 1086). Our sources are Liang's *Zhongguo Lidai Huko Tiandi Tianfu Tongji*. Regarding the tax rate, we use Tuo's *Song Shi* (vol. 173, 'Shihuozi 126', and vol. 186, 'Shihuozi 139'), Wang's *Liangsong Caizheng Shi*, Li's 'Luexi Songdai Guanshizhi Zheng', and Guo's *Liangsong Chengxiang Shangpin Huobi Jingji Kaolue*. Undoubtedly, extra revenue could be extracted if the taxman collected more than five per cent of goods' value. On the other hand, Zone D was tax-free, and tax evasion was widespread in other zones, which led to the radical reforms of Wang Anshi (1021–86). So, over-taxation and tax aversion/haven could cancel each other to a great extent.

The value of tax burden per household (TAX) is calculated from tax payments in goods and cash, divided by the total households. Apart from the eight entries for the government non-agricultural revenues in cash, there are six official figures for agricultural revenues collected in foods (996, 1021, 1063, 1065, 1078, and 1086), and another six in silk (996, 1021, 1063, 1065, 1078, and 1086). Our sources are Liang's *Zhongguo Lidai Huko Tiandi Tianfu Tongji* and Wang's *Liangsong Caizheng Shi*. Food and silk are then converted to the period market value

²⁰⁶ Price conversion is based on Peng, *Zhongguo Huobi Shi*, p. 505; Guo, 'Songchaode Wujia Biandong Yu Jizang Lunzui', p. 72; Qi, *Songdai Jingjishi*, vol. 2, pp. 1104–7. For multiple currencies and exchange rates, see Guo, *Liangsong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 287–321, 331.

²⁰⁷ Note: During the Ming-Qing Period (1368–1911), the same nominal output levels, i.e. 1–2 *shi* per *mu*, were cited; see Buck, *Land Utilization in China*, p. 209; Li, *Duoshijiao Kan Jiangnan Jingjishi*, pp. 298–9; Wu, *Zhongguo Jingjishi Ruogan Wentide Jiliang Yanjiu*, pp. 142–4; Shi, 'Shijiu Shiji Shangbanqide Zhongguo Liangshi Muchanliang Ji Zongchanliang Zaiguji', pp. 57, 61. But one Qing *shi* per Qing *mu* = 1.6 *Song shi* per *Song mu*.

²⁰⁸ Qi Xia's estimate is 720 million *mu* for 1110; see his *Songdai Jingjishi*, vol. 1, pp. 59–60. If true, the entire Song workforce would have to do one thing only: to farm. And food would have become much cheaper. Qi clearly mistook the Song for the Ming-Qing.

for uniformity. The food and silk prices come from Cheng's *Songdai Wujia Yanjiu* and Yu's *Zhongguo Jiage Shi*.

Information of prices of rice and silk for living costs (RICEP, SILKP) comes from Cheng's *Songdai Wujia Yanjiu*, Guo's 'Songchaode Wujia Biandong Yu Jizang Lunzui', and Yu's *Zhongguo Jiage Shi*. In all, 16 rice prices are collected (996, 1003, 1009, 1029, 1042, 1053, 1069, 1075, 1080, 1086, 1088, 1094, 1099, 1108, and 1110). Ten silk prices are obtainable (1000, 1016, 1046, 1063, 1070, 1079, 1086, 1101, 1103 and 1107). All the information is from anecdotes, not market surveys; but it is as good as one can probably get.

Data for wars and natural disasters (WARDI) are derived from various records. Floods, storms, locust outbreaks, and communicable plagues are used as proxies for natural disasters. Our sources are Fu *et al.*'s *Zhongguo Junshi Shi*, Lidai Zhanzheng Nianbiao, Xia and Song *et al.*'s *Zhongguo Gudai Ziran Zaiyi Dongtao Fenxi*.

The final line-up is in Table 8.

