CHINA, EUROPE AND THE GREAT DIVERGENCE: A STUDY IN HISTORICAL NATIONAL ACCOUNTING, 980-1850

Stephen Broadberry, London School of Economics and CAGE, S.N.Broadberry@lse.ac.uk
Hanhui Guan, Peking University, guanhh@pku.edu.cn
David Daokui Li, Tsinghua University, lidk@sem.tsinghua.edu.cn

19 August 2014
File: China7e.doc

Abstract: GDP is estimated for China between the late tenth and mid-nineteenth centuries, and combined with population estimates. Chinese GDP per capita was highest during the Northern Song dynasty and declined during the Ming and Qing dynasties. China led the world in living standards during the Northern Song dynasty, but had fallen behind Italy by 1300. At this stage, it is possible that the Yangzi delta was still on a par with the richest parts of Europe, but by 1700 the gap was too large to be bridged by regional variation within China and the Great Divergence had already begun.

JEL classification: E100, N350, O100
***Keywords*:** GDP Per Capita; Economic Growth; Great Divergence; China; Europe

Acknowledgements: This paper forms part of the project "Reconstructing the National Income of Britain and Holland, c.1270/1500 to 1850", funded by the Leverhulme Trust, Reference Number F/00215AR. It is also part of the Collaborative Project HI-POD supported by the European Commission's 7th Framework Programme for Research, Contract Number SSH7-CT-2008-225342. David Daokui Li and Hanhui Guan also acknowledge financial support from Humanity and Social Science Promotion Plan of Tsinghua University (2009WKWT007) and National Natural Science Foundation (70973003)

1. INTRODUCTION

As a result of recent advances in historical national accounting, estimates of GDP per capita are now available for a number of European economies back to the medieval period, including Britain, the Netherlands, Italy and Spain (Broadberry, Campbell, Klein, Overton and van Leeuwen, 2014; van Zanden and van Leeuwen, 2012; Malanima, 2011; Álvarez-Nogal and Prados de la Escosura, 2013). A number of recent studies have also extended this approach to Asian economies, including India and Japan (Broadberry, Custodis and Gupta, 2014; Bassino, Broadberry, Fukao, Gupta and Takashima, 2014). So far, however, the economy which has been at the centre of the Great Divergence debate, China, has been conspicuously absent from this approach.

This paper uses historical national accounting methods to estimate GDP for China during the Northern Song, Ming and Qing dynasties, and combines the resulting series with population estimates to produce GDP per capita. An earlier study by Guan and Li (2012) demonstrated that sufficient information is available for a detailed reconstruction of the historical national accounts of China, using a sectoral approach similar to that adopted by Broadberry, Campbell, Klein, Overton and van Leeuwen (2011; 2014) for Britain. This means that it is no longer necessary to rely on the quantitative conjectures of Maddison (1998) to track the long term performance of the Chinese economy. These new, more firmly grounded estimates of Chinese GDP per capita can be used to compare economic performance during the Northern Song, Ming and Qing dynasties. China's GDP per capita reached its peak level during the Northern Song dynasty, before entering a long decline which lasted through the Ming and Qing dynasties, and indeed was only decisively reversed in the second half of the twentieth century (Maddison, 1998).

The results also shed new light on the timing of the Great Divergence. Northern Song China was richer than Domesday Britain in 1090, but by 1400 Britain was already ahead, and China was certainly poorer than Italy by 1300. By the seventeenth century, China was already substantially behind the leading European economies in the North Sea Area, despite still being the richest Asian economy. Even allowing for regional variation within China, it is clear that the Great Divergence between China and Western Europe was already well under way by 1700, before the start of the Industrial Revolution.

The paper proceeds as follows. Section 2 provides a general overview of data sources, while sections 3 to 6 discuss the derivation of the population and output estimates in the agricultural, industrial and service sectors. Section 7 aggregates the sectoral estimates to produce nominal and real GDP and combines the real GDP estimates with population to derive real GDP per capita. A preliminary assessment of Chinese economic performance is made in this section by comparing the three dynasties. Section 8 then places this performance in an international perspective by comparing GDP per capita in China with other economies to shed light on the origins of the Great Divergence. Section 9 concludes, while an appendix provides more detailed information on data sources and methods.

2. DATA SOURCES

This study draws on a large Chinese historical literature that is based in turn on a solid foundation of quantitative data collected by the Northern Song, Ming and Qing dynasties. China has a long tradition of recording history for the purpose of providing experience and lessons in national governance for future dynasties. To achieve this, governments usually established a special institution with responsibility for compiling and recording laws and policy, and these institutions collected important economic data. In addition to this official

historical literature, there are two additional types of material that have been drawn on in the estimates provided below, a private historical literature and regional gazetteers.

The official historical literature includes *Shihuo Zhi* for each dynasty, *Shilu and huidian* for the Ming and Qing dynasties, and *Huiyao* for the Northern Song dynasty. In a country with a highly centralised authority, local governments had to report information to the central government, and these sources contain much important economic data. *Shihuo Zhi* originated from the Han dynasty(202 B.C.-220 A.D.), and in ancient Chinese, *Shi* means agricultural production, while *huo* means production of subsidiary agriculture and textiles, and money circulation. For each dynasty, *Shihuo Zhi* recorded data on important areas of economic life, including land institutions, households and population, taxes and corvee (unfree labour), monetary institutions, salt laws, metals and mining, fiscal budgets, and the evolution of fiscal institutions. *Shihuo Zhi* thus contains much data on economic activity including the amount of arable land, the total population, fiscal revenue, and the output of salt and iron. Another important official historical source is *Shilu,* a kind of annual commissioned by the Emperors to record in detail on a daily basis events that happened in the royal palace and the whole country. *Shilu*, which were generally compiled by highly regarded contemporary scholars, have been accorded high value in the historiography. *Huiyao* and *huidian* chiefly recorded laws and institutions. *Song Huiyao*, for example, provides detailed information on the legal system of the Song dynasty, while *Ming huidian* and *Da Qing huidian* provide information on the administrative laws and regulations of the Ming and Qing dynasties.

The authors of private historical works were sometimes distinguished historians of their era. For example, Duanlin Ma, the author of *Wenxian Tongkao*, was a famous scholar,

who wrote a general history of legal and political institutions from remote times to the Northern Song. Tao Li, another historian living in the Song dynasty, wrote the historiographical work *Xu Zizhitongjian Changbian.* Privately written historical works also sometimes recorded important economic data based on the investigative research of the authors.

A gazetteer is a kind of encyclopedia of a particular province, prefecture or county. It is known in Chinese as *Difang Zhi*, which means "area record", and contains information about the natural geography, human geography, and economic geography of the area. Gazetteers provide important economic data for this study, particularly where an industry was concentrated regionally. *Guangdong Tongzhi Chugao in the reign of the Jiajing Emperor*, for example, is an important source of data for the iron industry around Foshan town, Guangdong province during the later stages of the Ming dynasty. Similarly, data on the porcelain industry of Jingdezhen were taken from *Raozhou Fuzhi in Jiangxi Province*. Both these sources filled important gaps in the official historical literature at the national level.

There are both advantages and disadvantages with each of these three kinds of historical literature. The official historical literature has full national coverage and is highly systematic, but in some cases lacks credibility. Since these historical records were designed to meet the Emperor's need to govern the country, the writers sometimes had an incentive to distort reality. Thus, for example, at the beginning of the Ming dynasty, the population and land data were recorded in a book named *Huangce*, since Emperor Hongwu wanted to know how much tax revenue could be raised from the people. Once this work had been done, the Emperor set a fixed fiscal revenue, so that later data on land and population do not reflect real developments, which can only be tracked from other sources. The private historical literature

is therefore more credible than some of the official historical literature, but since it is less complete, it should be seen as complementary to the official historical literature rather than as a substitute. Gazetteers are also more credible than some of the official historical literature, but they are also less complete, since they are only available at the sub-national level. In some cases, it is possible to simply aggregate area level data to the national level, but in other cases, it is necessary to make assumptions about the relationship between areas for which data are available and the rest of the country.

It is worth noting that although some data from the official historical literature are not very accurate, Chinese economic historians have drawn on other sources to publish adjusted data. In addition to referencing the primary sources used in the calculations, this study therefore also makes use of the findings of the pioneers of quantitative economic history in China, including Xia Qi (2009), Zhengzhong Guo (1993; 1997), Xi Song (1958), Shengduo Wang (1995), Lingling Wang (2005), Minsheng Cheng (2008) and Huarui Li (1991; 2001) on Song history; and Dixin Xu and Cheng-Ming Wu (1985), Bozhong Li (1998; 2010), Ping-ti Ho (1985), Ray Huang (2001), Xinwei Peng (1965), Hansheng Quan (1991), Yeh-chien Wang (2004), Yuquan Wang (2007), Xing Fang, Junjian Jing and Jinyu Wei (2007) and Kang Chao (1986) on Ming and Qing history.

Although some series are available on an annual basis, others are not. In particular, although it is possible to track long run trends in grain yields, there are no data on annual fluctuations. Since this was the largest sector of the Chinese economy, and since grain yield fluctuations were the key driver of annual fluctuations in GDP even in Britain, where agriculture accounted for a much smaller share of GDP, a decision was taken to work towards obtaining data every 10 years, along the lines of Liu and Hwang (1979).

3. POPULATION

Before reconstructing GDP from the output side, it will be helpful to set out trends in population, which will be needed to derive estimates of GDP per capita, the key indicator of overall economic performance in this study. In China, population data were systematically recorded throughout the period covered here, in connection with taxation. It is generally accepted that the officials were capable of recording the number of people accurately, but that the institutional details of the tax system at a particular time affected the incentives for the officials to count particular groups more or less carefully: landowners, households and individuals (Perkins, 1969: 193). Taking account of these factors has allowed historians to narrow the range of disagreement considerably, with the estimates of Liu and Hwang (1979) commanding widespread support for the Ming and Qing dynasties (Maddison, 1998; McEvedy and Jones, 1978).

The population data used here are taken from Liu and Hwang (1979) for the Ming and Qing dynasties and from Jianxiong Ge and Songdi Wu (2000) for the Northern Song dynasty. Ge and Wu's Northern Song estimates agree broadly with the figures derived by Kent Deng (2004: 43) for the Northern Song dynasty, obtained by multiplying the registered households by a family size of 5.77, the long term average from years when both household and population data are available. However, Ge and Wu suggest a slightly lower family size of 5.4.

The population data are plotted on a log scale in Figure 1, and show rapid growth during the Northern Song dynasty at an annual rate of 0.87 per cent. Following a substantial decline during the Mongol interlude, population growth returned during the Ming dynasty,

but at the slower rate of 0.32 per cent per annum. Following another population decline during the next dynastic change, the annual growth rate picked up to 0.70 per cent during the Qing dynasty.

4. AGRICULTURAL OUTPUT

Agricultural output is estimated mainly from data on the amount of land cultivated, the distribution of different crops and the crop yields per unit of land. This section provides an overview of the sources and methods, with more detail provided in Appendix A1. The standard Chinese measure of land area is the *mu*, which is 1/15th of a hectare or 1/6th of an acre. The livestock sector, which was much smaller in China than in Europe, was also included using information on additional outputs. This output-based approach is more direct than the alternative consumption approach, where agricultural demand is derived from estimates of real agricultural consumption per person multiplied by the population. Furthermore, Ruizhong Liu (1986) questions the reliability of the available data on consumption per capita during the Qing dynasty, which suggest very low estimates of kilocalorie consumption per capita.

Agriculture is first divided up into a number of different sectors, covering grain crops, cash crops and subsidiary agricultural outputs. For grain crops, the starting point for the estimation of output is the cultivated land area, which is derived ultimately from the official data, but also draws upon information obtained from gazetteers and private histories. Although it should clearly be borne in mind that land data were kept primarily for tax purposes, and that people like to avoid taxes, biases arising from this are unlikely to be too large because land is difficult to hide from officials, and people need to register their interest to retain ownership rights (Perkins, 1969: 217). A more serious worry concerns the lack of a

standard measure for the *mu*, which varied between regions and over time, although much effort has been devoted to documenting this (Perkins, 1969: 218-221).

Figure 2 plots on a log scale the cultivated land area for the Northern Song, Ming and Qing dynasties, while Figure 3 plots the same data on a per capita basis. As will become clear later, cultivated land per capita plays an important role in determining overall living standards, since agriculture was the largest sector of the economy. Although the cultivated land area grew substantially over time, albeit with a major decline between the Northern Song and Ming dynasties and a smaller decline between the Ming and Qing dynasties, it did not keep pace with the growth of population so that cultivated land per capita declined over time from a peak of around 9 *mu* during the Northern Song dynasty to just 3 *mu* by the late Qing period. The decline during the eighteenth century is broadly consistent with Huang's (1985: 2002) process of involution, and would be hard to square with the positive assessment of Chinese development until the nineteenth century offered by California School writers such as Pomeranz (2000) and Wong (1997).

The distribution of the cultivated land area between crops is also available from official sources, and the shares of important crops in benchmark years are shown in Table 1. For the Northern Song dynasty, Xia Qi (2009) and Hui Wu (1985) suggest that 64% of the cultivated land area devoted to grain production was in southern China, used for growing rice, with the other 36% in north China used for growing wheat. They also suggest that 6% of the cultivated area was used for growing cash crops rather than grain. For the Ming dynasty, the breakdown between grain crops was 54.4% for rice and 45.6% for wheat (Songyi Guo, 2000). Yi Luo (1999) provides an assessment of the Qing crop distribution data against the detailed crop breakdown for 1914-1918 from Perkins (1969) and the 1952 data from the

Statistical Yearbook of China. Rice and wheat accounted for 56 per cent of the cultivated area in 1700, declining to 47 per cent by 1850, with corn, potatoes and cash crops all increasing their shares significantly.

Grain yield data are also taken from official sources. As noted earlier, there are difficulties of interpretation associated with the variation in the size of a *mu* over both space and time, but painstaking work by historians to deal with this problem has produced a consensus that grain yields increased over time (Xia Qi, 1999; Yi Luo, 1999; Perkins, 1969). However, this increase in grain yields was not sufficient to offset the decline in cultivated land per capita. During the Northern Song, wheat yields were stable at 210 *jin per mu*, while husked rice yields increased from 195 to 230 *jin per mu* (corresponding to an increase in unhusked rice yields from 390 to 460 *jin per mu*), with the introduction of high yielding champa rice (Ping-ti Ho, 1956). Average grain yields for wheat and husked rice rose during the Ming dynasty from 220 *jin per mu* in 1402 to 256 *jin per mu* by 1626, and during the Qing dynasty from 230 *jin per mu* in 1685 to 295 *jin per mu* in 1850.

