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CHINESE NATIONAL INCOME, CA. 1661–1933¹

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In recent decades, national income has become increasingly important as a measure of a nation's economic health. In this study, we used a wide array of primary and secondary sources to arrive at values of the Chinese per capita gross domestic product during the period of 1661–1933. We found a persistent decline in the per capita gross domestic product between the seventeenth and nineteenth centuries, followed by a period of stagnation. This pattern, which shows up in many Asian countries, with the exception of Japan, provides a basis for improving our understanding of the patterns of global economic convergence and divergence.

JEL categories: N15, N35, N55, N65, O11

Keywords: China, growth, national income, Qing dynasty

INTRODUCTION

The gross domestic product (GDP) (i.e. the total value of all goods and services in an economy) is one of the most commonly used metrics for analysing economic growth worldwide. As such, it is frequently referred to in international debates related to well-being, economic catch-up and convergence, and factors driving growth.² It is therefore not surprising that attention was given to Chinese national accounting at a relatively early stage, with Colin Clark being one of the first scholars to attempt a reconstruction of China's national income, based on real wage data for the period

- 1 The appendices belonging to this paper and containing a more detailed description of the data and methodology can be downloaded from: https://mpira.ub.uni-muenchen.de/70873/1/MPRA_paper_70873.pdf. The research leading to these results received funding from the European Research Council under the European Union's Horizon 2020 Programme/ERC-StG 637695 – HinDI, as part of the project 'The historical dynamics of industrialization in Northwestern Europe and China ca. 1800–2010: a regional interpretation'. We would like to thank two anonymous referees for their comments, which considerably improved this paper.
- 2 Van Zanden *et al.*, *Global Well-Being*; Broadberry *et al.*, *China, Europe*; Mokyr, *The Lever of Riches*

[Correction added on 12 October 2017, after first online publication: The name of the first author has been corrected from "Xu Yi" to "Yi Xu".]

1925–34.³ However, little research was conducted on this topic during the second half of the twentieth century. This changed in the last decade when, together with results of various historical studies on Western and other Asian economies, also Chinese estimates have started to appear in the literature. This trend towards increased quantification of historical data has, of course, met with some criticism, mostly based on technical aspects of the research, such as problems in defining index numbers, collecting comprehensive data for historical societies, and the application of purchasing power parities.⁴

A common feature of both waves of research on the Chinese GDP (in the early twentieth century and during the last decade) was their focus on the period of the 1930s, which coincided with the first systematic countrywide investigations on economic activity, including the collection of data on population size and structure, occupational status, the proportion of population living in urban *versus* rural areas, interest rates, rents, productivity, prices, wages, and the size of the labour force. Using this information, the first complete reconstruction of China's national accounts was completed for the year 1933, including reconstructions of productivity, income, and expenditure by Ou *et al.*⁵ The estimates of Ou *et al.* were then revised by Liu and Yeh, who re-evaluated the data sources used to reconstruct the national accounting; this estimate of Liu and Yeh remains the most influential source on early Chinese national income in Western academic research.⁶ For example, Maddison used it in his famous work on Chinese long-term growth.⁷ As a result, the estimates obtained for 1933 are considered a reliable and robust benchmark for historical studies of China's GDP.

While post-1933 estimates are considered relatively robust, the same is not true for estimates from preceding periods, mainly because the collection of historical data proceeded much more slowly in China than in the West. Consequently, Chinese datasets may be strongly disputed (e.g. the urbanisation ratio, agricultural production, domestic and international trade, government income and expenditures, wages, interest rates, and the development of modern industry) or available data may cover only small regions, which are not necessarily representative of the country as a whole (e.g. occupational status, prices excepting grain prices, handicraft industries, transportation, finance, personal services, house rent, and labour productivity). Nevertheless, some ambitious scholars have generated national income estimates for China during historical periods or benchmark years. For example, Chang examined national income in the 1880s, and Perkins and Rawski examined national income during 1914–18.⁸ Even more ambitious scholars, such as Liu, Broadberry *et al.*, and Maddison, tentatively extended their historical GDP

3 Clark, *The Condition*.

4 Deng and O'Brien, *China's GDP per Capita from the Han Dynasty*.

5 Ou *et al.*, *National Income of China*; Ou, *Correction on National Income of China*.

6 Liu and Yeh, *The Economy of the Chinese Mainland*.

7 Maddison, *Chinese Economic Performance*.

8 Chang, *The Income of the Chinese Gentry*; Perkins, *Growth and Changing Structure*; Rawski, *Economic Growth*

reconstructions to earlier periods; the reconstructions of Liu and Broadberry *et al.* extend to the seventeenth century and the Sung dynasty, respectively, while that of Maddison goes to 1 AD.⁹

The tentative nature of Chinese historical data leaves considerable room for discussion regarding historical developments of the per capita GDP. Perhaps the most famous is the so-called ‘Great Divergence’ debate, in which standards of living in China and Europe were compared. In this debate, the California school claimed that until the nineteenth century, the most advanced sectors of China were economically on par with those in Europe.¹⁰ However, this position was opposed by other scholars, who claimed that the Chinese economy had already been surpassed by the economies of Europe centuries earlier.¹¹ The latter studies show trends roughly similar to those found in the earlier studies of Bairoch and Maddison, which suggested that the Chinese economy had entered a stagnating or downward economic trend sometime between the Sung and Qing dynasties.¹² However, all of the studies mentioned previously have relied on incomplete secondary sources, which has left them open to criticism on grounds of poor data quality, thus leading to a continued debate on the performance of the Chinese economy prior to the twentieth century.