Table 8. Time-Series Dataset

Year	Households	A-output	Non A-income	Tax	R-price	S-price	W/D
997	4574257	531292712.5	2.4E+11	3457.22267	300	1013	248
1000	5719209	561000000	2.64984E+11	2828.411036	475	971	0
1003	6864160	794942937.8	2.92568E+11	2409.373136	650	929	55
1006	7417570	845956630.2	3.23025E+11	2275.00168	515	895	29
1009	8402537	900244017.2	3.56651E+11	2050.420468	380	862	33
1012	8412470	959868841.8	3.9378E+11	2093.327858	415	831	0
1015	8422403	1019493666	4.3477E+11	2136.133886	450	800	50
1018	8545276	1107645339	4.80029E+11	2170.090024	503	954	28
1021	8677677	1154527950	5.3E+11	2170.465091	533	1042	10
1024	9898121	1145716209	5.44702E+11	1863.031732	563	1138	6
1027	10030405	1132699506	5.59813E+11	1790.953432	615	1310	0
1030	10162689	1119682802	5.75342E+11	1720.751436	667	1482	30
1033	10296565	1098440741	5.91302E+11	1646.211746	745	1848	20
1036	10663027	1085889435	6.07705E+11	1569.919802	794	2109	10
1039	10179989	1077601675	6.24563E+11	1859.466838	829	2303	6
1042	10307640	1065288486	6.41889E+11	2334.660459	885	2629	12
1045	10682947	1053115991	6.59695E+11	3073.791938	978	3000	20
1048	10723695	1041082588	6.77996E+11	2564.027214	1080	2565	13
1051	10747954	1033136804	6.96803E+11	2320.899075	1154	2310	5
1054	10792705	1021331689	7.16133E+11	2062.041732	1275	1975	13
1057	10825580	1001955497	7.36E+11	4832.942321	1093	1520	31
1060	11091112	990506677.6	7.96991E+11	4791.557818	997	1300	10
1063	12462317	982946899	8.63037E+11	4314.032491	938	1300	6
1066	14181485	968000000	9.34555E+11	4160.036419	829	1300	5
1069	14414043	973830886.6	1.012E+12	4123.493713	780	1300	21
1072	15091560	982643140.6	1.04708E+12	2175.776882	990	1300	17
1075	15684529	991535135.8	1.08338E+12	1272.13729	1200	1300	37
1078	16402631	1000507596	1.12094E+12	832.7358763	1633	1300	34
1081	16730504	1006534296	1.15979E+12	804.9506367	2067	1300	7
1084	17211713	1015642320	1.2E+12	782.5216653	1344	1550	27
1087	17957092	1037695870	9.6E+11	3193.425194	620	1800	23
1090	18655093	1075521066	9.68607E+11	2004.352768	865	1588	12
1093	19120921	1098874819	9.77291E+11	1587.31024	870	1473	12
1096	19435570	1122735673	9.86054E+11	1326.963131	815	1367	11
1099	19715555	1138930058	9.94894E+11	1207.070243	760	1300	13
1102	20264307	1163660667	1.00381E+12	1085.88359	980	1400	11
1105	20456273	1189202604	1.01281E+12	1065.377429	1090	1450	0
1108	20648238	1214744538	1.02189E+12	1045.252609	1200	1500	24
1111	20882258	1232236729	1.03106E+12	1060.446705	1200	2000	2

Note: The original data available are fragmentary with gaps in between. Such gaps are filled with figures derived from the existing data with a linear growth rate. A-output = Agricultural output; Non A-income = non-agricultural income; R-price = Rice price; S-price = Silk cloth price; W/D = Wars and natural disasters.
Source: See the body of text in Appendix.

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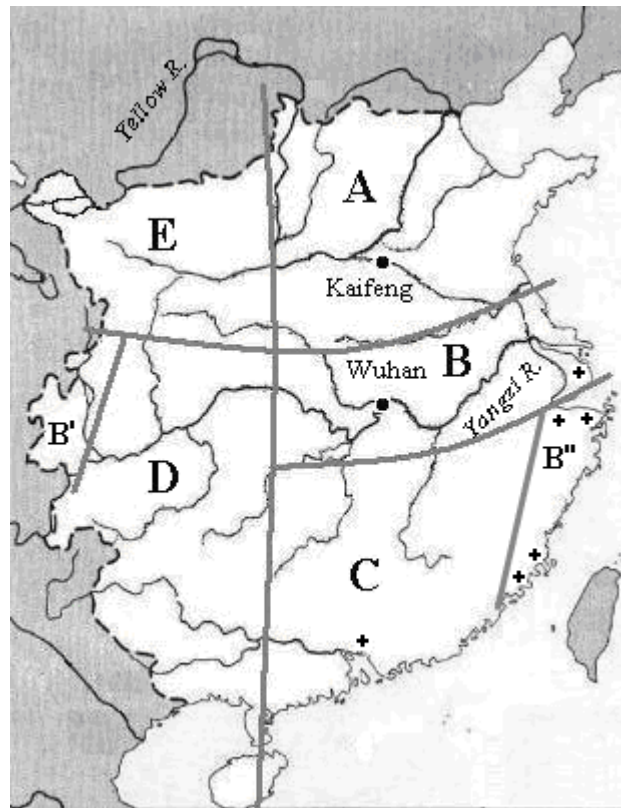
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Figure 1. Song Eco-Economic Zones, River Systems and Sea Ports