Quantities of grain crops are obtained by multiplying grain yields with cultivated areas to yield the volume of gross output. These gross outputs are then multiplied by prices obtained from the work of modern economic historians, including Xia Qi (2009) for the Northern Song dynasty, and Xinwei Peng (1965) for the Ming and Qing dynasties. To derive the value of net output, it is necessary to subtract the value of agricultural inputs such as seed and fertiliser, which was assumed to account for 15 per cent of gross output, following Xing Fang (1996) and Yi Luo (1999). It should be noted that since the share of value added was held constant throughout the period, this adjustment does not affect the trend of agricultural output.

A number of cash crops, including cotton, soyabeans, rape, peanuts, tobacco, sugar cane, sugar beet and hemp, occupied cultivated land. The share of cultivated land occupied by cash crops, derived from official sources, rose from 6 per cent during the Northern Song dynasty to 8 per cent during the Qing dynasty, with the intermediate level of 7.65 per cent during the Ming dynasty being derived as a weighted average of 7 per cent in the northern dry farmland areas and 8.2 per cent in the southern paddy farmland areas. The value of cash crops per *mu* was set at 1.2 times the value of grain crops per *mu*, following the research of Yi Luo (1999). Other cash crops, such as tea and fruit, did not occupy cultivated land, but were important enough to have attracted the attention of officials, so that it is possible to reconstruct trends in output from the production side during the Northern Song and Ming dynasties, and from the consumption side during the Qing dynasty.

Subsidiary agricultural output included animal husbandry, fisheries and forestry. Although no data are available on the specific outputs, estimates of the ratio of subsidiary agricultural output values to the value of grain outputs are available for the twentieth century from Perkins (1969) and Guangshao Tu (1984). The ratio in earlier periods was picked to be consistent with the twentieth century data and a very small increase over time, from 10 per cent during the Northern Song and Ming dynasties to 12 per cent in the Qing dynasty.

Figure 4 plots indices of the main categories of agricultural production. The index for grain crops is the same as the index for subsidiary agricultural outputs during the Qing dynasty, since the latter is proportional to the output of grain crops. The two indices differ for earlier periods because the proportional share changes between dynasties. Although subsidiary agricultural output increased by more than population, grain output failed to keep

pace with population growth, so that agricultural output per head declined between the Northern Song and Qing periods.

5. INDUSTRIAL OUTPUT

Industrial output is estimated from official data on quantities produced in state-run industries, quantities purchased by the government in highly regulated industries and revenue raised from the taxation of less heavily regulated industries. Information is also available from gazetteers and private historical works, particularly where an industry was regionally concentrated. Many economic historians have worked on the original data to provide cross-checks and make up for the shortcomings of individual sources. Industry is divided into four main sectors: metals and mining; food processing; manufacturing; and building. As in agriculture, the basic approach is to obtain data on the volume and value of each output. In general, the gross output values are converted to a value added basis by using the ratio of inputs to outputs from Baosan Wu and Yusun Wang (1947) throughout the period. This adjustment to a value added basis therefore does not affect the trend of real growth, but rather pins down the level of GDP in current prices. In a number of cases such as rice wine and silver, however, the ratio of net to gross output values is taken directly from the historical literature of the time, as detailed in Appendix A2.

The metals and mining sector includes iron, gold, silver, copper, tin and lead. There have been numerous studies of the iron industry since the strong claims of Hartwell (1962) that China produced as much as 150,000 tons of iron in 1078. Many subsequent researchers argue that Hartwell seriously overestimated iron production in the Northern Song dynasty, and the estimates used here are taken from the work of Sen Liu (1993), obtained by aggregating the annual quantities of iron used for coining and government purchases. For the

Ming dynasty, the state-run iron industry was based mainly in Zunhua City and the output estimates are based on the official records. The private iron industry is tracked during this period using tax revenue, with the tax rate set at one-fifteenth of output. For the Qing dynasty, iron industry output is based on regional data for Guangdong, which became the centre of the iron mining and metallurgical industry. Longqian Li (1979) added estimates from other provinces to the Guangdong data to estimate the total volume of iron production. Information on other metals, such as gold, silver, copper, lead and tin is derived using similar methods from similar sources, as outlined in Appendix A2. The data clearly suggest that the output of the metals and mining sector was much lower during the Ming than during both the Northern Song and Qing dynasties. This seems to be largely the result of developments in the state-owned sector, where there was a sharp decline in both the production of weapons and the minting of coins. A famous politician and historian of the Ming dynasty, Qiujun, estimates that the Ming output of the metals and mining sector was about one to two tenths of the level of the previous dynasty (*Daxue Yanyi Bu, Vol. 29*, Shanze Zhili (profits from metals and mining)). The private sector could not offset such a sharp decline until the Qing dynasty, when the government gave up its prohibition of private production, and officials met imperial demand by purchasing metal products in the market.

Food processing is divided into four main sections covering rice wine; tea-processing; sugar; and other food-processing industries. Rice wine output in the Northern Song dynasty is derived by Huarui Li (2001) from the tax levy on rice wine production. During the Ming and Qing periods, by contrast, output is estimated from the demand side using per capita rice wine consumption estimates for benchmark years (Xing Fang et al., 2007; *Anwu Sizhong*, Vol, 26). Value added in the tea-processing industry is assumed to be 8 per cent of the value of the agricultural output of tea, in line with the ratio estimated by Zhongli Zhang (1987).

Sugar output is estimated for the Qing dynasty from provincial data on Taiwan, Guangdong and Fujian, where production was concentrated, with an allowance for other areas. For the Ming and Northern Song periods, value added in the sugar industry was assumed to be 50 per cent of that of the tea-processing industry, somewhat lower than the ratio of 70 per cent noted by Zhongli Zhang (1987) for the 1880s, when sugar was more widely used. Other food processing industries, including grain milling and seed crushing, are assumed to grow in line with agricultural output, following the approach of Broadberry, Campbell, Klein, Overton and van Leeuwen (2011; 2014) for England.

The key products covered by the manufacturing sector include: salt; silk cloth; cotton cloth; coinage; paper; porcelain; transport equipment, and other manufacturing industries. Salt output is taken from the study by Zhengzhong Guo (1997), who collected salt production data on a regional basis and aggregated it to the national level. Silk cloth output is derived from output data for the industry, which was divided between a state-managed sector and a private sector. Data for both sectors are taken from Jinmin Fan and Jin Wen (1993) for the Qing period and derived from regional data for the Ming period. For the Northern Song dynasty, silk output is estimated from the demand side using estimates of silk consumption per household (Zengyu Wang, 1983; Shengduo Wang, 1995). After the Yuan dynasty, cotton cloth replaced hemp fabric amongst the lower classes, so that cotton textiles became an important handicraft sector in the Ming and Qing dynasties. Output is estimated from the amount of labour engaged in cotton production, work time per labourer and labour productivity (Xinwu Xu, 1992). The coinage industry was significant during the Northern Song dynasty but negligible in the Ming and Qing dynasties. Historical sources suggest that value added in the coinage industry was 40 per cent of the value of the coinage in the early Northern Song dynasty, declining to 30 per cent by the later stages (*Xiaochu Ji*, Vol. 17;

Wenxian Tongkao Qianbi Kao). The output of the paper industry is estimated during the Northern Song dynasty by aggregating the amount of paper transported from different regions to the central government. For later periods, it is assumed to maintain the same share of manufacturing output as in the 1880s (i.e. to grow at the same rate as manufacturing as a whole). This is equivalent to the standard procedure in economic history of constructing an industrial production index form a weighted sample of industries. Porcelain output during the Northern Song dynasty is based on the work of Jilang Su (1997), who estimated profits and costs of porcelain production in South Fujian and Guangdong province, which accounted for half of total production in China. For the Ming dynasty, porcelain production is estimated separately for the government and private sectors, while for the Qing period, estimates for Jingdezhen are available from Miaotai Liang (1991). Transport equipment and other manufacturing (fur products, metalware, furniture, clothing, stationery and decorations) are assumed to have grown at the same rate as manufacturing as a whole. This is the same, assumption as made for paper during the Ming and Qing dynasties, so that these industries are included in the level of value added, but do not distort the rate of growth.

Building is assumed to grow in line with population, but with an allowance for urbanization. This follows the procedure of Broadberry, Campbell, Klein, Overton and van Leeuwen (2011; 2014) in the estimation of English economic growth, 1270-1700. The population and urbanization data are taken from Jianxiong Ge and Songdi Wu (2005) for the Northern Song dynasty and from Shuji Cao (2005) for the Ming and Qing dynasties.

Indices of industrial production for the four main sectors are plotted in Figure 5. Manufacturing, food processing and building all grew rapidly within the Northern Song, Ming and Qing dynasties, but with some setback across the dynastic changes. Output in

metals and mining followed a more volatile path with a burst of rapid growth during the mid-Song period, followed by a period of stagnation after 1078. As noted by Hartwell (1962; 1966; 1967), the boom was driven by iron. Metals and mining remained depressed during the Ming dynasty, before picking up again during the Qing dynasty, with a particularly rapid growth phase during the eighteenth century.

6. SERVICE SECTOR OUTPUT

The service sector has received much less attention from economic historians than agriculture and industry. Following Broadberry, Campbell, Klein, Overton and van Leeuwen (2011), the service sector is broken down into four subsectors: commerce; finance; housing; and government. The output of the commercial and financial subsectors is estimated largely from data on marketed output and tax revenue raised from businessmen by the government. For other services, output is estimated largely through tracking the number of workers and the revenue per worker. Unlike agriculture and industry, where abundant data are available on the volume of output in real terms, the main measure of service sector output is derived in current price terms. In the next section, the ratio of service sector nominal output to the value of nominal output in agriculture and industry will be used to increase the real output of agriculture and industry proportionally, so as to arrive at a measure of real GDP. This implies a long run constancy in relative prices between services and commodities.[1]

The output of the commercial sector is estimated from data on the value of agricultural and industrial goods to be distributed. It is assumed that all industrial output was marketed, and the share of agricultural output marketed is taken from Hui Wu (1987). This

[1] Although there are continuous price series for many commodities, price data for services are much more sporadic. However, it is possible to show that house rents, which formed the largest component of expenditure on services, moved closely together with the price of grain, which formed the largest component of expenditure on commodities, during the Qing dynasty (Huanchun Hong, 1988). The more limited house rent data from the Northern Song dynasty are also consistent with this pattern (Minsheng Cheng, 2008).

series of gross marketed output is projected back from an 1840 benchmark estimate of GDP in commerce, derived using Zhongli Zhang's (1987) estimate of the ratio of GDP in commerce to GDP in agriculture and industry during the late Qing dynasty. The size of the financial sector during the Qing dynasty is estimated from data on pawn shops, benchmarked on the share of finance in services during the 1880s calculated by Zhongli Zhang (1987). The ratio from the 1880s is assumed to hold throughout the Ming and Northern Song dynasties. Following Broadberry, Campbell, Klein, Overton and van Leeuwen (2011), it is assumed that housing and domestic service grew in line with population, with an allowance for urbanisation. The total population is decomposed into rural and urban population according to the urbanisation rate and divided by the average family size to determine the numbers of households. The number of households is then multiplied by the average rent in rural and urban areas respectively, to determine the total housing rent (Xing Fang, 1996: 92; Huanchun Hong, 1988: 271-274, 646-647).

Data on the shares of the main service sectors in total service sector output are shown in Figure 6. The most significant long term trend was the decline in the share of government, which was offset by a growing share of commerce and housing, with the share of finance remaining stable.

7. NOMINAL AND REAL GDP AND PER CAPITA REAL GDP

7.1 Constructing the estimates

Sections 4 to 6 have described how the net output of the agricultural, industrial, and service sectors has been derived. In the agricultural and industrial sectors, the general approach has been to establish the quantity of each product, together with the value of net output in current prices. Aggregating across all sectors produces an estimate of nominal GDP in agriculture

and industry during the three dynasties. The next step is to arrive at an estimate of agricultural and industrial GDP in real terms. Using 1840 as the benchmark year, for all years the quantity of each product is multiplied by the 1840 price, with the same proportional adjustment for net output as a share of gross output, to arrive at net output in 1840 prices. Aggregating across all sectors produces real agricultural and industrial GDP in 1840 prices.

However, this approach cannot be applied to the service sector, where although the current price value of net output is available, obtained from revenue data, there are no data on output volumes or unit prices of individual services. The approach used here has been to take the ratio of nominal GDP in services to nominal GDP in agriculture and industry for each year between 980 and 1840. This ratio has then been applied to the real GDP of the agricultural and industrial sectors to estimate aggregate real GDP. As noted earlier, this implies a long run constancy in relative prices between services and commodities.

Figures 7 and 8 show nominal and real GDP of the Northern Song, Ming and Qing dynasties. It is also interesting to put the real GDP data from Figure 8 together with the population data from Figure 1 to derive real GDP per capita in Figure 9, since real GDP per capita is the most widely used indicator of the level of material living standards over the long run.

7.2 Comparing the Northern Song, Ming and Qing dynasties

This section sheds light on the long term evolution of the Chinese economy between 980 and 1840 by comparing the growth rate of GDP and the average level of GDP per capita during the three dynasties. Although China's territory expanded between the Northern Song and Ming dynasties, and expanded further between the Ming and Qing dynasties, it is

nevertheless useful to compare these three dynasties. First, most of the newly extended territory was sparsely populated, so that it did not have a particularly large effect on the aggregate volume of economic activity. Second, our main concern is with GDP per capita, which was affected even less by territorial changes. The average annual growth rate of real GDP during the Northern Song, Ming and Qing dynasties was 0.90%, 0.35%, and 0.58%, respectively, although there were also sharp falls in the level of real GDP across dynastic changes. Population outpaced real GDP over the long run, so that GDP per capita trended downwards. In constant 1840 prices, GDP per capita during the Northern Song dynasty averaged 26.5 taels, falling to 19.8 taels in the Ming dynasty and 14.2 taels in the Qing dynasty. Per capita incomes were thus around three-quarters of the average Northern Song level during the Ming dynasty, and had fallen further to just 54 per cent of the Northern Song level during the Qing dynasty.

This general pattern of economic decline since the Northern Song dynasty is broadly consistent with much of the literature on Chinese economic performance before the recent revisionist work of the California School. The traditional view of peak Chinese performance during the Northern Song dynasty is reflected in the work of economic historians such as Robert Hartwell (1966), Mark Elvin (1973) and Karl August Wittfogel (1957), and can also be seen as consistent with the view of Chinese science expressed by Joseph Needham (1954). The very different pattern of long run Chinese economic performance proposed by California School writers such as Kenneth Pomeranz (2000) and Bin Wong (1997), who deny any divergence between China and the West before the nineteenth century, will be examined critically in the next section. Before moving on to that, however, it is worth noting that there is also some contrast with the pattern in Maddison (1998), who produced "guesstimates"

showing per capita GDP rising from $450 in 1990 international prices to $600 during the Northern Song dynasty, before stagnating at $600 until the nineteenth century.