Therefore, to improve our estimates of China’s historical GDP before the twentieth century, in 2008, we launched a research project led by Professor Shi Zhihong, which covered the entire span of the Qing dynasty. The goal of this project was to fill the gap in existing historical data relating to the Qing dynasty. These data can be roughly divided into two types. The first type consisted of modern surveys conducted since the final decade of the Qing rule (ca. 1910s), such as ‘*The First Statistical Tables of Agriculture and Commerce*’, which reported detailed information on the main sectors of the economy. However, as these first surveys were incomplete and unreliable, we also included data from regional censuses, local gazetteers, private notes, and account books to improve their coverage. The second type of data, which was obtained mainly for the years prior to 1910, consisted of government publications, such as those for cultivated land, population, government expenditure, international trade, titles of engraved books, grain prices and gentry service, as well as regional sources, which included certain economic sectors in specific regions, such as Qing mining, custom tax, ceramics

9 Liu, *Chinese GDP*; Broadberry *et al.*, *China, Europe and the Great Divergence*; Maddison, *Chinese Economic Performance*.

10 For example, Pomeranz, *The Great Divergence*; Pomeranz, *Ten Years After*.

11 For example, for the Yangtze region, see Li, *Zhongguo de Zaoqi Jindai Jingji* and Li and Van Zanden, *Before the Great Divergence*. For China as a whole, see, for example, Liu, *Chinese GDP*; Ma and De Jong, *China’s per Capita GDP*; Broadberry *et al.*, *China, Europe and the Great Divergence*.

12 The estimates of both Bairoch in *International Industrialization Levels* and Maddison, in *Chinese Economic Performance* relied on the assumption of a downward trend in industry and a roughly constant per capita consumption of agricultural products, hence resulting in a largely stagnant per capita GDP. Even though many scholars would question the reliability of their estimates, they nevertheless are clear proponents of a stagnant or declining per capita income in China in the early modern period.

industry archives, local and special gazetteers (*Xiangtuzhi*, 乡土志), stone inscriptions, and private notebooks.¹³

Based on the results of this project, and combined with existing literature, we here provide for the first time estimates of the Chinese GDP for eight benchmark years during the Qing dynasty that offer the best quality data available (1661, 1685, 1724, 1776, 1812, 1850, 1887, and 1911). These benchmarks years are linked to the first ‘solid’ GDP estimate of 1933, as provided by Liu and Yeh.¹⁴ Our resulting estimates, even though limited by available sources, are, in our view, the best possible at this time, and as we will see in the following sections are broadly consistent with alternative estimates and sources.

The remainder of this paper is organised as follows. In the second section, we discuss population and urbanisation. The next four sections address agriculture, industry, services, and total GDP respectively. Consistent with Maddison, we found that the gap in the per capita GDP between China and Western Europe already existed before the early Qing dynasty, but that the gap with Southern Europe did not arise until the eighteenth century. This result is cross-checked in the following section on Crosss Check: The Demand Side, using a demand approach that results in virtually identical estimates to that of the output approach used in the first sections.¹⁵ Finally, a brief summary and conclusions are presented in the last section.

POPULATION AND URBANISATION

The determination of accurate population sizes is a necessary first step in our analysis. Population size during the Qing dynasty is relatively uncontroversial. In general, government publications such as the *Daqing Lichao Shilu* 《大清历朝实录》, *Qingchao Xuwenxian Tongkao* 《清朝文献通考》, and *Shiyichao Donghualu* 《十一朝东华录》 provided annual census data for the Qing dynasty, for tax purposes. However, not only were tax amounts frozen starting in the early Qing dynasty, but women and children were not taxed and were therefore not included in the registers. Similarly, migrants were also not counted in the censuses in the region of residence, even those who had migrated into a region generations prior to the censuses, but were, as a rule, registered in their region of origin. Therefore, we applied several corrections

13 Based on the new historical data unearthed during this project, a number of research papers have been published related to GDP estimates, including, on population and agriculture. Shi, *Re-estimation of Cultivated Land*; Shi, *Re-estimation of Yield and Output*; and Shi, *Estimation of Production Indicators*. Further, on the industrial sector, Xu and Van Leeuwen, *The Performance of Chinese Industry*; Xu, *Re-estimate of Production in the Silk Industry*; Xu and Zhang, *Estimate of Production in Mining*; Xu and Zhang, *Re-estimate of Production in Industry*; Ni, *Research on the Customs Duties*, on customs duties and trade output; Shi and Xu, *Public Finance*, on government expenditures; Xu, van Leeuwen and Földvári, *Human Capital in Qing China*, on personal services; Xu *et al.*, *Urbanization in China*, on urbanisation; and Ni *et al.*, *A Study on the Historical Quantification*.

14 Liu and Yeh, *The Economy of the Chinese Mainland*.

15 Maddison, *Chinese Economic Performance*.

Table 1. Population and agricultural figures for 1661–1933

Year	Population		Agricultural value added				Total	
	Population mln	Urbanisation (%)	Food crops (%)	Cash crops (%)	Livestock, forestry, and fisheries (%)	Total (%)	Index (1933 = 100)	
1661	120	10.5	72.7	12.9	14.4	100.0	42	
1685	146	9.8	73.1	12.5	14.4	100.0	49	
1724	202	8.6	73.6	12.1	14.3	100.0	62	
1766	286	7.3	73.3	13.9	12.8	100.0	73	
1812	369	7.0	70.9	17.3	11.8	100.0	84	
1850	436	7.0	71.0	17.3	11.7	100.0	94	
1887	436	7.0	67.7	20.7	11.6	100.0	96	
1911	439	11.3	66.7	21.6	11.7	100.0	98	
1933	500	15.0	64.7	22.9	12.4	100.0	100	

to the official figures by applying the data of various researchers.¹⁶ Cao and Shi recently conducted highly detailed analyses of the Chinese population, and their adjusted numbers were for the years 1661, 1776, 1820, and 1911.¹⁷ The numbers of Liu and Yeh (which are similar to those of Maddison) were used for 1933.¹⁸ The remaining benchmarks, in 1685, 1724, 1850, and 1887, were interpolated based on the population growth ratios of Cao.¹⁹

Table 1 lists the population estimates used in this study, which, as noted previously, are comparable with those employed in other studies. Admittedly, debate exists on Chinese population numbers, but this debate focuses mainly on the Ming dynasty, which falls outside the scope of the present paper. The most remarkable feature of the data is the rapid (by Chinese standards) compound annual population growth rate of 0.53 per cent during the period of 1661–1933, a figure comparable with growth rates in pre-Industrial England, excluding recurring population declines due to plagues and famines, which also affected pre-Qing China.²⁰ This population growth is thus by no means extraordinary; however, what makes it surprising, as we will see in the following sections, is that population growth is one of the prime causes of the long-term decline in the per capita GDP, although as pointed out by Deng, various other explanations have been provided, including higher yields, more intensive farming, the introduction of New World crops,

16 For example, Deng, *Unveiling China's True Population Statistics*; Liang, *Chinese Historical Population*; Maddison, *Chinese Economic Performance*.