Note: A, B, D and E – mainly temperate; D – subtropical; B' (Chengdu Fu) and B" (Liangzhe and Fujian Lu) shared a similar farming pattern with B. The territorial sizes of those zones were not identical with their farmland sizes. Sea ports are marked by crosses.

Source: Tan, *Jiangming Zhongguo Lishi Ditu Ji*, pp. 41–2, 51–4; Qi, 'Songdai Shehui Shengchanlide Fazhan Jiqizai Zhongguo Gudai Jingji Fazhan Guochengzhongde Diwei', pp. 43–5; Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 164.

Figure 2. Geopolitical Map of Song China



Note: Along the northern border were the Khitan Kingdom (Liao) and the Tangut Kingdom (Xixia) prior to 1127. The grey line = new international border between the Jurchen Jin and the Southern Song after 1127. GW = the line where the old Great Wall had laid. Numbers represent provinces (*lu*), as in 1111 AD. Kaifeng was the capital of the Northern Song; Lin-an, that of the Southern Song.

Source: Based on Tan, *Jiangming Zhongguo Lishi Ditu Ji*, pp. 51–4.

Table 1. Official Registered Numbers of Households, 1003–1100

	Households	Index	Poll-taxpayers	Index
1003*	6,864,160	100	14,278,040	100
1020	9,716,716	142	22,717,272	159
1042*	10,307,640	150	22,926,101	161
1061*	11,091,112	162	22,683,112	159
1080	16,730,504	244	23,830,781	167
1100	19,960,812	291	44,914,991	316
Annual %		1.1		1.2

Note: * The closest observation points available at the beginning of a decade.

Source: Based on Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 122–4; Wu, *Zhongguo Renkoshi*, pp. 346–8.

Table 2. Fluctuations in Farmland vs. Growth in Household Numbers, 1021–85

	Farmland (10^5 <i>qing</i>)	Index	Households (10^6)	Index
1021	52.5	100	8.7	100
1054	22.8	43	10.8	124
1065	44.0	84	12.9	148
1085	24.8	47	18.0*	207
Average		36.0		12.6

Note: * Year 1086 figure. One *qing* = 100 *mu*.

Sources: Data for farmland, based on Tuo, *Song Shi*, vol. 173, 'Shihuozi 126'. Data for households, based on Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 122–4; Wu, *Zhongguo Renkoushi*, p. 346–7.

Table 3. Urban Commercial Tax-Paying Shares, 1077 (10⁶ coins)

Zone	Urban centres	Revenue	Tax % (I)	RHS % (II)	I/II
A	48	1,376.6	42.2	23.6	1.8
B	49	1,263.0	38.8	41.1	0.9
C	20	391.1	12.0	19.4	0.6
D	–	–	–	8.3	–
E	10	228.6	7.0	7.5	0.9
Total	127	3,259.3	100.0	100.0	1.0

Note: RHS – Regional Household Shares in China's Total.

Source: Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 223–8; Wu, *Zhongguo Renkoushi*, pp. 122–35; Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, p. 164.