In understanding the reasons for the higher level of GDP per capita during the Northern Song dynasty, and the subsequent decline in living standards, it is important to bear in mind the large share of agriculture in economic activity, which can be seen in Figure 10. The share of agriculture in current price GDP increased from 63.1% in the Northern Song to 74.5% in the Ming before falling back slightly to 67.8% in the Qing dynasty, when it was still higher than during the Northern Song. Given the decline in the cultivated land per capita in Figure 3, and the failure of grain yields to rise sufficiently to offset this over time, this led inevitably to a decline in living standards over time. This represents what Huang (2002) calls a process of involution, with population expansion leading to a growing division of land holdings, driving down living standards towards bare bones subsistence.

8. THE GREAT DIVERGENCE

8.1 Comparing Britain and China

It is possible to compare the new GDP per capita estimates for China with the British estimates from Broadberry, Campbell, Klein Overton and van Leeuwen (2011). However, to do so requires converting the estimates for both countries into a common currency. Following the work of Maddison (2001, 2010), this is usually done in terms of 1990 international dollars. As well as presenting their series for Britain in terms of constant 1700 pounds sterling, Broadberry, Campbell, Klein Overton and van Leeuwen (2011) also report figures in 1990 international dollars, converting Maddison's (2010) figure for 1850 from a United Kingdom to a Great Britain basis. If we can establish Chinese GDP per capita as a proportion

of British GDP per capita in the mid-nineteenth century, we can thus arrive at a figure for Chinese GDP per capita in 1990 international dollars.

We have data for nominal GDP per capita in 1840 in both countries and prices for a number of important commodities, which can be used to convert the nominal GDP per capita comparison to real terms. Table 2 sets out the 1840 price data for seven commodities, which can be grouped into categories covering food and non-food items, with the former divided between unprocessed grain products (wheat and rice) and more processed foods (sugar, tea and salt). The non-food commodities cover textiles (cotton cloth) and metals (bar iron). Sources are listed in the notes to the table. Weights are based on Feinstein (1995) and Horrell, Humphries and Weale (1994) for Britain, adapted for China to reflect the importance of rice production. Details are again given in the notes to the table. Using British weights, the appropriate price ratio or purchasing power parity (PPP) in 1840 is £1 = 2.11 tael, while at Chinese weights the PPP is £1 = 1.96 tael. Taking the geometric mean of British and Chinese weights, the Fisher index PPP is £1 = 2.03 tael. The nominal exchange rate in 1840, given by the silver weight of the tael compared to the pound sterling was £1 = 3.20 tael. The PPP was therefore substantially below the exchange rate, as found by Allen (2009: 540-543) for the Yangzi Delta in 1820. Note, however, that the PPP was substantially lower for food (£1 = 1.53 tael) than for non-food commodities, where the PPP was close to the exchange rate (£1 = 3.04 tael). This is again something which Allen (2009: 541) found for the Yangzi Delta in 1820, and is explained by the possibility of arbitrage in tradable commodities. Food can be treated as effectively non-tradable because of the high cost of transporting low value but bulky items.

Table 3 provides an estimate of Chinese GDP per capita in 1840 benchmarked on Great Britain. Nominal GDP and population are taken directly from this study for China and from Broadberry, Campbell, Klein, Overton and van Leeuwen (2011) for Britain. At the silver exchange rate, Chinese GDP per capita was only 14.95 per cent of the British level. However, allowing for the lower price level in China by using the PPP suggests that Chinese GDP per capita was 23.57 per cent of the British level. Taking the 1840 level of British GDP per capita in 1990 international dollars as $2,521, from Broadberry, Campbell, Klein, Overton and van Leeuwen (2011) and Chinese GDP per capita in that year as 23.57 per cent of the British level, suggests a figure for Chinese GDP per capita in 1990 international dollars of $594. This is reassuringly close to the figure of $600 suggested by Maddison (2010) for 1850.

Table 4 presents the GDP per capita series for both China and Britain for the long period 980-1850. These estimates suggest that Northern Song China was substantially richer than Britain at around the time of the Domesday Book in the late eleventh century. However, per capita incomes declined in China during the later years of the Northern Song dynasty and remained at this lower level after the Mongol Interlude. With per capita incomes rising in Britain after the Black Death of 1348 and the recurrent plague outbreaks had significantly reduced population, Britain was already ahead by the first half of the fifteenth century. Per capita incomes stagnated in both China and Britain during the Ming dynasty, so that China's per capita income fluctuated around 90 per cent of the British level. China then fell further behind during the Qing dynasty as per capita incomes declined in China and incomes started to increase rapidly in Britain from the mid-seventeenth century. By the mid-nineteenth century, Chinese per capita GDP was just 20 per cent of the British level.

8.2 The Little Divergence within Europe

So far, we have compared China only with Britain. However, Britain was a relatively poor part of Europe in the eleventh century and a relatively rich part by 1850, as can be seen in the new estimates of GDP per capita presented in Table 5. Before the Black Death struck in 1348, per capita incomes were substantially higher in Italy and Spain than in England and Holland. There then followed a substantial reversal of fortunes between the North Sea Area and Mediterranean Europe, so that by 1800, per capita incomes were substantially higher in Britain and the Netherlands than in Italy and Spain. This “Little Divergence” accompanied the “Great Divergence” between Europe and Asia.

8.3 Reversals of fortune within Asia

Table 6 also suggests a reversal of fortunes within Asia. Japan had very low levels of per capita GDP until 1450, but then experienced episodic growth of the kind seen in Britain and Holland. A phase of positive growth between 1450 and 1600 was followed by a plateau before a second phase of growth from the 1720s. Japan’s more rapid growth after the Meiji Restoration of 1868, which marked the first transition to modern economic growth in Asia, was therefore built on this earlier period of dynamism. By contrast, Chinese per capita GDP was on a downward trajectory from its high point during the Northern Song dynasty. On these estimates, Japan overtook China during the eighteenth century. Like China, India experienced declining GDP per capita from the Mughal peak under Akbar, circa 1600. Japan also pulled decisively ahead of India only during the eighteenth century.

8.4 The Great Divergence

The GDP per capita figures presented here suggest that China was richer than Britain in 1090. However, they also suggest that China was certainly poorer than Italy by 1300. During the

Ming dynasty, Chinese GDP per capita declined, so that by the early seventeenth century, despite still being the richest Asian country, China had already fallen substantially behind the leading West European economies in the North Sea Area. However, we need to be careful here, since a smaller region of China such as the Yangzi Delta may still have been on a par with the richest parts of the North Sea Area in 1500. For the Yangzi Delta to have been on a par with Holland in 1500 would only have required per capita incomes to have been around 32 per cent higher than in China as a whole, which is quite consistent with the scale of regional differences within China during the nineteenth century (Li and van Zanden, 2012).

But with the rise of Holland during its Golden Age, 1570-1650, and Great Britain from the mid-seventeenth century, there can be little doubt that the Great Divergence was already well underway before the Industrial Revolution of the eighteenth century. By this stage, the discrepancies between the aggregate per capita income levels for China and the leading North Sea Area economies were surely too large to be bridged by regional variation within China. It is worth noting that Pomeranz (2011) now accepts that his earlier claim of China on a par with Europe as late as 1800 was exaggerated, and he now settles for the earlier date of 1700.

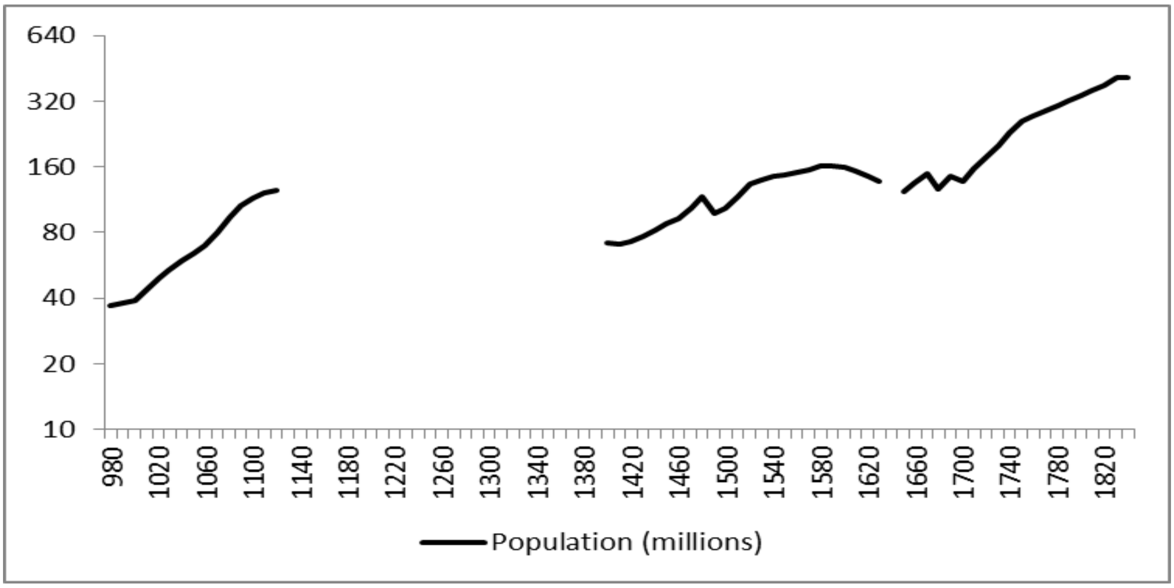
9. CONCLUDING COMMENTS

This paper provides estimates of Chinese GDP and relative standing in the world constructed from the output side between 980 and 1840, covering the Northern Song, Ming, and Qing dynasties. These GDP estimates are combined with population data to track the path of average living standards. China's GDP per capita reached its peak level during the Northern Song dynasty, before entering a long decline which lasted through the Ming and Qing dynasties. Per capita incomes were around three-quarters of the average Northern Song level

during the Ming dynasty, and had fallen further to just 54 per cent of Northern Song level during the Qing dynasty.

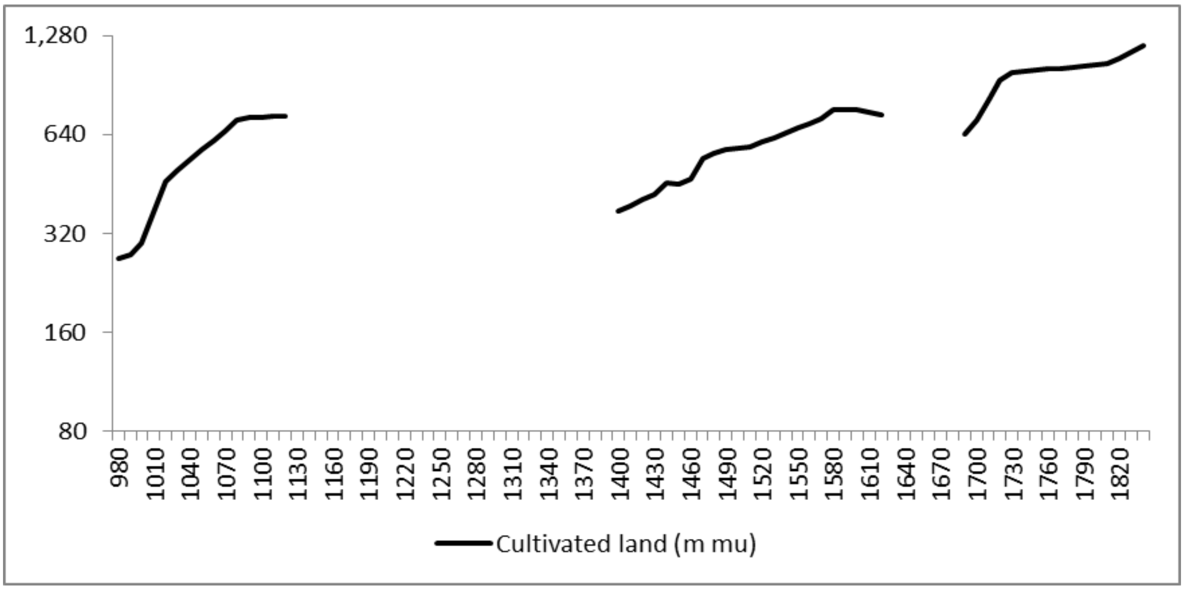
From an international perspective, Northern Song China was substantially richer than Domesday Britain in 1090, but by 1400 Britain had overtaken China. Although China led the world in living standard during the Northern Song dynasty, China had fallen behind Italy by 1300. At this point, however, and even until the seventeenth century, it is quite possible that a relatively rich Chinese region such as the Yangzi Delta was on a par with the most developed parts of Europe. But Chinese GDP per capita declined at the beginning of the Ming dynasty and then stagnated, so that by the beginning of the eighteenth century, the gap between China and the most developed parts of Europe was too large to be bridged by regional variation within China. Since China was still the richest Asian country at this time, it is therefore likely that Western Europe was ahead of Asia not just by the early nineteenth century, but already by the late seventeenth century.

FIGURE 1: Chinese population during the Northern Song, Ming and Qing dynasties (millions, log scale)



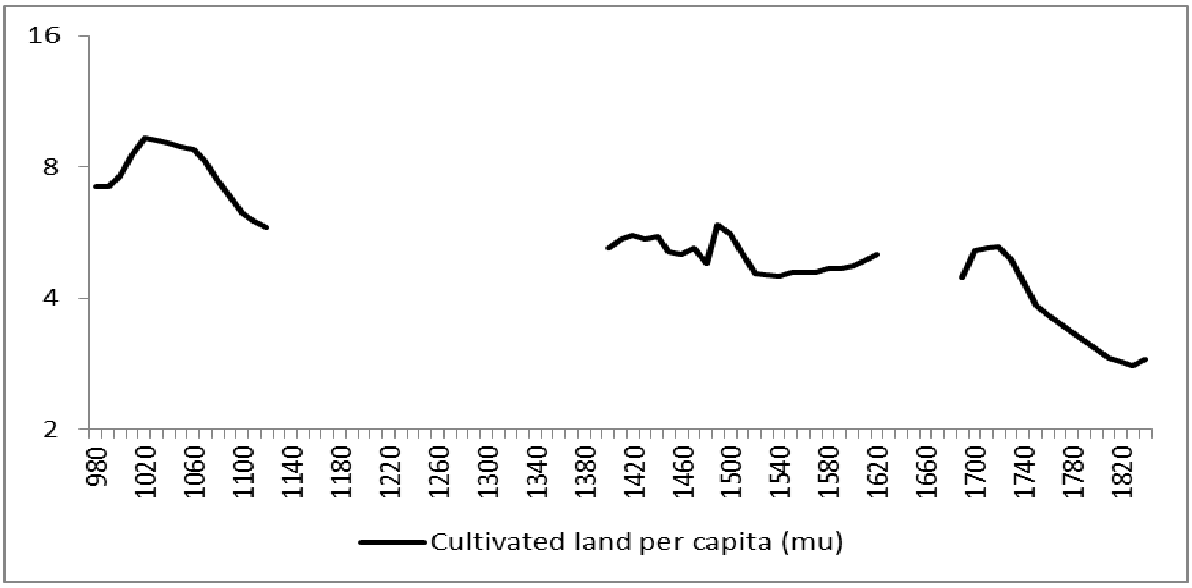
Sources: Jianxong Ge and Songdi Wu (2005); Liu and Hwang (1979).