17 Cao, *Chinese Population History*; Shi, *Re-estimation of Yields*.

18 Liu and Yeh, *The Economy of the Chinese Mainland*.

19 Cao, *Chinese Population History*.

20 Broadberry *et al.*, *British Economic Growth*.

decreasing tax burdens, and a decline in the total number of disasters, all of which were factors affecting population growth during the Qing dynasty.²¹

Rising population also likely generated a higher urbanisation ratio, which is often used as a partial proxy for trends in income in non-agricultural sectors. The urbanisation ratios reported in Table 1 are for cities of over 2,000 inhabitants, a definition that was first used in the 1953 Chinese census to characterise a residential area as a city.²² Our estimates for the years 1776–1893 were taken from Xu *et al.*, who based their data, with minor modifications, on Cao.²³ These estimates are comparable with those of Skinner; however, Cao is clearer about his sources, and his estimates are therefore preferred.²⁴ For 1644, 1850, and 1918, Xu *et al.* obtained their information from various gazetteers and from the 1918 countrywide Christian survey.²⁵ For 1933, the most reliable countrywide survey on the size of the urban population was conducted by Notestein and Qiao Qiming.²⁶ However, in this survey, some of the residents who engaged in agriculture inhabited towns and were hence viewed as part of the urban population; thus, their estimates are about twice as high as the estimates for 1918. By using the ratio of non-agricultural urban to agricultural urban residents from the 1949 census (National Bureau of Statistics 1990), we arrived at a non-agricultural urban population ratio for 1933.²⁷

AGRICULTURE

Historically, agriculture has been by far the largest sector in the Chinese economy. In 1933, agricultural output made up approximately 60 per cent of the total GDP, and its share was even higher in preceding centuries.²⁸ During the Qing dynasty, 65 per cent of the GDP in China was attributable to agricultural produce, and close to 80 per cent of agricultural production was attributable to the arable sector. It is therefore logical that studies assessing agricultural productivity in China have focused on calculations of total arable production. Such calculations are commonly performed by assessing both yields and acreage and then deriving the total output as their product.

There is consensus regarding trends in total agricultural acreage, although some discussion remains about the absolute land area, as the available statistics refer to tax units rather than actual amounts of land in production. Therefore, various authors

21 Deng, *China's Population Expansion*.

22 Rozman, *Urban Networks*, is in this case an exception: he used 3,000 inhabitants as the lower limit.

23 Xu *et al.*, *Urbanisation in China*; Cao, *Chinese Population History*.

24 Skinner, *The City*.

25 Xu *et al.*, *Urbanisation in China*.

26 See Buck, *Land Utilization in China*.

27 National Bureau of Statistics, *The Compilation of Historical Statistics of All Provinces, Autonomous Regions and Municipalities Directly Under The Central Government, ca.1949–1989*.

28 See, for example, Liu and Yeh, *The Economy of the Chinese Mainland*; Ou, *National Income of China*.

Table 2. Comparison of estimates of industrial and services output in China obtained in different studies (in mln 1990 GK dollars)

Year	Industry			Services	
	This text	Bairoch	Liu	This text	Liu
1660			5,839.3		13,285.7
1661	7,448.9			13,528.7	
1680			8,666.7		18,333.3
1685	8,860.1			15,651.1	
1720			11,289.0		21,925.4
1724	11,322.6			19,618.2	
1750		27,588.4	12,537.5		25,181.3
1760			11,800.5		23,371.1
1766	13,521.0			23,079.4	
1800		13,702.1	14,458.2		28,949.5
1810			14,692.7		29,627.7
1812	16,787.1			27,355.2	
1840		12,527.6	16,636.1		34,891.7
1850	18,276.5			32,303.7	
1860		7,690.8			
1880		7,690.8			
1887	19,641.8			40,543.5	
1911	21,094.6	5,480.8		48,185.9	
1933	26,588.1	6,706.4		65,258.0	

Sources: This study; Bairoch, *International Industrialisation Levels*; Liu, *Chinese GDP*.

have applied corrections to derive the total land area under cultivation. The corrections are based on two methods. In the first, available tax data on cultivated land are used as the basis, and a correction coefficient converts the tax data to arable land amounts. This method was used, for example, by Guo, who, in turn, followed the approach of Zhang.²⁹ However, the method is only suitable when using the official records from the early Qing dynasty, as the official records increasingly deviated from reality after the Qianlong Reign (mid-Qing, 1735–95). Therefore, over the course of the Qing rule, the actual figures are increasingly difficult to derive by simple modification of the official records. Indeed, Table 2 shows that the values derived by Zhang and Guo for the amount of agricultural land are much lower than those obtained by most other scholars.³⁰ A second problem with the use of tax records is related to Zhang's adjustment values, which did not distinguish between government and private fields. Because government fields were under direct government control, the government data on arable government land were more reliable and robust than the data for private fields, as the private fields may have

29 Guo, *Food production*; Zhang, *Re-estimation of Population Size*.

30 Zhang, *Re-estimation of Population Size*; Guo, *Food Production*.

escaped detection, for example, by individuals evading taxation. A final problem with the tax record approach is that the adjustment coefficients were applied indiscriminately to all provinces, despite the fact that the amount of arable land in different provinces varied.