Table 4. Growth in Metal Outputs (in *Catties*), 727–1077

AD	Iron	Copper*	Tin	Lead
727†	2,070,000	-	-	-
997§	-	4,122,000	269,000	793,000
1077/8§	28,500,000¶	21,744,750	6,159,300	7,943,350
Annual growth %				
727–1077/8	0.8‡	-	-	-
997–1077/8	-	2.1	4.0	2.9

Note: One Tang/Song *catty* = 0.6 kg. * Large quantities of copper were also produced from iron sheet with sulphuric acid. † Tang government taxable iron output, used here as a benchmark. § Song government procurements only, hence the minimum. ¶ Based on (1) 5.7 million *catties* received by the state (or 3,400 metric tons) in 1078 and (2) the compulsory *erba choufen* scheme of 20:80 output-sharing between the state and the producer. ‡ The growth rate of household numbers from 726 AD to 1077 AD was only 0.2 per cent per year in comparison.²⁰⁹

Source: Iron, based on Qi, *Songdai Jingjishi*, vol. 2, pp. 586–92; Hu, *Zhongguo Shougongye Jingji Tongshi*, pp. 149–50. Other metals, based on Ma, *Wenxian Tongkao*, vol. 18, Entry ‘Mining’; Du, ‘Tang Song Jingji Shili Bijiao Yanjiu’, p. 44. Tang output, based on Ouyang, *Xin Tangshu*, vol. 54, ‘Shihuozi’.

²⁰⁹ For the household numbers, see Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 6, 124.

Table 5. Crop Choices during Song Times

	Calendar Month	Growth cycle (days)
Food crops		
Winter-wheat*	9 th – 3 rd (the following year)	175
Millet	2 nd – 7 th	145
Rice α†	3 rd – 5 th	58
Rice β†	3 rd – 7 th	116
Buckwheat§/Rice γ†	4 th – 9 th	145
Cash crops		
Hemp	1 st – 6 th	145
Sugarcane§	2 nd – 10 th	230
Early sesame	3 rd – 7 th	116
Early legume	4 th – 7 th	87
Late sesame	5 th – 9 th	116
Vegetables	3 rd – 10 th	201
Tea, fruits, mulberry trees	3 rd – 10 th	201

Note: A Chinese calendar month has 29 days. Rice α–γ = rice choices; their sowing timing did not allow two rice crops within the same calendar year. * Suited for Zones A, B (including B' and B") and E. † Suited for Zones B, C and D. § Sugarcane is perennial and requires re-planting once every three years.

Source: Chen, *Chenfu Nongshu*, pp. 2–5; Wang, *Tangshuang Pu*; Guo, *Liansong Chengxiang Shangpin Huobi Jingji Kaolue*, pp. 258, 264–8; Liang, *Nansongde Nongcun Jingji*, p. 117; Cheng, *Songdai Diyu Jingji*, pp. 98–100.

Table 6. Households' Growth in Five Most Populated Prefectures, 980–1102

	Zone	980	Index	1102	Index
Kaifeng	A	178,631	100	261,117	146
Quanzhou	B	96,581	100	201,406	209
Fuzhou	B	94,470	100	211,552	224
Jizhou	C	126,453	100	335,710	265
Tanzhou	C	52,906	100	439,988	832

Source: Based on Liang, *Zhongguo Lidai Huko Tiandi Tianfu Tongji*, pp. 132–60; Hu and Zhang, *Demographic Geography*, vol. 1, p. 249; Wu, *Zhongguo Renkoushi*, pp. 574, 584.

Table 7. Empirical Results

	Model 1 (1)	Model 2 (2)	Model 3 (3)	Model 4 (4)
Agricultural output (LAOUTPUT)	0.42 (0.06)***		0.44 (0.06)***	
Lagged agricultural output (LAOUTPUTlag1)		0.44 (0.05)***		0.42 (0.05)***
Non agricultural incomes (LINCOME)	0.39 (0.09)***	0.39 (0.07)***		
Lagged non agricultural incomes (LINCOMElag1)			0.33 (0.07)***	0.37 (0.06)***
Tax (LTAX)	-0.12 (0.02)***	-0.11 (0.02)***	-0.11 (0.02)***	-0.11 (0.02)***
Rice price (LRICEP)	-0.15 (0.05)**	-0.22 (0.04)***	-0.14 (0.04)***	-0.19 (0.04)***
Silk price (LSILKP)	-0.07 (0.04)	-0.02 (0.04)	-0.08 (0.04)**	-0.06 (0.03)
Disaster (LWARDI)	-0.03 (0.01)*	0.00 (0.01)	-0.01 (0.01)	-0.00 (0.01)
Obs	39	38	38	38
Adj R-sq	0.96	0.97	0.97	0.97

Notes: 1. Standard errors are in parentheses. 2. ***, ** and * are coefficients significant at the 1%, 5% and 10% levels, respectively.

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