FIGURE 2: Cultivated land of the Northern Song, Ming and Qing dynasties (million mu, log scale)



Sources: See Appendix A1 for a detailed discussion of sources and methods.

FIGURE 3: Cultivated land per capita of the Northern Song, Ming and Qing dynasties (mu, log scale)



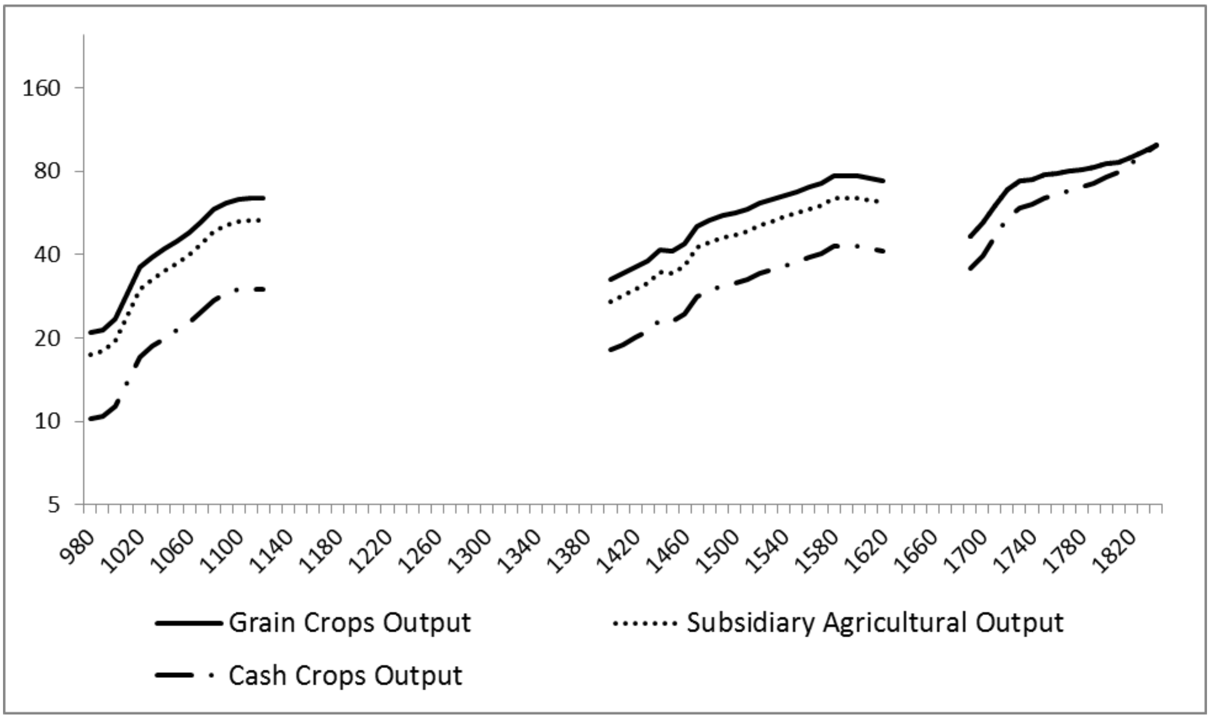
Sources: See Appendix A1 for a detailed discussion of sources and methods.

TABLE 1: Shares of important crops

	1000	1400	1700	1750	1800	1850
Rice	60.0	50.2	33.0	31.0	29.0	27.0
Wheat			23.0	22.0	21.0	20.0
Barley			7.0	7.2	7.3	7.2
Millet			8.0	8.2	8.4	8.2
Corn			0.0	1.2	2.3	3.5
Potatoes			0.5	0.5	0.8	1.2
Sorghum			8.1	8.3	8.4	8.3
Other crops	34.0	42.1	9.4	9.7	9.8	9.6
Cash crops	6.0	7.7	11.0	12.0	13.0	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

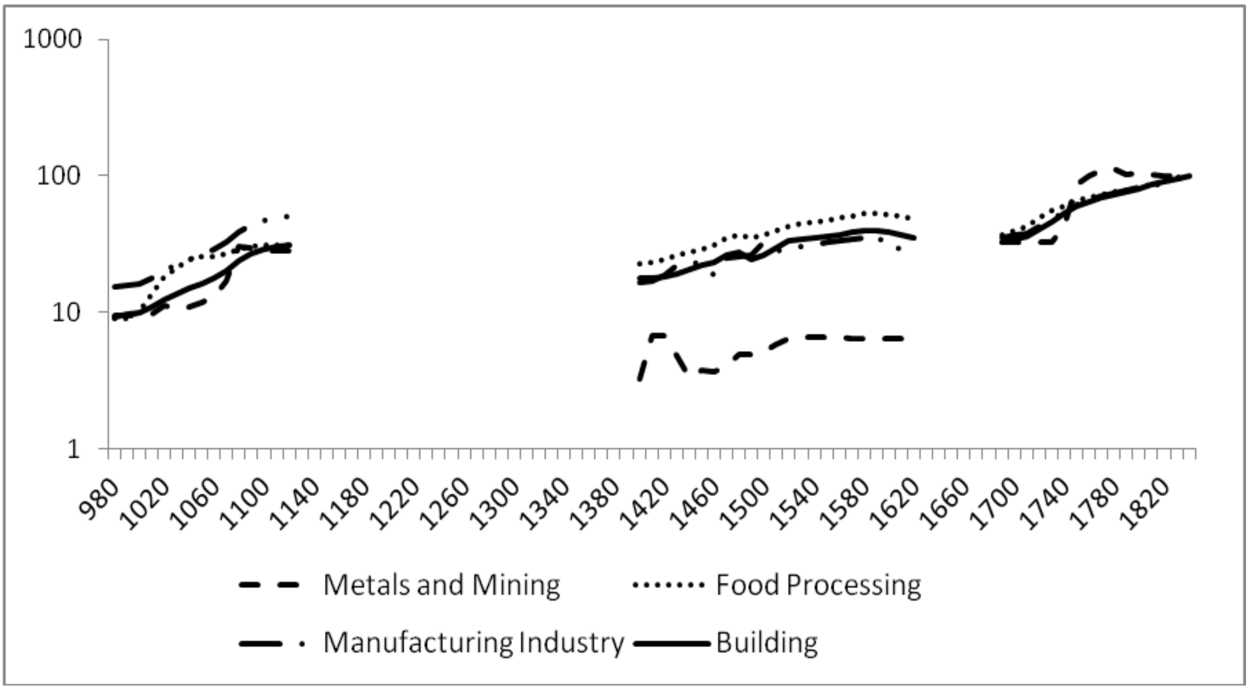
Sources: Hui Wu (1985); Songyi Guo (2000); Yi Luo (1999).

FIGURE 4: Indices of agricultural output (1840=100)



Sources and notes: See Appendix A1 for a detailed discussion of sources and methods. The index of grain crops is the same as subsidiary agriculture during the Qing dynasty, since subsidiary agricultural output is assumed proportional to the output of grain crops.

FIGURE 5: Indices of industrial output (1840=100)

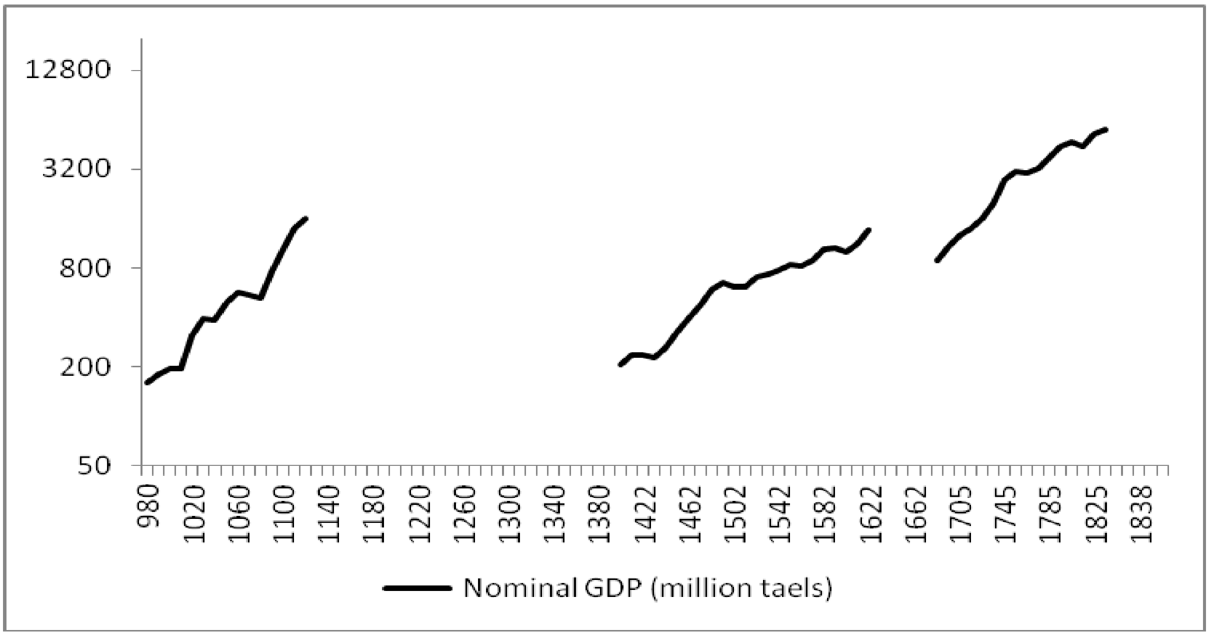


Sources: See Appendix A2.

FIGURE 6: Subsectoral shares of service sector output

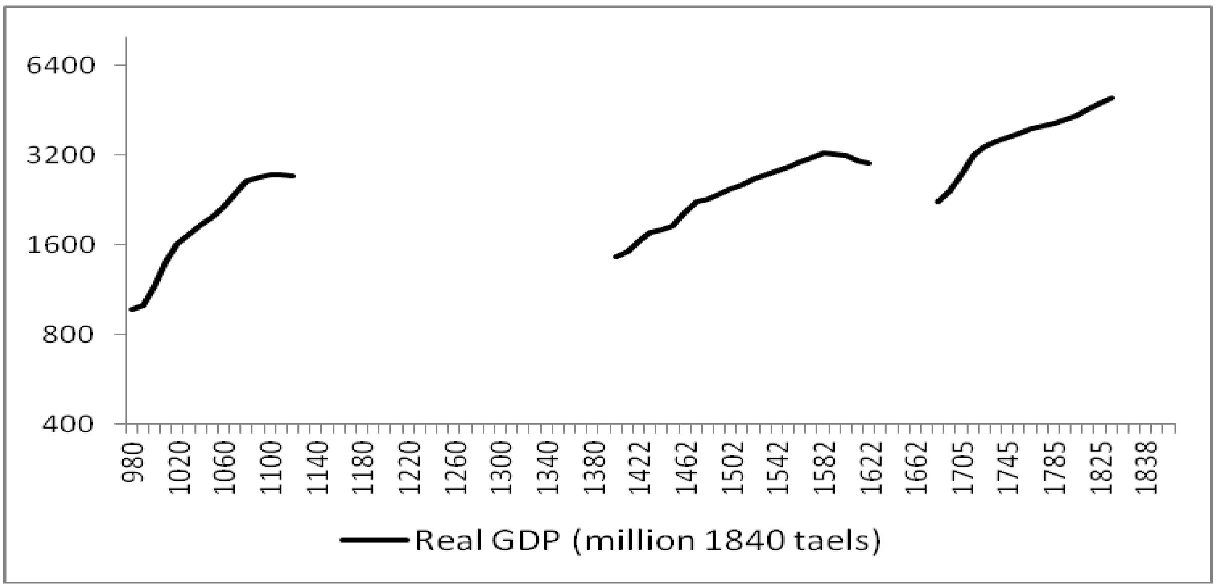
Sources: See Appendix A3.

FIGURE 7: Nominal GDP of the Northern Song, Ming and Qing dynasties (million silver taels, log scale)



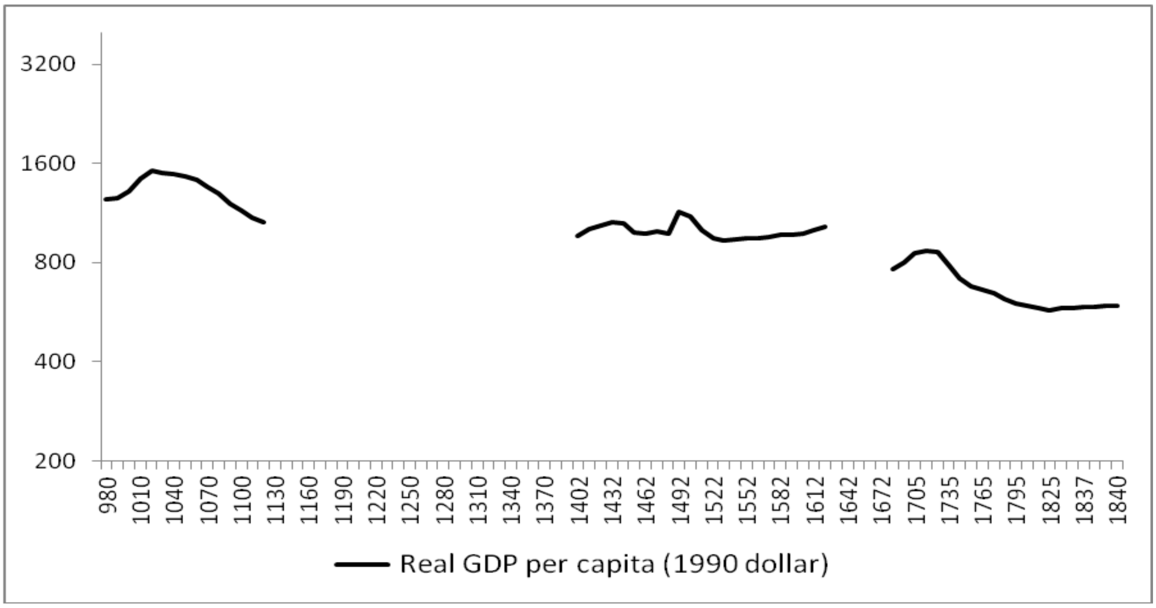
Sources: See Appendices A1 to A3.