The second method, which was applied, for example, by Perkins, is to work backwards from a ‘solid’ modern benchmark.³¹ Perkins believed that the mid-Qing acreage figures were of particularly low quality, and that the 1950s acreage data depended on the assumed effectiveness of the 1953 census and the statistical collection procedures of the State Statistical Bureau.³² Thus, he rejected the Qing arable land figures after 1766 and worked backwards from twentieth century data to estimate the amount of cultivated land in the mid-nineteenth century. As a modern benchmark, he used Buck’s land classification for the early 1930s and figures provided by the State Statistical Bureau for 1957.³³

In our study, we utilised the work of Shi, who started from nineteenth and twentieth century benchmarks using a method similar to that of Perkins.³⁴ As in Perkins, the point of departure for the analysis was data provided by the State Statistical Bureau; however, Shi used figures from 1952 instead of those from 1957. In 1952, the economy had largely recovered from the preceding wars, and the agricultural statistics were relatively complete. In addition, as 1952 is only 3 years after the advent of New China in 1949, the 1952 data largely avoid distortions caused by these changes. The 1952 data also closely match the estimates of Liu and Yeh for 1933, which we took as our point of departure.³⁵ However, for the early Qing dynasty, the coefficient adjustment method was used to correct the official records for cultivation in private fields, while taking into account provincial differences.

The calculations described thus far consider the total cultivated land area. However, the types of crops grown may change dramatically over time, which, *via* yields, affects total production. Unfortunately, it is difficult to arrive at a detailed breakdown of the types of crops under cultivation at any given time. However, the data provided by Shi do enable a division of land under cash and food crop production.³⁶ We found an increase of approximately 8 per cent of land under cash crop cultivation in 1661 to 15 per cent in 1933, with most of the increase occurring near the turn of the nineteenth century.

31 Perkins, *Agricultural Development*.

32 Perkins, *Agricultural Development*.

33 Buck, *Land Utilization in China*.

34 Shi, *Estimate of Arable Area*; Shi, *Re-estimation of Cultivated Land*; Shi, *Re-estimation of Yield and Output*; Shi, *Estimation of Production Indicators*.

35 Liu and Yeh, *The Economy of the Chinese Mainland*.

36 Shi, *Estimation of Production Indicators*. In our sources, cash crops are defined as products that were directly or indirectly intended for industry, such as cotton, hemp, and mulberry, *versus* food products, that include crops such as sugar cane, tea, peanuts, tobacco, soy beans, bamboo, flowers, and fruit. In this text, we follow the same definition.

As noted previously, calculations of total agricultural output require information about cultivated land as well as yields. In general, yields can be determined using two methods. In one method, used by Perkins, one assumes the food consumption per person and multiplies this value by the total population.³⁷ This value, in turn, is divided by the acreage under cultivation, thus providing an estimate of the average yield per unit of land. A second and more direct approach is to collect yield observations across China and to average those yields to obtain a countrywide yield. When calculating the average yield for the entire country using this method, the accuracy depends strongly on the total number of yield observations used in the calculations. Wu and Guo have so far provided the most widely accepted historical average yield values for China.³⁸ Nevertheless, their methods are subject to two weaknesses. First, neither study presented yield data for the Qing dynasty, with the exception of yields for 2–4 benchmark years. Second, their yields were based on only 1,000 observations, which is a relatively small dataset when compared with the size of the country.

Nevertheless, to take advantage of the second approach, we use a set of about 3,000 yield observations taken from Shi, representing yields of both rice and other crops, and covering approximately 800 counties; for nearly half of the counties, average yields were available for the eight benchmark years in the Qing dynasty identified in this study, giving a fair geographic coverage.³⁹ The average yield was calculated by dividing the cultivated land of China into four categories, that is, southern China rice fields (which, in turn, were divided into wet rice fields and wheat–rice multi-crop rotation fields), northern China rice fields, northern China drought grain fields (i.e. wheat, beans, etc.), and southern China drought grains in wheat–rice multi-crop rotation fields. Knowing the average yield for each of these four classes, we can weigh the area of each class in terms of its proportion of the total arable land to arrive at an average yield.⁴⁰

The total food production can be obtained as the product of the average yield for food crops and the total area under cultivation. Combining this result with the food estimates of Liu and Yeh for 1933 gives the value added in food crops, expressed in 1933 prices.⁴¹ However, to arrive at the total arable land, cash crops must also be considered. Unfortunately, except for 1850–1911, data on the average yields of cash crops are not available. However, based on late Qing data, Shi established that the ratio of income derived from a mu of cash crops relative to food crops was 1.9, which

37 Perkins, *Agricultural development*.

38 Wu, *Grain Yield per Mu*; Guo, *Food Production*.

39 Shi, *Re-estimation of Yields*; Shi, *Estimation of Production Indicators*.

40 For the late nineteenth century, we lack information on new high-yield food crops, such as sweet potatoes and corn. Fortunately, Wu Hui estimated that these new food crops increased the average yield by approximately 1 dou (斗). According to this source, Shi revised his estimate to 2–2.2 dan/mu. This range for the average grain yield is approximately 310–341 shi jin/mu (in the modern Chinese measurement system), or approximately 2327–2560 kg/ha or 23.3–25.6 kg/a (in metric units). Hence, we increased our average yield in the late Qing by this amount. An overview of alternative estimates can be found in Appendix I to this paper.

41 Liu and Yeh, *The Economy of the Chinese Mainland*.

allows us, based on the acreage of cash crops, to calculate an index for the cash crop sector for the period prior to 1850.⁴² Of course, other agricultural products should also be added to the total agricultural output, including those from livestock, forestry, and fisheries. The contributions of these sectors to total production are given in Table 1.⁴³ The sum of these sectors and the arable land sector provides an index of agricultural output for the different benchmarks, expressed in terms of 1933 prices in the final column to Table 1.