FIGURE 8: Real GDP of the Northern Song, Ming and Qing dynasties (million 1840 taels, log scale)



Sources: See Appendices A1 to A3.

FIGURE 9: Real GDP per capita of the Northern Song, Ming and Qing dynasties (1990 international dollars, log scale)



Sources: See Appendices A1 to A3.

FIGURE 10: Agriculture's share of GDP during the Northern Song, Ming and Qing dynasties

See Appendix A1.

TABLE 2: A China/GB PPP for 1840

	China tael/lb	GB £ per lb	PPP Tael per £	Chinese weights	British weights
Rice	0.01407	0.02500	0.56	0.201	0.000
Wheat	0.00900	0.00691	1.30	0.134	0.335
Sugar	0.04900	0.02191	2.24	0.134	0.134
Tea	0.09347	0.13021	0.72	0.134	0.134
Salt	0.00544	0.00134	4.07	0.067	0.067
Cotton cloth	0.04195	0.00402	1.83	0.284	0.284
Iron	0.20690	0.11301	10.44	0.046	0.046
FOOD			1.53		
OTHER			3.04		
TOTAL			2.03		

Sources and notes:
GB:
Rice: Beveridge (1939: 433). The figure of 6s per 12 lb from the Lord Steward's Department actually refers to 1830.
Wheat: UK Board of Trade (1903: 70). The figure of 66s 4d per imperial quarter is taken originally from the *London Gazette*.
Sugar: UK Board of Trade (1903: 162). The average price per cwt unrefined sugar exclusive of duty.
Tea: UK Board of Trade (1903: 177). Average price per lb in bond.
Salt: UK Board of Trade (1903: 188). Data originally from Greenwich Hospital.
Iron: Mitchell (1988: 762). English merchant bar iron at Liverpool.
Cotton cloth: Mitchell (1988: 761). Average value of cotton piece goods exported, converted from yards to lb using 1840 ratio from Robson (1957: 331).
Weights: Based on Feinstein (1995) for the mid-nineteenth century. Food and non-food items have weights of 0.67 and 0.33, respectively. For the breakdown within food, Feinstein (1995) suggests that grain based products (wheat flour and bread) accounted for around half of expenditure on food. Thus wheat is given a weight of 0.335 and rice, which was prohibitively expensive, has a weight of zero. The remaining expenditure on food has been allocated across sugar, tea and salt, with equal weights for sugar and tea and a smaller weight for salt, again broadly consistent with budget studies. Within non-food, the breakdown between cotton and iron is in proportion to the value added in these two industries, from Horrell et al. (1994).
China:
Rice: Xinwei Peng (1965: 850).
Wheat: *Zheng Guangzu* (1990).
Sugar: Fu Chongju (1987).
Tea: Xiangao Yao (1962, vol 1: 582), based on export prices.
Salt: *Qingshi Gao, Shihuozhi Yanfa*.
Iron: Kong (1981: 509, 527), wrought iron.
Cotton cloth: Xiangao Yao (1962, vol 1: 557, 616), based on export prices.
Weights: The weights are the same as for Britain, apart from an allowance within food for rice, based on the late-Qing ratio between wheat and rice production (30:20). Within non-food, the breakdown between cotton and iron is broadly consistent with the late-Qing shares of value added in textiles and metals production.

TABLE 3: A benchmark estimate of China/GB GDP per capita in 1840

China	
Nominal GDP (million tael)	5,337
Population (million)	412
GDP per capita (tael)	12.95
England	
Nominal GDP (£ million)	496.30
Population (million)	18.332
GDP per capita (£)	27.07
Exchange rates	
Silver exchange rate (tael per £)	3.20
PPP (tael per £)	2.03
Comparative China/GB GDP per capita (%)	
At silver exchange rate	14.95
At PPP	23.57
GDP in 1990 international dollars	
GB	2,521
China	594

Sources and notes: Nominal GDP and population from Figures 1 and 7 for China, and from Broadberry, Campbell, Klein, Overton and van Leeuwen (2011) for Britain. Silver exchange rate derived from the silver weight of the tael and pound sterling from van Glahn (1996: 133) and Craig (1953), respectively. PPP from Table 2. GDP for Britain in 1990 international dollars from Broadberry, Campbell, Klein, Overton and van Leeuwen (2011).

TABLE 4: GDP per capita levels in China and Britain (1990 international dollars)

	China ($1990)	GB ($1990)	China/GB (GB=100)
980	1,247		
1020	1,518		
1050	1,458		
1090	1,204	754	159.7
1120	1,063		
1270		759	
1300		755	
1400	960	1,090	88.1
1450	983	1,055	93.2
1500	1,127	1,114	101.2
1570	968	1,143	84.7
1600	977	1,123	87.0
1650		1,110	
1700	841	1,563	53.8
1750	685	1,710	40.1
1800	597	2,080	28.7
1840	594	2,521	23.6
1850	594	2,997	19.8

Sources and notes: GB: Broadberry, Campbell, Klein, Overton and van Leeuwen (2011); Walker (2012). China: Figure 9.

TABLE 5: GDP per capita levels in Europe (1990 international dollars)

	England/ GB	Holland/ NL	Italy	Spain
1270	759			957
1300	755		1,482	957
1348	777	876	1,376	1,030
1400	1,090	1,245	1,601	885
1450	1,055	1,432	1,668	889
1500	1,114	1,483	1,403	889
1570	1,143	1,783	1,337	990
1600	1,123	2,372	1,244	944
1650	1,100	2,171	1,271	820
1700	1,630	2,403	1,350	880
	1,563			
1750	1,710	2,440	1,403	910
1800	2,080	2,617	1,244	962
		1,752		
1820	2,133	1,953	1,376	1,087
1850	2,997	2,397	1,350	1,144

Sources and notes: England/Great Britain: Broadberry, Campbell, Klein, Overton and van Leeuwen (2011). The data refer to the territory of England before 1700 and Great Britain after 1700; Holland/Netherlands: van Zanden and van Leuwen (2012). The data refer to Holland before 1800 and the Netherlands after 1800; Italy: Malanima (2011); Spain: Álvarez-Nogal and Prados de la Escosura (2013).

TABLE 6: GDP per capita levels in Europe and Asia (1990 international dollars)

	England/ GB	Holland/ NL	Italy	Japan	China	India
730				551		
900				476		
980					1,247	
1020					1,518	
1050					1,458	
1090	754				1,204	
1120					1,063	
1150				508		
1280	679			552		
1300	755		1,482			
1400	1,090	1,245	1,601		960	
1450	1,055	1,432	1,668	552	983	
1500	1,114	1,483	1,403		1,127	
1570	1,143	1,783	1,337		968	
1600	1,123	2,372	1,244	605	977	682
1650	<u>1,110</u>	2,171	1,271	619		638
1700	1,563	2,403	1,350	597	841	622
1750	1,710	<u>2,440</u>	1,403	622	685	573
1800	2,080	1,752	1,244	703	597	569
1850	2,997	2,397	1,350	777	594	556

Sources: GB: Broadberry, Campbell, Klein, Overton and van Leeuwen (2011); Walker (2012); Holland/Netherlands: van Zanden and van Leuwen (2012); Italy: Malanima (2011); China: Figure 9; Japan: Bassino, Broadberry, Fukao, Gupta and Takashima (2014); India: Broadberry, Custodis and Gupta (2014).

APPENDIX 1: DATA SOURCES AND METHODS

A1 AGRICULTURE

A1.1 Grain Crops

A1.1.1 Northern Song grain crops

For the amount of cultivated land, we can find the official statistics of 976, 997, 1021, 1051, 1066 and 1083 from *Wenxian Tongkao, Tianfu kao, Lidai Tianfu Zhizhi*[2] and *Songshi, Shihuo Zhi, Nongtian*[3]. However, due to the fiscal reform of "the law of two kinds of taxes", land tax revenue was based on the reported amount of land. As a result, the actual amount of cultivated land was under-reported for tax evasion purposes during the middle and late periods of the Northern Song. For example, Xia Qi (2009) finds that the actual amount of cultivated land was far greater than the official amount after 1051. Therefore, we follow Xia Qi's method to derive the actual amount of cultivated land during the middle and last stages.

Grain yield per *mu* is available mainly from *Song Huiyao Jigao, Shihuo* and *Xu Zizhi Tongjian Changbian*. Here, we use the average country level estimates from Xia Qi (2009) and Hui Wu (1985). Grain yields were generally higher in Southern China than in Northern China, while Eastern China had higher yields than Western China. Looking at the entire Northern Song period, the grain yield per *mu* increased gradually. According to the data from Xia Qi (2009) and Hui Wu (1985), Southern China accounted for 64% of the total cultivated land and Northern China for the remaining 36%. They also estimate that 6% of total cultivated land was occupied by cash crops rather than grain crops. The yield of the cash crops was generally higher than that of the grain crops, as will be discussed in detail later.

For both Southern China and Northern China, the amount of cultivated land is multiplied by the grain yield per *mu* to arrive at grain output for each year, with separate calculations for the two regions. The regional estimates are then aggregated to arrive at annual estimates of the grain output of China as a whole. The price series of various grain crops are taken from Xia Qi (2009) and Hansheng Quan **(**1991**),** both of whom estimate the price series of rice and wheat, and argue that the prices of other crops (such as millet and beans) are similar to the price of wheat. Using grain production multiplied by the price of the different crops, produces annual estimates of the value of grain output. To derive the value of net output in the grain producing sector, it is necessary to subtract the value of agricultural inputs such as seed and fertilizer, which was set at around 15%, following the research of Xing Fang (1996) and Yi Luo (1999).

A1.1.2 Ming grain crops

The amount of cultivated land after 1400 can be derived at a 10-year frequency from the data of Paul K. C. Liu and Kuo-shu Hwang (1977), and interpolated to arrive at annual estimates. Grain yield per *mu* is derived by Songyi Guo (2000) from a sample of land rent rate data, covering 37 southern rice areas and 8 northern wheat areas, based on three different grades of land (high, middle, and low).

Xinwei Peng **(**1965**)** records the price series of rice measured in silver throughout the Ming dynasty based on a 10-year frequency. Data on the price of wheat are more limited for this period, but suggest a price of around 80% of the price of rice. By taking the shares of rice and

[2] Examinations of the historical literature, especially concerning the land tax and land tax institutions of every dynasty.

[3] History of the Song Dynasty, Notes on economic activities, Land used by Agriculture.

wheat in the total cultivated land area, and multiplying by the price of rice and wheat respectively, it is possible to arrive at the value of gross output. Net output is then derived by subtracting around 18% of the gross value to account for agricultural inputs such as seed and fertilizer.

A1.1.3 Qing grain crops

The amount of cultivated land is taken from Yi Luo (1999) for 1685 and 1700; from Zhihong Shi (2001) for 1724 and 1850; and from Songyi Guo (2000) for 1812. Starting from the distribution of the main crops in 1914-1918 (Perkins, 1969)[4] and the crop distribution data[5] in 1952, Yi Luo (1999) provides estimates of the geographical distribution of many important crops during the Qing dynasty, shown in Table 1.

Recent research suggests that the grain yield per *mu* increased gradually during the Qing dynasty (Yi Luo, 1999). Grain output is derived by multiplying these grain yields by the cultivated land area. Multiplying these estimates by the price of grain crops then yields output values. Grain crop prices during the Qing dynasty are taken from the work of Xinwei Peng (1965), Hansheng Quan (1991) and Yeh-chien Wang (2003) for rice, and from Guangzu Zheng's ''Yibanlu" (2003) and Yi Luo (1999) for other crops. Net output is derived by subtracting 18% of the gross value to account for agricultural inputs such as seed and fertilizer (Yi Luo, 1999).

A1.2 Cash Crops

A1.2.1 Northern Song cash crops

Although some cash crops occupy cultivated land, others do not. The amount of cultivated land occupied by cash crops was about 6% of the total cultivated land. Based on research by Yi Luo, (1999) the value of cash crops per *mu* was about 1.2 times the average value of the grain crops per mu[6]. The output value of the cash crops is thus obtained by multiplying the amount of cultivated land used for cash crops by the yield per *mu*.

Other cash crops, such as tea and fruit, which do not occupy cultivated land, were important agricultural products during the Northern Song. There are numerous official tea purchasing records throughout the Northern Song, when tea production was strictly regulated by the government. There was also a large amount of "private tea", which is taken into consideration by referencing Hongsheng Sun's (1986) research. Because of the big price gap between different grades of tea, the average price is used to calculate the total output value of the tea industry, following the work of Jinfang Ge (2008) and Minsheng Cheng (2008). According to Baosan Wu and Yusan Wang (1947), the net value of tea is around 85% of the gross value.

A1.2.2 Ming cash crops

---

[4] Perkins used data from the Republic of China Agricultural Bureau of Investigation to calculate the crop distribution in 1914-1918.

[5] See *Statistical Yearbook of China*,1952.

[6] Ruizhong Liu (1986) estimates the value of cash crops per *mu* to be about 2 times the average value of the grain crops per *mu*. Yi Luo (1999) argues that the return from cash crops could not have been much higher than this since when a high return cash crop was introduced in a particular area, although there may have been specific geographical factors in some cases, it would typically diffuse to other areas, thus reducing the return from cash crops close to the return from grain crops within a short period of time. He argues that 1.2 times is more reasonable, and we use this value in our calculations. Philip Huang (1985) has also researched this phenomenon.

Northern dry farmland and southern paddy farmland accounted for 45.6% and 54.4% of the total cultivated land area, respectively. The proportion of cultivated land used for cash crops was 7% on the northern dry farmland, and 8.2% on the southern paddy farmland, so cash crops accounted for 7.65% of the total cultivated land. As in the Northern Song dynasty, the average value of cash crops (such as cotton, soybeans, rape, peanut, tobacco, sugar cane, beet, hemp, maintains, etc.) per *mu* on cultivated land was about 1.2 times the average value of grain crops per *mu*. Multiplying this cash crop yield per *mu* by the amount of cultivated land for cash crops yields the total value of gross output for cash crops on the cultivated land. The production of tea, which did not occupy cultivated land, can be constructed from the consumption side. Per capita tea consumption during the Ming dynasty was assumed to be the average of the Northern Song and Qing dynasties, and this was multiplied by population to arrive at total consumption, which was assumed to be equal to production. As a result of limited information, it is not possible to calculate the value of other cash crops not occupying cultivated land, such as fruits.

A1.2.3 Qing cash crops

During the Qing Dynasty, the average value per *mu* of cash crops on cultivated land is assumed to be 1.2 times the average level of grain crops, and the cultivated land for cash crops accounts for 11-15% of the total cultivated land. Other cash crops that did not occupy cultivated land, including tea, fruits, etc., were also important. In particular, the production of tea increased sharply during the Qing dynasty. Based on the records in *Qing Shilu*, it is possible to estimate the domestic consumption of tea, which amounts to 1.5 to 1.8 million Jin[7] per year both before and during the middle period of the Kangxi Emperor and 2.5 to 3.4 million Jin per year from the late period of the Kangxi Emperor to the period of the Yongzheng Emperor, and climbing to 6.9 million Jin per year during the reigns of the Qianlong and the Jiaqing Emperors. Besides the amount of tea consumed domestically, the amount of tea produced for export can also be taken into account. China exported about 40 to 50 thousand Dan [8] per year after 1760. The total production of tea each year is estimated by adding total exports to domestic consumption. The value of tea output is then obtained by multiplying the volume of output by the price of tea with reference to the work of Wenxi Tan (1994) and Miantang Huang (2008). Net output of tea amounted to 85 % of the gross value in 1933, according to Baosan Wu and Yusan Wang (1947). Since tea was a labour intensive crop without rapid technological progress, this ratio was assumed stable from the Northern Song to the Qing dynasty.

A1.3 Subsidiary Agricultural Output

Subsidiary agriculture includes animal husbandry, fisheries, forestry, and other sidelines. According to Perkins (1969), from 1914 to 1918, the output value of livestock raising[9] was equivalent to 11.2% of the output value of grain crops in China. Guangshao Tu (1984) argues that the output value of the subsidiary agricultural industries accounted for 19.6% of the output value of grain crops in the 1930s. In this paper, the ratio of the value of subsidiary agricultural outputs to the value of grain crops is assumed to be 10% during the Northern Song and the Ming, and 12% during the Qing dynasty.

A2 INDUSTRIAL OUTPUT

A2.1 Metal and Mining Industries

[7] Jin: a unit of weight in ancient China, 1 Jin=500 grams.
[8] Dan: a unit of weight in ancient China, 1 Dan=100 Jin.
[9] Not including poultry, fisheries, and forestry.

A2.1.1 Northern Song metals and mining

The most accessible data on the mining and metallurgical industries of ancient China are the quantities purchased by the government, called *ke e(r)* or tax quota. Since the iron industry is very important to the national economy, there are numerous studies of the production of iron, which can be used for reference. For other minerals, the *ke e(r)* is used to calculate the output value.

Hartwell (1962) claims that the amount of iron produced in China was about 75,000 to 150,000 tons in 1078. Many subsequent researchers argue that Hartwell seriously overestimated iron production. Sen Liu (1993) provides alternative estimates of the output of iron by aggregating the annual quantities of iron used for coinage and the *ke e(r)*, with an allowance for iron used in daily life and for making tools. Sen Liu's (1993) estimates are used here.

For other metals, such as gold, silver, copper, lead and tin, the volume of output is estimated from the *ke e(r)*, following the research of Lingling Wang (2005) and Shengduo Wang (1995), based on the original data from *Xu Zizhi Tongjian Changbian*, *Wenxian Tongkao*, *Song Huiyao Jigao*. Because of the government's strict regulation of the production of copper and tin, which were used for minting in the Northern Song, the gap between real output and the *ke e(r)* of every year is very small, but the gap for gold and silver is a little larger. For the period 1078-1125, the original data show too steep a decline because they cover only the southern area of Northern Song China. For gold, silver, copper, lead and tin, output has been held constant after 1078. For iron, Sen Liu's (1993) data exclude Sichuan, for which a separate estimate has been made.

The price series of gold and silver are taken from Shige Kato (2006), Xia Qi (2009), Shengduo Wang (1995) and Wencheng Wang (2001). The price of iron is taken from Lingling Wang (2005) and Minsheng Cheng (2008), while the price series of copper, tin, lead, vitriol and cinnabar are from Minsheng Cheng (2008). The production of the vitriol industry can be constructed from the relevant records of *Song Huiyao, Shihuo*; *Songshi, Shihuozhi*; *Wenxian Tongkao*.

Since few data are available for the Northern Song coal industry, the value of coal output is estimated on the assumption that the ratio of coal output to iron output was the same during the Northern Song as during the Ming dynasty. Yinxing Song (1954) established that coal accounted for 70 per cent of the fuel used in the Northern Song iron industry, while the share of fuel in costs is assumed to be the same as Baosan Wu and Yusun Wang (1947) found for 1933. Coal used in porcelain and salt is estimated to be one third of the level used in iron production.

A2.1.2 Ming metals and mining

Silver was used universally as currency at the beginning of the Ming dynasty, but the production data are limited. The production of silver is determined from the official tax records of the silver mining industry. For the Ming dynasty, the tax rate on the silver mining industry was around 30%, which was levied on the amount of silver produced. The output value of the silver mining industry during the Ming dynasty can thus be estimated from the tax revenue of *Ming Shilu*.

The state-run iron industry was mainly in Zunhua City, and the production of the state-run iron industry can be derived from the official records. The production of the private iron

industry can be calculated from the tax revenue, which can be found in *Ming Shilu*; *Daming Huidian, Vol.194*; and *Guangdong Tongzhi Chugao of Jiajing Empero*(Qichen Huang, 1989). For the Ming dynasty, the tax rate on the iron mining industry was always 6.66% or 1/15th of total output.

Information on the production of coal during the Ming dynasty is limited. In *Tiangong Kaiwu*, a famous encyclopedia for manufacturing and technology in ancient China, Yingxing Song mentions that 70% of the fuel used for smelting iron was coal. It is therefore possible to calculate roughly the production value of coal from the production of iron, given information on the share of fuel in total costs. Other metal mining industries were small in size. The tax rate on the gold mining industry was 20%, so the output value of gold can be estimated from the tax revenue. Tax data on the private copper industry and production data on the state-run copper industry are available only infrequently, but can be used to provide estimates of total copper production in those years. For other mining and metallurgical industries, such as lead and tin, output is assumed to move in line with the output of copper, consistent with the situation during the Northern Song dynasty.

A2.1.3 Qing metals and mining

During the Qing dynasty, the government gave up the right to monopolize the mining of minerals. In some provinces, there are thus gaps in the data on copper production. Abundant data exist for Yunnan province, which was an important centre of copper mining, and to which estimates for other provinces are added, based on more fragmentary information, Copper output data come from Zeyi Peng (1962). Since Guangdong became the centre of the iron mining and metallurgical industry during the late Ming dynasty, a similar approach can be used to estimate the production of iron. Data from Longqian Li (1979) are used to estimate the output of iron in Guangdong, to which estimates of output from other provinces are added to get the total volume of iron production.

For coal mining, output is estimated from iron output, together with the share of coal in the cost of iron production using data from Yingxing Song (1954), supplemented with an allowance for coal used in porcelain production and domestic consumption.

For the Qing dynasty, at least before the mid period of the Qianlong Emperor, private capital was allowed to participate in the mining and metallurgical industries of gold, silver and tin， but the data series are also limited here. Zhongli Zhang (1987) has estimated the output value of those three mining and metallurgical industries in 1887, and argues that the output value of the gold industry was 83% of the iron industry; the output value of the silver industry was the same as the copper industry; and the output value of the tin industry was three times that of the copper industry. By assuming that those ratios also held during the early Qing dynasty, it is possible to derive the output value of those three industries. By aggregating these data, the total output value of the mining and metallurgical industries during the Qing dynasty can be estimated.

A2.2 Food Processing

A2.2.1 Rice wine industry

For the Northern Song dynasty, the production of wine can be calculated by the tax levy on rice wine production. Huarui Li (2001) gathers data on tax revenue from wine production in Dongjing and Hangzhou, two flourishing commercial regions in the Northern Song, and uses it to derive estimates of wine output. According to this research, 10,000 Guan of tax revenue translates into 8,000 to 12,000 Dou of wine output. The output of rice wine is estimated for

some key years and then interpolated log-linearly to calculate the output for other years. The cost of production was about 35% of the gross output value in the wine industry (Huarui Li, 1991).

For the Ming dynasty, given the scarcity of data on wine production, output is estimated from the demand side. Based on data from the Qing dynasty, it is assumed that 10% of the population drank rice wine approximately 250 days per year, and consumed one Jin of wine per day[10]. Total rice wine consumption can therefore be estimated and it is assumed that production was roughly equal to consumption. This volume information can be combined with data on the price of wine from Miantang Huang (2008) to derive the value of wine output during the Ming dynasty. As in the Northern Song, net output was assumed to be 65% of the gross value. The demand approach is also used for estimating rice wine output during the Qing dynasty.

A2.2.2 Tea processing industry
According to Zhongli Zhang (1987), value-added in the tea-processing industry in the 1880s was 8% of the value of tea output. This ratio is applied throughout the Northern Song, Ming and Qing dynasties to the tea output data from the agricultural sector.

A2.2.3 Sugar industry
Zhongli Zhang (1987) estimates that value-added in the sugar industry accounted for 70% of that of the tea-processing industry in the 1880s. In line with qualitative evidence of lower sugar consumption during earlier times, this ratio is set at 50% during the Northern Song and the same assumption is used for the Ming dynasty. During the Qing dynasty, sugar was produced mainly in Taiwan, Guangdong and Fujian. Data on output in these provinces can be gathered, and an allowance can also be made for other areas, such as some parts of Guangxi, Jiangxi, Jiangsu and Zhejiang provinces. By aggregating this data, it is possible to calculate the output of sugar for China as a whole. The price of sugar can be obtained from Miantang Huang (2008) and Wenxi Tan (1994) and combined with the volume data to derive the value of output during the Qing dynasty.

A2.2.4 Other food processing industries
The food-processing industry also includes the milling and oil refining industries, for which few data are available. Following Broadberry, Campbell, Klein, Overton and van Leeuwen (2011), we assume other food processing industries grew in line with agricultural output. The level of other food processing is set in relation to sugar and tea-processing during the 1880s, from Zhongli Zhang (1987).

A2.3 Manufacturing Industry
A2.3.1 Salt
For the Northern Song dynasty, salt output is based mainly on the work of Zhengzhong Guo (1997), who collected data on salt production in different regions and then aggregated it to arrive at national salt output. According to Xia Qi (2009), the price of salt was determined by the government because of the salt monopoly at that time. The data of Baosan Wu and Yusun Wang (1947) suggest that the net value of salt accounted for 62 % of the gross value in 1933, and this ratio is assumed to hold all the way back to the Northern Song dynasty.

[10] See Xing Fang et al. (2007) p.426,or Bao Shichen (1968), Vol.26.

For the Ming dynasty, although salt tax data were recorded in *Ming Shilu*, they do not provide reliable estimates of salt output, which is estimated from the consumption side. Salt consumption per capita is assumed to be the average of the Northern Song and Qing dynasties and is multiplied by population to arrive at total consumption, which is assumed to be equal to output. *Ming Shilu* also recorded the price of salt measured by silver in some years. The net output of the Ming salt industry was assumed to be 62% of the gross output.

The salt output of the Qing dynasty is also based on the research of Zhengzhong Guo (1997), who collected the data of salt production in most years. The price of salt from Wenxi Tan (1994) is used to calculate the gross value, and the net value of salt production amounts to 62% of the gross value.

A2.3.2 Silk cloth

For the Northern Song dynasty, there are no historical materials recording silk cloth production, so output must be estimated using the consumption approach. First, silk consumption per household is estimated and then multiplied by the total number of households to derive total silk consumption in the country as a whole. By assuming that total production is equal to total consumption, silk cloth output can be determined on an annual basis. Since raw silk accounts for over 80% of the value of silk cloth, all silk cloth prices are determined by the price of raw silk. The data of Baosan Wu and Yusun Wang (1947) suggest that the net value of silk accounted for 40 % of the gross value in 1933, and this ratio is assumed to hold all the way back to the Northern Song dynasty.

For the Ming dynasty, the silk cloth industry can be divided into two subsectors, the state-managed sector and the private sector. The silk cloth industry managed by the state contained two parts: central and local. Silk cloth output from the central government was produced mainly in Suzhou, Songjiang, Zhenjiang, Hangzhou, Jiaxing and Huzhou, and recorded in the official historical literature. Total output was about 11,000 pieces, accounting for one third of the silk cloth industry managed by the government. It is difficult to find data on the privately managed silk fabric industry, which must be estimated using government-provided data on the number of looms and silk cloth production. According to Xinwei Peng (1965), the price of raw silk can be determined for most years of the Ming dynasty. Based on Baosan Wu and Yusun Wang (1947), the net value of silk fabric was 40% of the gross value.

For the Qing dynasty, the silk fabric industry can also be divided into two parts, the state-managed sector and the private sector. The output data for both sectors are taken from Jinmin Fan and Wen Jin (1993). The net value of silk fabric was also 40% of the gross value.

A2.3.3 Cotton cloth

After the Yuan dynasty, hemp fabric was replaced by cotton cloth as the wearing of cotton textiles spread to the lower classes. Cotton textiles thus became an important handicraft sector in the Ming and Qing dynasties. Output is estimated from data on the amount of labour engaged in cotton production, work time per labourer and labour productivity or consumption per person (Fuming Li 2005; Xinwu Xu, 1992).

A2.3.4 Coinage

Coinage was regulated during the Northern Song dynasty. The official unit and metal content of coinage was *Qian Mo*, which was also strictly regulated by the government. From the beginning of the Song dynasty to the reign of the Shenzong Emperor, the government used the same standard to mint copper coins. According to historical information, the GDP of the

coinage industry amounted to 40% of the value of the coinage in the earlier stage, and 30% in the later stage (*Xiaochu Ji*, Vol. 17; *Wenxian Tongkao Qianbi Kao*).

The Ming government minted a small number of copper coins and did not mint silver coins at all. It is hard to find data for the exact amount. Hence, the coinage industry in the Ming dynasty can be assumed to be negligible. The same is true for the Qing dynasty.

A2.3.5 Paper

During the Northern Song dynasty, *Yuan Feng Jiu Yu Zhi*; *Xu Zi Zhi Tong Jian Chang Pian*; and *Song Huiyao Jigao Shihuo* recorded the amount of paper transported from different regions to the central government. These data can be aggregated to estimate paper output for the country as a whole (Huaxian Wei, 2006). Based on Minsheng Cheng's (2008) research, the net value of paper production was 55% of the gross value.