INDUSTRY

Data on industrial output in Republican China are plentiful. Estimates of industrial output have been provided by Bairoch, Chang, Guan, Kubo, Ou, Liu and Yeh, Perkins, and Rawski.⁴⁴ However, with the exception of Bairoch, who calculated the value of industrial production for several large economies for benchmark years back to 1750, none of these studies extends back before the end of the nineteenth century.⁴⁵ Yet, while Bairoch's study provides the only long-term estimates of Chinese industrial output, the sources of data remain rather ambiguous, and the results on occasion are based on major assumptions. For example, Chinese industrial output in 1750 was assumed to be 10 per cent lower than that of Europe (excluding Russia), and output estimates for 1800, 1860, and 1880 were based on industrial import–export data. In addition to Bairoch, Chang and Liu have presented estimates of industrial output for periods prior to the twentieth century; however, because of source limitations, their estimates are only approximate.⁴⁶

Therefore, we constructed a new industrial output data series, starting with an industrial classification. The classification is important because various existing studies all used different classification schemes. For example, with the exception of Bairoch, who arrived at the value added for industry as a whole, most other estimates for industry value added in Qing China excluded some industrial sectors that are present in modern-day statistics.⁴⁷ Therefore, combining the classifications of Ou, Liu and Yeh, Peng, and Li and Xu, we arrived at a comprehensive classification of manufacturing in Qing China, which consists of 12 sectors, each of which includes various sub-types.⁴⁸ As compared with the classifications of Ou

42 Shi, *Estimation of Production Indicators*.

43 Shi, *Estimation of Production Indicators*.

44 Bairoch, *International Industrialization Levels*; Chang, *The Income of the Gentry*; Guan, *Industrial Production of China*; Kubo, *Industrial Development*; Ou, *National Income of China*; Liu and Yeh, *The Economy of the Chinese Mainland*; Perkins, *Growth and Changing Structure*; Rawski, *Economic Growth*.

45 Bairoch, *International Industrialization Levels*.

46 Bairoch, *International Industrialization Levels*; Chang, *The Income of the Chinese Gentry*; Liu, *Chinese GDP*.

47 Bairoch, *International Industrialization Levels*. For example, Chang, *The Income of the Gentry*; Liu, *Chinese GDP*.

48 Ou, *National Income of China*; Liu and Yeh, *The Economy of the Chinese Mainland*; Peng Z.Y., *Materials of Craft Industry History in Modern China, 1840–1949*; Li and Xu, *Chinese Handcraft Economic History, Ming and Qing*.

and Liu and Yeh for Republican China, we omit for the Qing dynasty electrical appliances, hydropower, and gas, which were small to non-existent during that period.⁴⁹

For each of these sectors, we calculated the total output and linked this output value to the value-added estimates of Liu and Yeh for 1933, with two exceptions.⁵⁰ First, for the construction subsector, we used the upgraded figures of Yeh.⁵¹ Second, for the mining subsector, we relied on the data of Ou, whose estimates are more detailed and complete than those of Liu and Yeh.⁵²

For 1911, we based our data on Guan, who provided an improved production value of industry subsectors reported in *the First Statistical Tables of Agriculture and Commerce* for 1912; the 1912 data can also be used for 1911, as these statistics reported the data for the period from 1911 to 1912.⁵³ From this starting point, we made two modifications. First, we converted all estimates from Guan to 1933 prices using the prices in 1911/1912 taken from *The First Statistical Tables of Agriculture and Commerce* and the prices in 1933 reported by Ou.⁵⁴ Second, Guan completed the missing or incomplete industrial sectors in the *First Statistical Tables of Agriculture and Commerce*, by assuming that growth in these sectors was in line with the 1920s export data.⁵⁵ Because exports were growing faster than domestic production, this caused an overestimate of the growth of industrial output. Therefore, we used various other sources to complete the missing data, details of which are reported in Xu and Zhang.⁵⁶

For the period before 1911, we used various indicators to represent trends in individual subsectors. The indicators are derived from either direct output estimates (e.g. for silk, mining, and ceramics), indirect proxies (e.g. numbers of labourers, numbers of factories, taxation amounts, and consumption), figures of inputs in industrial sectors (e.g. for sawn timber, cotton ginning, cotton yarn, and cotton cloth), or by combining existing proxies with Supporting Information (e.g. by adding service life to the stock of boats, we were able to calculate the replacement rate in relation to the shipbuilding sector).

By linking the resulting volume indices to the 1933 benchmark, we projected the data from the different industrial subsectors backwards. Table 2 compares the results for total industry obtained in this study with the results of three other studies. The results reported by Liu (and by Chang) are much lower than those of the two other studies, because their datasets were more limited.⁵⁷ On the other hand, the

49 Liu and Yeh, *The Economy of the Chinese Mainland*.

50 Liu and Yeh, *The Economy of the Chinese Mainland*.

51 Yeh, *China's National Income*.

52 Ou, *National Income of China*; Liu and Yeh, *The Economy of the Chinese Mainland*.

53 Guan, *Industrial Production of China*.

54 Ou, *National Income of China*.

55 Guan, *Industrial Production of China*.

56 Xu and Zhang, *Re-estimate of Production*.

57 Chang, *The Income of the Chinese Gentry*; Liu, *Chinese GDP*.

Figure 1. Indices of industrial output (1933 = 100).

pre-1800 estimates of Bairoch are more than twice as high as ours, while his post-1800 estimates are lower than ours.

Trends in industrial output for the different subsectors, as determined in this study, are plotted in Figure 1. The trends in most subsectors are consistent with the average trend. The construction index grew more slowly than the average, while metals and mining increased more rapidly, especially after the 1850s, corresponding to the modernization of the Chinese economy. Most importantly, however, we found an upward trend in industrial output since the mid-seventeenth century, a result which contradicts previous findings, such as those presented by Bairoch, who found a strongly declining level of industrialization during this period.⁵⁸

SERVICES

To estimate the value added of services, we used the method proposed by Deane and Cole of subdividing the services into a number of basic categories and linking them to the 1933 value-added shares from Liu and Yeh (see Table 3).⁵⁹

Trade and transport is by far the largest sector in the service industry. The trade and transport index was calculated as the sum of the commercialised shares in

⁵⁸ Bairoch, *International Industrialization Levels*.