The paper industry in the Ming dynasty was well developed, with a high degree of variety, flourishing mostly in four provinces, Jiangxi, Fujian, Zhejia and Anhui. Since we lack time series output data for paper during the Ming and Qing dynasties, the most neutral way of allowing for the paper industry is to assume that its share of manufacturing output did not change from the share estimated by Zhongli-Zhang (1987) for the 1880s. This is equivalent to the standard procedure in economic history of constructing an index of industrial production from a weighted sample of industries.

A2.3.6 Porcelain

Porcelain output during the Northern Song dynasty is estimated on the basis of Jilang Su (1997), who calculated the profits and costs of porcelain production in the south east region from the numbers of kilns in South Fujian and Guangdong provinces, the numbers of firings by each kiln in every year, and the numbers of porcelain products in each kiln per firing. We assume that South Fujian and Guangdong provinces accounted for two-thirds of national output, broadly in line with the share of the south eastern porcelain industry during the Ming and Qing dynasties.

For the Ming dynasty, porcelain production is estimated separately for the government and private sectors and then added together to derive total porcelain production (Miaotai Liang, 1991). The data for the government-managed porcelain industry are for imperial kilns, while the data for the privately-managed porcelain industry are based on the number of private kilns and the average production per kiln. Since there are different types of porcelain, the average price has to be used (Sakuma Shigeo, 1999). According to *Jiangxi sheng da zhi, taoshu*, the cost of production is 40% of gross output, which suggests that the net value of porcelain production accounted for around 60% of the gross value of porcelain production.

For the Qing dynasty, the output of Jingdezhen can also be obtained from Miaotai Liang (1991) covering the period from the Yongzheng Emperor to the Guangxi Emperor. According to Zhongli Zhang (1987), the south eastern porcelain industry centred on Jingdezhen accounted for 70% of Chinese porcelain output. The ratio of net value to gross value in Qing China is assumed to be the same as during the Ming dynasty.

A2.3.7 Transport equipment

Based on Zhongli Zhang's (1987) classification, the building and repairing of ships, handcarts and oxcarts is categorized under transport equipment within the manufacturing sector. The building and repairing of ships is the most important part of this industry,

although there are less data on this in the historical materials of the Northern Song. The 3.9% share of transport equipment in manufacturing in the 1880s from Zhongli Zhang (1987) is assumed to be constant throughout the Northern Song, Ming and Qing dynasties.

A2.3.8 Other manufacturing industries

There are a number of other manufacturing industries for which no systematic production data are available, including fur products, metal ware, furniture, clothing, stationery and jewellery. For these industries, the same method is used as for the transport equipment industry. The 8.0% share of other manufacturing to total manufacturing output in the 1880s from Zhongli Zhang (1987) is assumed to hold throughout the Northern Song, Ming and Qing dynasties.

A2.3.9 Building

Building is assumed to grow in line with population, but with an allowance for urbanization. This follows the procedure of Broadberry, Campbell, Klein, Overton and van Leeuwen (2011) in the estimation of English economic growth, 1270-1700. The population and urbanization data are taken from Jianxong Ge and Songdi Wu (2005) for the Northern Song dynasty and from Paul K. C. Liu and Kuo-shu Hwang (1979) and Shuji Cao (2005) for the Ming and Qing dynasties.

A3 SERVICE SECTOR OUTPUTS

A3.1 Commerce

The output of the commercial sector is estimated indirectly from data on the value of agricultural and industrial output, together with information on the share of output marketed. By taking account of the urbanisation rate of different dynasties, and using grain output minus food consumption, seeds, and feedstuff, Hui Wu (1987) has derived the commercialisation rate of agriculture as 17% during the Northern Song, 16% during the Ming, and 17.2% during the Qing dynasty before 1840, rising to 20.7% during the later Qing after 1840. It is assumed that all industrial output was marketed. This series of marketed agricultural and industrial output is used to project back from 1840 the nominal value added in commerce, which is derived using Zhongli Zhang's (1987) estimate of the ratio of GDP in commerce to GDP in agriculture and industry for the 1880s.

A3.2 Finance

In the early stage of the Qing dynasty (pre- 1840), finance includes three subsectors: pawn shops, Qianzhuang (local banks), and Piaohao (inter-regional banks established by Shanxi businessmen). The GDP of the financial sector consists of the personal revenue of the professionals working in these subsectors plus the profits accruing to the capital employed.

Data on the numbers of pawn shops and the capital employed can be combined with data on interest rates to calculate the GDP generated by pawn shops during the Qing dynasty (Qiugen Liu, 1995). Although historical data are unavailable for Qianzhuang and Piaohao, Zhongli Zhang (1987) has estimated GDP for China in the 1880s in Qianzhuang and Piaohao as well as pawn shops. The ratio of the GDP of Qianzhuang and Piaohao to the GDP of pawn shops is assumed to be the same as during the 1880s throughout the Qing dynasty. Combining the GDP of pawn shops in the early stages of the Qing dynasty with this ratio, it is possible to derive the GDP of the whole financial sector. For the Northern Song and Ming dynasties, no financial data are available, so the ratio of financial sector GDP to total GDP during the Qing dynasty is assumed to hold during the other two dynasties. This assumes that during the

Northern Song and Ming dynasties, usurious loans were on a similar scale to transactions dealt with by Qianzhuang and Piaohao during the Qing dynasty (Wenshu Wang, 2008).

A3.3 Housing and domestic service

Following Broadberry, Campbell, Klein, Overton and van Leeuwen (2011), it is assumed that housing and domestic service grew in line with population, with an allowance for urbanisation. The total population is decomposed into rural and urban population according to the urbanisation rate and divided by the average family size to determine the number of households. The number of households is then multiplied by the average rent in rural and urban areas respectively, to determine the total housing rent. The urbanization data are taken from Songdi Wu (2005) for the Northern Song dynasty and from Shuji Cao (2005) for the Ming and Qing dynasties. Rent data come from Minsheng Cheng (2008) for the Northern Song dynasty and from Xing Fang (1996) and Huanchun Hong (1988) for the Qing dynasty. No independent rent data are available for the Ming dynasty, but are assumed to be the same as during the Qing dynasty.

A3.4 Government

Government can be separated into four parts: the maintenance of the palace of the dynasty; soldiers' and military officers' pay; officials' emoluments and pensions; and the salary of other office clerks. Data for all these parts of government can be obtained from the historical literature of each dynasty. This method can be applied to all three dynasties. The number of soldiers and civil servants and their pay are taken from Hongqi Li (1988) and Shengduo Wang (1995) for the Northern Song dynasty. For the Ming dynasty, data for all parts of government can be obtained from Ming Shilu and Wanli Kuaiji Lu. For the Qing dynasty, data are taken from Feng Chen (2008) and Zhihong Shi and Yi Xu (2008).

REFERENCES

Primary historical sources

Anwu Sizhong, Vol.26, (Bao Shichen), Taipei: Wenhai Press Company, 1968.

Collation and Annotation of Mingshi Shihuo Zhi (Mingshi Shihuo Zhi Jiaozhu), (Li Xun), Peking: Zhonghua publishing house, 1982.

Da Ming huidian, Code of the Great Ming Dynasty (Li Dongyang), Yangzhou：Jiangsu Guangling ancient books sculpture and printing press, 1989.

Daxue Yanyi Bu, Vol.29, (Qiujun), Shanghai: Shanghai Bookstore Press, 2012.

Guangdong Tongzhi Chugao in the reign of the Jiajing Emperor, (Jing Dai and Chuang Yue), Beijing Shumu Wenxian Press, 1996.

Jiangxi sheng da zhi,(Wang Zongmu),Taipei:Chengwen Press,1989.

Ming huidian, Code of the Ming Dynasty (Shen Shixing), Edited in the Wanli Emperor, Peking: Book and literature publishing house, 1988.

Ming Shilu, Beijing: Photocopy of Academia Sinica Institute of History and Philology,1962.

Qing Shilu, Peking: Zhonghua Publishing House, 2008.

Qingshi Gao, Shihuozhi Yanfa (Zhao erxun), Beijing: Zhonghua publishing house, 1976.

Raozhou Fuzhi in Jiangxi Province, (Chen Ce), Taipei: Chengwen Press Company, 1989.

Song Huiyao Jigao, (Xu Song), Peking: Zhonghua publishing house, 1957.

Wanli Kuaiji Lu, *Fiscal notes on the Wanli Emperor* (Chuang Xueyan), Peking: book and literature publishing house, 1988.

Wenxian Tongkao, General Textual Research on Some Historical Literature (Ma Duanlin), Peking: Zhonghua publishing house, 1986.

Xiaochu Ji, (Wang Yucheng), Shanghai: The Commercial Press, 1937.

Xu Zizhi Tongjian Changbian, (Li Tao), Beijing: Zhonghua Book Press 1992.

Yiban Lu Zheng Guangzu), Beijing: Chinese Bookstore, 1990.

Yuan Feng Jiu Yu Zhi,(Wang cun), Peking: Zhonghua publishing house, 1984.

Secondary sources

Allen, Robert (2009), "Agricultural Productivity and Rural Incomes in England and the Yangtze Delta. c. 1620 – c. 1820", *Economic History Review*, 62, 525-550.

Álvarez-Nogal, Carlos and Leandro Prados de la Escosura (2013), "The Rise and Fall of Spain, 1270-1850", *Economic History Review*, 66, 1-37.

Bassino, Jean-Pascal, Stephen Broadberry, Kyoji Fukao, Bishnupriya Gupta and Masanori Takashima (2014), "Japan and the Great Divergence, 730-1870", London School of Economics, http://www2.lse.ac.uk/economicHistory/whosWho/profiles/sbroadberry.aspx.

Bernhard, Wolfram (1956), "Data on the Structure of the Chinese City in the Pre-Industrial Period", *Economic Development and Cultural Change*, 5, 253-268.

Beveridge, William (1939), *Prices and Wages in England from the Twelfth to the Nineteenth Century, Vol. I, Price Tables: Mercantile Era*, London: Longmans, Green.

Broadberry, Stephen., Bruce Campbell, Alexander Klein, Mark Overton and Bas van Leeuwen (2011), "British Economic Growth, 1270-1870: An Output-Based Approach", London School of Economics, http://www2.lse.ac.uk/economicHistory/whosWho/profiles/sbroadberry.aspx.

Broadberry, Stephen., Bruce Campbell, Alexander Klein, Mark Overton and Bas van Leeuwen (2014), *British Economic Growth, 1270-1870*, Cambridge: Cambridge University Press (forthcoming).

Broadberry, Stephen, Johann Custodis and Bishnupriya Gupta (2014), "India and the Great Divergence: An Anglo-Indian Comparison of GDP per capita, 1600-1871", *Explorations in Economic History*, (forthcoming).

Cao, Shuji (2005), *Chinese Population History: Ming Dynasty* (Zhongguo Renkoushi Vol.4, Ming Dynasty), Shanghai: Fudan University Press.
Chao, Kang (1986), *Man and Land in Chinese History: An Economic Analysis*, Stanford: Stanford University Press.
Chen, Feng (2008), *Reserch on Fiscal Policy and Monetary Policy of Qing Dyanaty*(Qingdai Caizheng Zhengce he Huobi Zhengce Yanjiu),Wuhan: Wuhan University Press.
Cheng, Minsheng (2008), *Song Dynasty Price Research* (Songdai Wujia Yanjiu), Beijing: People's Publishing House.
Crafts, Nicholas and Charles K. Harley (1992), "Output Growth and the Industrial Revolution: A Restatement of the Crafts-Harley View", *Economic History Review*, 45, 703-730.
Craig, John (1953), *The Mint: A History of the London Mint from A.D. 287 to 1948*, Cambridge: Cambridge University Press.
Deng, Kent G. (2004), "Unveiling China's True Population Statistics for the pre-Modern Era with Official Census Data", *Population Review*, 43, 32-69.
Elvin, Mark (1973), T*he Pattern of the Chinese Past*, Stanford: Stanford University Press.
Fan, Jinmin and Jin Wen (1993), *Silk History in Jiangnan* (Jiangnan Sichoushi Yanjiu), Beijing: Chinese Agriculture Press.
Fang, Xing (1996), "The Consumption of Farmers in Jiangnan during Qing Dynasty" (Qingdai Jiangnan Nongmin de Xiaofei), *Researches in Chinese Economic Histroy*, 3, 91-98.
Fang, Xing, Jing Junjian and Wei Jinyu (2007), *General History of Chinese Economy: Qing Dynasty*, Beijing: China Social Sciences Press.
Feinstein, Charles (1995), "Changes in Nominal Wages, the Cost of Living and Real Wages in the United Kingdom over Two Centuries, 1780-1990", in Pieter Scholliers and Vera Zamagni (eds.), *Labour's Reward: Real Wages and Economic Change in 19th- and 20th-Century Europe*, Aldershot: Elgar, 3-36.
Fu Chongju (1987), *Chengdu Research* (Chengdu Tonglan), Chengdu:Bashu PublishingHouse.
Ge, Jianxiong and Wu Songdi (2000), *Chinese Population History, Vol.3*, (Zhongguo Renkoushi,·Vol.3), Shanghai: Fudan University Press.
Ge, Jinfang (2008), *History of Handicraft Industry in Southern Song Dynasty* (Nansong Shougongye Shi), Shanghai: Shanghai Ancient Books Publishing House.
Guan, Hanhui and David Li (2012), "Chinese Economic Growth (980-1840)", Peking University and Tsinghua University.
Guo, Zhengzhong (1993), *Measurement of length, capacity and weight from 3 to 10 century* (San Zhi Shisi Shiji Zhongguo de Quanheng Duliang), Beijing: China Social Sciences Press.
Guo, Zhengzhong (1997), *History of Ancient Chinese Salt Industry* (Zhongguo Gudai Yanye Jingjishi), Beijing: People's Publishing House.
Guo, Songyi (2000), *Grain production and living standards of peasants in the Ming and Qing dynasties* (Mingqing Shiqi de Liangshi Shengchan yu Nongmin Shenghuo Shuiping), Journal of History Research Institute of Chinese Academy of Social Sciences, Vol.1, 373-396.
Hajnal, J. (1965), "European Marriage Patterns in Perspective", in , D.V. Glass and D.E.C. Eversley, (eds.), *Population in History: Essays in Historical Demography*, London: Edward Arnold, 101-143.
Hartwell, Robert (1962), "A Revolution in the Chinese Iron and Coal Industries During the Northern Sung, 960-1126 A.D", *Journal of Asian Studies*, 21, 153-162.
Hartwell, Robert (1966), "Markets, Technology, and the Structure of Enterprise in the

Development of the Eleventh-Century Chinese Iron and Steel Industry", *Journal of Economic History*, 26, 29-58.