⁵⁹ Deane and Cole, *British Economic Growth*; Liu and Yeh, *The Economy of the Chinese Mainland*. A similar method was applied for China by Chang, *The Income of the Gentry*, for a limited number of years. Following Chang's approach, Liu, in *Chinese GDP*, derived estimates for 1600–1840, based on a combination of data sources. Yet, because neither his data nor his benchmark years match our study, we recalculated the service sector independently.

Table 3. Value added share of services in 1933

Commerce	Trade and transport	64.3%
	Finance	3.1%
Government		12.2%
Residential rent		15.3%
Personal services	Domestic	2.2%
	Teachers	0.9%
	Other	2.0%
Total services		100.0%

Sources: Liu and Yeh, *The Economy of the Chinese Mainland*.

agriculture and industry, taken from Xu and Wu.⁶⁰ The value added of financial services was more difficult to calculate. The standard method of estimating the value added of financial services involves estimating the returns and wage bills of financial institutions. However, information on the numbers of banks (*Qianzhuang* 钱庄 and *Piaohao* 票号) is lacking, and only some data are available on pawnshops and on the initial capital employed. Using the initial capital and interest rate from pawn shops, we can arrive at some tentative estimates of capital income, which, when combined with the wages of the total number of employees in these pawn shops, results in the total value added of pawn shops. Assuming that the value added of pawn shops changes in line with the remaining financial services, it is possible to arrive at the total value added in the financial sector.⁶¹ However, because we are considering initial capital, if the financial sector is developing, the difference between initial and total capital will be increasingly large over time, resulting in an underestimate of the growth of finance. Therefore, following Cameron and Mayhew, who noticed that the velocity of money in circulation decreases in a developing financial sector, we used the inverse of the velocity measure.⁶² Because the velocity is primarily calculated for individuals, it is necessary to multiply the velocity by the population so as to obtain the total development of the financial sector. This approach results in higher growth rates in the early Qing dynasty, which confirms the growth in industry and agriculture that we found in previous sections.

Finally, the government sector is based on the deflated government expenditure, the housing sector is based on estimates of house rent by Ou for cities and countryside (projected backwards using the urban and agricultural populations as reported in Section on Population and Urbanisation).⁶³ The personal services

60 Xu and Wu, *History of Capitalism Development in China*.

61 Chang, *The Income of the Chinese Gentry*; Liu, *A Study of the Activities Forms of Usurious Loan Capital in Early Qing*; Liu, *The Usurious Loan Capital of the Ming and Qing Dynasties*.

62 Cameron, *England, 1750–1844*; Mayhew, *Population, Money Supply*. A similar method was also applied by Broadberry *et al.*, *British Economic Growth*, for England.

63 Ou, *National Income of China*.

Figure 2. Indices of service output (1933 = 100).

sector, as in the approach of Chang, is based on the urban population (for domestics) and the gentry group (as *jinshe* (进士), *juren* (举人) and *shengyuan* (生员), for doctors, teachers, and lawyers).⁶⁴

The results for the total service sector output are plotted in Figure 2. Commerce grew at almost exactly the same rate as the average of government services, stagnating until the 1850s and then increasing in the wake of the modernization movement. The housing and personal services sector developed steadily and was interrupted only briefly by the massive population decline during the Taiping rebellion. As indicated in Table 2, little controversy exists regarding the service sector. Our estimates for 1887 are similar to those of Chang, and for the earlier period, trends are roughly identical to those found by Liu.⁶⁵

GDP AND PER CAPITA GDP

To determine the GDP, we linked our indices of agriculture, industry, and services to the 1933 benchmark of Liu and Yeh.⁶⁶ If the structure of the economy was fundamentally changing during this period, the use of the 1933 benchmark may cause an overestimation of the growth of the GDP (the so-called Gerschenkron effect). This effect is caused by giving a greater weight to more rapidly growing sectors. To correct for this potential bias, we changed the weights of the 1850 values for agriculture, industry, and services. However, the use of different weighting factors did not significantly change the results. The results, presented in Figure 3,

⁶⁴ Chang, *The Income of the Chinese Gentry*.

⁶⁵ Chang, *The Income of the Chinese Gentry*; Liu, *Chinese GDP*.

⁶⁶ Liu and Yeh, *The Economy of the Chinese Mainland*.

Figure 3. The gross domestic product and its component sectors (1933 = 100).

show that agriculture grew more slowly than the GDP, services grew much faster than the GDP, and industry grew at about the same rate as the GDP.

The per capita GDP was obtained by dividing the value of the GDP by the population (see Figure 5). To provide a sense of the reliability of the results, we also report the error margins with 95 per cent probability. The error margins are based on Feinstein and Thomas’ subjective margins of error, which have been applied in various studies, among them Van Zanden and Van Leeuwen’s calculation of the GDP for Holland.⁶⁷ The basic approach to calculating the error is to attach subjective margins of error (i.e. 3 per cent for ‘firm estimates’, 10 per cent for ‘good estimates’, 20 per cent for ‘rough estimates’, and 35 per cent for conjectures) to each sub-series within agriculture, industry, and services. Because these error margins are based on 95 per cent probability values, they are equivalent to two standard errors. If the series are constructed independently of one another, these errors may offset each other. Hence, Feinstein and Thomas suggested the use of the following equation to arrive at the overall error margin⁶⁸:

$$\sigma_v = \sqrt{\sigma_x^2 + \sigma_y^2 + 2r_{xy}\sigma_x\sigma_y}$$

That is, the standard error of the overall series is equal to the standard error of each sub-series plus the correlation coefficient of each series. Doing this

67 Van Zanden and Van Leeuwen, *Persistent But not Consistent*; Feinstein and Thomas, *A Plea for Errors*.
68 Feinstein and Thomas, *A Plea for Errors*.