Hartwell, Robert (1967), "A Cycle of Economic Change in Imperial China: Coal and Iron in Northeast China, 750-1350", *Journal of the Economic and Social History of the Orient*, 10, 102-159.

Ho, Ping-ti (1956), Early-Ripening Rice in Chinese History", *Economic History Review*, 9, 200-218.

Ho, Ping-ti (1985), "Nansong Zhijin Tudi Shuzi de Kaoshi he Pingjia(Nansong Zhijin Tudi Shuzi de Kaoshi he Pingjia)*", China Social Sciences Press*, 3, 125-160.

Hong, Huanchun (1988), *Economic material of rural Suzhou in Ming and Qing dynasty* (Mingqing Suzhou Nongcun Jingji Ziliao), Nanjing: Jiangsu ancient book publishing press.

Horrell, Sara, Jane Humphries and Martin Weale (1994), "An Input-Output Table for 1841", *Economic History Review*, 47, 545-566.

Huang, Miantang (2008), *Collation and Annotation of Price Issues in Chinese History* (Zhongguo Lidai Wujia Wenti Kaoshu), Jinan: Qilu Press.

Huang, Philip (1985), *The Peasant Economy and Social Change in North China*, Stanford, CA: Stanford University Press.

Huang, Philip (2002), "Development or Involution in Eighteenth-Century Britain and China?: A Review of Kenneth Pomeranz's The Great Divergence: China, Europe and the Making of the Modern World Economy", *Journal of Asian Studies*, 61, 501-538.

Huang, Qichen(1989), *History of production of iron and steel in 14-17th century China* (14-17 Shiji Zhongguo Gangtie Shengchanshi), Cetral China ancient book.

Huang, Ray (2001). *Fiscal and taxation in 16th Century Ming China*(16 Shiji Mingdai Zhongguo zhi Caizheng yu Shuishou) ,Beijing: Sanlian publishing house Press.

Institute of Qing History in Renmin University (1983), Mining Industry in Qing Dynasty (Qingdai de Kuangye), Beijing: Zhonghua publishing house Press.

Kato, Shige (2006), *Research in Gold and Silver in Tang and Song Dynasty* (Tangsong Shidai Jinyin zhi Yanjiu), Beijing: Zhonghua Book Company.

Kong, Lingren (1981), *Selective Archives of Kongfu in Qufu* (Qufu Kongfu Dangan Ziliao Xuanbian), Qilu Publising House.

Li, Bozhong (1998), *Agricultural Development in Jiangnan, 1620-1850*, New York, St. Martin's Press.

Li, Bozhong (2010), *Economy in Early Morden China: the GDP of Huating-Lou in 1820* (Zhognguo de Zaoqi Jindai Jingji –1820yr. Huating–Louxian Diqu GDP Yanjiu), Beijing: Zhonghua Book Company.

Li, Bozhong and van Zanden, Jan Luiten (2012), "Before the Great Divergence? Comparing the Yangzi Delta and the Netherlands at the Beginning of the Nineteenth Century", *Journal of Economic History*, 72, 956-989..

Li, Fuming (2005), *Institution, Moral Principles and Economic Growth: Social and Economic Research in Shanghai during 1500-1840* (Zhidu Lunli yu Jingji Fazhan: Mingqing Shanghai Diqu Shehui Jingji Yanjiu: 1500-1840), Beijing: Wenshi Press.

Li, Hongqi (1988). "Official Statistics in Song Dynasty" **(**Songdai Guanyuan Shu de Tongji), *Songshi yanjiu ji*, 18, 78-103.

Li, Huarui (1991), "Discussion about Prices and Profits of Liquor (Shilun Songdai Jiujia yu Jiu de Lirun)"*Researches In Chinese Economic History*, 3.

Li, Huarui (2001), *Production and Taxation of Liquor in the Song Dynasty* (Songdai Jiu de Shengchan he Zhengque), Baoding: Hebei University Press.

Li, Jingshou (2005), *Research in Song Dynasty's Commercial Tax* **(**Songdai Shangshui Wenti Yanjiu), Kunming: Yunnan University Press.

Li, Longqian (1979), "Seeds of Capitalism in Guangdong's Mining and Smelting Industry in the Early Qing Dynasty (Qingdai Qianqi Guangdong Caikuang, Yezhuye zhong de Ziben Zhuyi Mengya)", *Academic Research*, 5.

Liang, Fangzhong (1980), *Statistics of Households, Land and Feudal Land Tax in Ancient China (Zhongguo Lidai Hukou, Tiandi, Tianfu Tongj),* Shanghai: Shanghai Renmin Press.

Liang, Miaotai (1991), *Research on the Urban Economy in Jingdezhen during the Ming and Qing Dynasties* (Mingqing Jingdezhen Chengshi Jingji Yanjiu), Jiangxi People's Publishing House.

Liang, Taiji and Bao Weimin (2008), *Songshi Shihuo Zhi Buzheng*, Beijing: Zhonghua Book Company.

Liu, Guanglin, "Long-term Changes in Prices, Wages and the Size of the Monetary Economy in Pre-industrial China, 1000-1770", Working Paper.

Liu, Paul K. C. and Kuo-shu Hwang (1979), "Population Change and Economic Development in Mainland China since 1400", in Chi-ming Hou and Tzongs-hian Yu (eds.), *Modern Chinese Economic History*, Taipei: Academia Sinica, 61-90.

Liu, Qiugen (1995), *History of Pawn Industry in China* **(**Zhongguo Diandang Zhidushi), Shanghai: Shanghai Guji Publishing House.

Liu, Ruizhong (1986), "Estimation of Chinese GDP Per Capita and Comparison to United Kingdom in 1700s **(**18 Shiji Zhongguo Renjun Guomin Shouru Guji Jiqi yu Yingguo de Bijiao)", *Researches In Chinese Economic History*, 3, 105-120.

Liu, Sen (1993). "Iron Coins and the Production of Iron in the Song Dynasty **(**Songdai de Tieqian yu Tiechanliang)", *Researches in Chinese Economic History,* 2, 86-90.

Liu, Ta-chung and Yeh Kung-chia (1965), *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-1959*, Princeton: Princeton University Press.

Luo, Yi (1999), *Population and Economic Growth in the 18th Century* (18th Shiji Zhongguo de Renkou yu Jingji Zengchang), Doctoral Dissertation in School of Economics, Peking University.

Maddison, Angus (1998), *Chinese Economic Performance in the Long Run*, Beijing: Xinhua Press.

Maddison, Angus (2001), *The World Economy: A Millennial Perspective*, Paris: Organisation for Economic Co-operation and Development.

Maddison, Angus (2010), "Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD", Groningen Growth and Development Centre, http://www.ggdc.net/MADDISON/oriindex.htm.

Malanima, Paolo (2011), "The Long Decline of a Leading Economy: GDP in Central and Northern Italy, 1300-1913", *European Review of Economic History*, 15, 169-219.

McEvedy, Colin and Richard Jones (eds.) (1978), *Atlas of World Population History*, Harmondsworth: Penguin.

Mitchell, Brian R. (1988), *British Historical Statistics*, Cambridge: Cambridge University Press.

Needham, Joseph (1954), *Science and Civilization in China*， Volume1, Cambridge: Cambridge University Press.

Peng, Xinwei (1965), *Chinese Monetary Histor*y (Zhongguo Huobishi), Shanghai: Shanghai People Press.

Peng, Zeyi(1962),*Historical materials of handicrafts development in modern time* (Zhongguo Jindai Shougongyeshi Ziliao), Beijing: Sanlianpublishing house.

Perkins, Dwight H (1969), *Agricultural Development in China, 1368-1968*, Chicago: Aldine.

Pomeranz, Kenneth (2000), *The Great Divergence: China, Europe, and the Making of the*

Modern World Economy, Princeton: Princeton University Press.
Pomeranz, Kenneth (2011), "Ten Years After: Responses and Reconsiderations", Historically Speaking, 12(4), 20-25. Project Muse, https://muse.jhu.edu/login?auth=0&type=summary&url=/journals/historically_speaking/v012/12.4.coclanis.html.
Robson, R. (1957), *The Cotton Industry in Britain*, London: Macmillan.
Qi, Xia (2009), *History of the Economy in the Song Dynasty* (Songdai Jingjishi), Beijing: Zhonghua Book Company.
Quan, Hansheng (1991), *Researches in Chinese Economic History* (Zhongguo Jingjishi Yanjiu), Taipei: The New Asia Institute of Advanced Chinese Studies.
Sakuma Shigeo(1999), *Research on history of porcelain production of Jingde town* (Jingdezhen Yaoyeshi Yanjiu) Tokyo: First Publishing house.
Shi, Zhihong (1994), *Small Peasant Economy in Early Qing Dynasty* (Qingdai Qianqi de Xiaonong Jingji), China Social Sciences Press.
Shi, Zhihong (2001), "Re-estimation of Cultivated Land in China during Early 19th Century (19 Shiji Shangbanqi de Zhongguo Gengdi Mianji Zaiguji) ", *Researches in Chinese Economic History*, 4, 85-97.
Shi, Zhihong and Yi Xu (2008), *Public Finance in Late Qing Dynasty :1851-1894*(Wanqing Caizheng : 1851-1894),Shangahai: Shanghai University of Finance and Economics Press.
Song, Xi (1958), "Geographic distribution of rice production in the Northern Song dynasty"(Beisong Daomi de Chanliang Fenbu), symposium of research about Song History,Taipei:Committee of Editor of Chinese books series (National compiling library), 131-175.
Song, Yingxing (1954), *Tiangong Kaiwu, Vol.10-11*, Shanghai: The Commercial Press.
Su, Jilang (1997), A *Spatial Model of the Porcelain Export Industry in South Fujian and Guangdong: a Comparative Analysis*, (Liangsong Minnan Guangdong Waimaoci Chanye de Kongjian Moshi:Yige Bijiao Fenxi) in Chuang Yanhui (ed.), *Essays on the History of Ocean Development in Chin*a, Vol.6, Academia Sinica, Institute of Zhongshan Humanity and Social Science Research .
Sun, Hongsheng (2001), "Tea Economy of Tang and Song Dynasty"(Tangsong Chaye Jingji), Beijing: Social Science Literature Press.
Tan, Wenxi (1994), *History of Price in Chin*a (Zhongguo Wujiashi), Wuhan: Hubei People's publishing House.
Tu, Guangshao (1984), *The Surplus of National Income in China: 1931-1936*, (Zhongguo Guomin Shouru de Jiexu:1931-1936),Master's Thesis in School of Economics, Peking University.
UK Board of Trade (1903), *Report on Wholesale and Retail Prices in the United Kingdom in 1902, with Comparative Statistical Tables for a series of Years*, (HC321), British Parliamentary Papers, LXVIII.
van Zanden, Jan Luiten and Bas van Leeuwen (2012), "Persistent but not Consistent: The Growth of National Income in Holland, 1347-1807", *Explorations in Economic History*, 49, 119-130.
von Glahn, Richard (1996), *Fountain of Fortune: Money and Monetary Policy in China, 1000-1700*, Berkeley: University of California Press.
Walker, James T. (2012), "National Income in Domesday England", University of Reading.
Wang, Lingling (2005), *Research in Mining Industry in Song Dynas*ty (Songdai Kuangyeye Yanjiu), Baoding: Hebei University Press.
Wang, Shengduo (1995), *Fiscal History in Song Dynasty* (Liangsong Caizhengshi), Beijing: Zhonghua Book Press.
Wang, Shengduo (1995), *Monetary History in Song Dynasty* **(**Liangsong Huobishi), Beijing: China Social Sciences Press.

Wang, Wencheng (2001). *Studies on Silver Monetization in Song Dynast*y **(**Songdai Baiyin Huobihua Yanjiu), Kunming: Yunnan University Press.

Wang, Wenshu (2008), *Research on usurious loans in Song dynasty* (Songdai Jiedaiye Yanjiu), unpublished dissertation, Hebei University, China.

Wang, Yeh-chien (2003), *Essays on economic history of Qing dynasty* (Qingdai Jingjishi Lunwenji), Taipei: Daoxiang Press.

Wang Yuquan(2007), *General History of Chinese Economy: Qing Dynasty* (Zhongguo Jingji Tongshi: Mingdai Jingjijuan), Beijing: China Social Sciences Press.

Wang Zengyu (1983), *Research on military institution of Song dynasty* (Songchao Bingzhi Chutan), Beijing: Zhonghua publishing house.

Wei, Huaxian (2006), *Production and Consumption of Four Products in the Song Dynasty* (Songdai Silei Wupin de Shengchan he Xiaofei Yanjiu), Chengdu: Sichuan Science & Technology Press.

Wittfogel, Karl August (1957), *Oriental Despotism: A Comparative Study of Total Power*, New Haven: Yale University Press.

Wong, Roy Bin (1997), *China Transformed: Historical Change and the Limits of European Experience*, Ithaca: Cornell University Press.

Wu, Baosan and Wang Yusun (1947), *China's National Income in 1933*(Zhongguo Guomin Suode: 1993yr), Shanghai: Zhonghua Book Press.

Wu, Chengluo (1984), *Chinese History of Weights and Measure*s (Zhongguo Dulianghengshi), Shanghai: Shanghai Book Press.

Wu, Hui (1985), *Researches of Grain Yield in Ancient China* (Zhongguo Lidai Liangshi Muchanliang Yanji), Beijing Agriculture Press.

Wu, Hui (1998), " *A estimation on commercialization rate and commercialization volume about historical grain production"*, (Lishi shang Liangshi Shangpinlv Shangpinliang Cegu) ,Research on Chinese Economic history, Vol.6,pp.16-31.

Xu, Dixin and Wu Cheng-Ming (1985), *History of Capitalist Development in China: The Budding of Capitalism Vol.1* (Zhongguo Ziben Zhuyi Fazhanshi,Vol.1), Beijing: People's Publishing House.

Xu, Xinwu (1992), *The history of cotton production in Jiangna*n (Jiangnan Tubushi), Shanghai Social Science Press.

Yan, Zhongping, (1948), *Collation and Annotation of Copper Industry in Yunnan during Qing Dynasty* **(**Qingdai Yunnan Tongzheng Kao), Beijing: Zhonghua Book Press.

Yao, Xiangao (1962), *Historical Data About Trade of Modern China* (Zhongguo Jindai Duiwai Maoyishi Ziliao), Beijing: China Publishing House.

Zhang, Zhongli (1987), "Estimates of China's National Income in 1880s", (Zhongguo Guomin Shengchan Zongzhi de Culue Guji in 1880s), *Nankai Economic Quarterly*, 1.