Figure 4. Gross domestic product per capita (1990 GK dollars) and 95% probability error margins.

multiplicatively for all sub-series, we arrived at the overall error margin; the result is reported in Figure 4. The main conclusion is that, even though each individual series has an error, the errors generally offset each other. The resulting error margins, even though substantial, show that the finding of stagnant and decreasing per capita GDP levels is not rejected.

Another way of reviewing the data is by a cross-check. For example the pre-twentieth century data seem to confirm the human height data of Baten *et al.*, as well as the findings of Broadberry, Guan, and Li.⁶⁹ Indeed, Figure 5 indicates a decline in all per capita GDP estimates. However, controversy exists regarding the exact amount of the decline. If we accept the extremely low levels of per capita income of Liu, it seems unlikely that China would have ever dominated the world economy.⁷⁰ On the other hand, if we adopt the more conservative estimates of Broadberry, Guan, and Li, we might conclude that China was overtaken by most southern European countries midway through the eighteenth century (see, e.g. Table 4 for Spain).⁷¹

For the post-1900 period, our compound annual growth rate between 1911 and 1933 was 0.09 per cent, which is lower than the estimate of 0.33 per cent of Yeh, and certainly lower than Rawski's estimate of 1.1 per cent.⁷² Because growth rates in

69 Baten *et al.*, *Evolution of Living Standards*; Broadberry *et al.*, *China, Europe, Liu, Chinese GDP*.

70 Liu, *Chinese GDP*.

71 The exception is Italy, which had higher levels of per capita GDP than those of other southern European countries.

72 Yeh, *China's National Income*; Rawski, *Economic Growth*.

Figure 5. Comparison of estimates of the per capita gross domestic product (in 1990 GK dollars). Sources: This text; Maddison, *Chinese Economic Performance*; Broadberry *et al.*, *China, Europe*; Ma and De Jong, *China's per Capita GDP*; Liu, *Chinese GDP*.

industry and services are usually comparable in this paper and Rawski, the main difference between the estimates is that our output-based estimate of agricultural output grew over this period by roughly 2 per cent, while population grew by almost 14 per cent (see Table 1). The resulting per capita growth of agricultural production is thus much lower than that of Rawski, which is based on the use of several agricultural wage series as proxies for agricultural labour productivity. Of course, it remains difficult to assess the reliability of each study. However, a comparison of the human height data of Ma with the national income of the Yangtze region suggests that, with the exception of the Yangtze itself, stature stagnated or declined between the 1910s and the 1930s, thus suggesting at best, stagnating economic development in China as a whole.⁷³

The decline in the per capita GDP up to the nineteenth century, followed by stagnation, is a pattern that is common in other Asian countries as well, with the exception of Japan. Table 4 shows that in China in 1661, while income levels were the highest in Asia, they were significantly lower than those in north-western Europe. Then, at the start of the eighteenth century, income levels in China fell below those of southern Europe, with the exception of Italy. The main reason for the reversal was the continued decline in the per capita GDP in China, *versus* the

⁷³ Ma, *Economic Growth in the Lower Yangzi Region*. In addition, we need to mention the recent developments in the construction of purchasing power parities (PPP's). The 2011 ICP round has shown that the relative per capita income is upwardly biased (i.e. Chinese price levels in previous ICP rounds were underestimated). Since the 1933 estimate is linked to the previous ICP rounds, changing the ppp to 2011 will result in a reduction in the 1933 benchmark. If this reduced 1933 figure is combined with the rapid growth between 1911 and 1933, an extremely low per capita GDP figure is implied for 1911.

Table 4. Per capita gross domestic product in Asian and European countries (in 1990 GK dollars)

Asia						Europe				
China	India	Java	Indonesia	Japan		England/GB/UK	Holland	Netherlands	Italy	Spain
1661	852	638		557	1,661	1,030	1,978		1,398	687
1685	820	630		592	1,685	1,350	2,250		1,437	751
1724	751	598		615	1,724	1,586	2,239		1,505	799
1766	622	573		596	1,766	1,806	2,718		1,533	783
1812	565	519	507	641	1,812	2,012	2,408	1,800	1,433	916
1850	538	556	462	681	1,850	2,718		2,371	1,481	1,079
1887	572	526	548	696	952	1,887		3,277	1,751	1,585
1911	568	691		836	1,356	1,911	4,709	3,863	2,199	2,017
1933	579	700		938	2,122	1,933	5,277	4,956	2,565	2,486

Sources: This study; Bassino *et al.*, *Japan and the Great Divergence*; Broadberry *et al.*, *India and the Great Divergence*; Van der Eng, *The Sources of Long-term Economic Growth*; Van Zanden, *Economic Growth in Java*; Broadberry *et al.*, *British Economic Growth*; Malanima, *The Long Decline*; Van Zanden and Van Leeuwen, *Persistent but not Consistent*; Alvarez-Nogal and Prados de la Escosura, *The Rise and Fall of Spain*.

Note: The line breaks indicate England (prior to 1700), Britain (1700–1870), and the UK (post 1870).

increase in the per capita GDP in European countries. Various causes for this reversal have been proposed in the literature, including a lack of pasture in China (and hence a lack of capital formation and non-human energy), low wages that inhibited the introduction of capital-intensive machinery, agricultural involution, and the absence of what is called the European marriage pattern.⁷⁴ In this study, we do not address these issues. However, a more detailed examination of the Chinese economy, as well as comparative studies of Asian countries (all of which, with the exception of Japan, share the same pattern of economic decline) may prove useful.

CROSSS CHECK: THE DEMAND SIDE

As noted previously, although it is possible to derive benchmark estimates of the per capita GDP, data scarcity remains a problem; this is true of the historical data for many countries, and is the reason for the use in many cases of indirect demand-based methods to calculate the per capita GDP.⁷⁵ We therefore applied a similar demand-side approach to cross-check our results.

⁷⁴ See, for example, Carmichael and Van Zanden, *Towards an Ethnographic Understanding*.

⁷⁵ See, for example, Malanima, *The Long Decline*; Alvarez-Nogal and Prados de la Escosura, *The Rise and Fall of Spain*.

The first step in this method was to calculate the agricultural demand, which constitutes by far the largest share of the total GDP. This calculation can be made using a demand equation that incorporates population, prices, and an assumed income and price elasticity.⁷⁶ The basic equation used in the method is

$$c = ap^e i^g m^b.$$

where c is the per capita consumption, p is the nominal price of agricultural production, i is the nominal income per capita, m is the nominal price of non-agricultural goods, a is an arbitrary constant, and e , g , and b are the own price, income, and cross-price elasticities, respectively (the elasticities must sum to zero). Hence, p , i , and m can be expressed in real terms by normalising to the consumer price index C , such that

$$Q = rcN = raP^e I^g M^b N,$$

where Q is the agricultural output, $P = p/C$ (the real price of agricultural products), $I = i/C$ (the real income per head), $M = m/C$ (the real price of non-agricultural products), N is the total population, and r is the ratio of total agricultural production to total agricultural consumption (i.e. the percentage of agricultural imports). The equation for Q is subject to various biases. First, most of the wages in use are day wages, suggesting a constant number of working days. This assumption has been defended by Dasgupta and Bishwanath and Malanima, who claim that in pre-modern societies, people traded off income with work hours; that is, if incomes declined, people worked more, or women had to increase levels of commercial activity.⁷⁷ Second, values of r , own price income and cross price elasticity must be defined. For r , the standard assumption for earlier times is that $r = 1$; that is, representing a balance between imports and exports. Especially for China, which, due to its large size and very limited proportion of exports to total production, this assumption is reasonable. More importantly, values of elasticities must also be defined. In present-day developing countries, where per capita incomes are roughly comparable to those in the top historical countries, income elasticities of 0.8 and own price elasticities of approximately -0.6 have been proposed.⁷⁸ However, because of their cross-sectional nature and focus on food rather than staples, these values are probably slightly high. Therefore, Allen defined the own price, income, and cross-price elasticity values as -0.6 , 0.5 , and 0.1 , respectively.⁷⁹ Malanima, however, set these values slightly lower for early modern Italy (-0.5 , 0.4 , and 0.1 , respectively), based on calibrations after 1861, for which both direct estimates and demand-side estimates were available.⁸⁰ On the other hand, Alvarez-Nogal and Prados de la Escosura for Spain, and Kaneda for Japan, defined income

76 See, for example, Allen, *Economic Structure*.

77 Dasgupta and Bishwanath, *Female Labour Supply*; Malanima, *The Long Decline*.

78 Lluch *et al.*, *Patterns in Household Demand*.

79 Allen, *Economic Structure*.

80 Malanima, *The Long Decline*.

elasticity as 0.3 and own price elasticity as -0.4 .⁸¹ For China, we prefer a lower elasticity value, because rice as a staple is unlikely to have a high elasticity, and because comparable Asian countries such as Japan also exhibit similar elasticity values.

Price and wage data for Beijing for the period of 1738–1922 are available from Allen *et al.*⁸² We used the subsistence basket as the consumer price index. Agricultural prices were based on the prices of wheat, sorghum, and rice, where rice prices were weighted at 50 per cent. For non-agricultural prices, we used soap, candles, lamp oil, fuel, and cloth, where cloth prices were weighted at 50 per cent. The previous procedure results in an estimate of agricultural output, to which we added the contributions of non-agricultural sectors. In many studies, the non-agricultural sectors for the period before 1918 are proxied using the urbanisation rate. We followed the same approach, using the urbanisation values of Xu *et al.*, and weighting these values by the share of services and industry in the total GDP for the benchmark year 1933.⁸³ However, using urbanisation as a proxy for non-agricultural sectors in the GDP suffers from some biases. For example, populations living in rural towns might still be working largely in agricultural occupations. Also, non-agricultural sectors may be better proxied by agricultural output than by the urbanisation rate. In both of these cases, the circumstances imply that the use of the urbanisation rate as a proxy for non-agricultural sectors may result in overweighting of the non-agricultural sectors in GDP. Rural non-agricultural employment is also a factor that may substantially bias the data in China and cause an underestimate in the weighting of urbanisation.⁸⁴ In summary, it seems reasonable to assume that the biases in the use of urbanisation balance themselves out; thus, we used the 1933 weighting of industry and services and linked this to the urbanisation ratio.

Our results are presented in Figure 6. The benchmarks seem to match our data well, with the largest deviation is preferable to view them as an approximate mean of previous and future years. As such, we are occurring in 1812. We must emphasise, however, that output-based benchmarks are only approximations for a given year, and it inclined to believe that the demand-side approach gives a fair representation. The most remarkable finding is the decline in GDP per capita in 1854 of about 23 per cent. This decline, which took place during the Taiping Rebellion (1850–64), is difficult to explain as the data are for Beijing, where the rebellion never reached. Nevertheless, as this decline is borne out by the real wage data, and more specifically by prices and inflation, as Peng pointed out, one may speculate that the rebellion nevertheless affected prices of foodstuffs and caused serious currency inflation in Beijing as well.⁸⁵

81 Alvarez-Nogal and Prados de la Escosura, *The Rise and Fall of Spain*; Kaneda, *Long-term Changes*.

82 Allen *et al.*, *Wages, Prices and Living Standards*.

83 Xu, *et al.*, *Urbanisation in China*.

84 See, for example, Rosenthal and Bin Wong, *Before and Beyond Divergence*.

85 Peng, *Change of Prices and Wages in Modern Beijing*.

Figure 6. Comparison of the per capita GDP using demand-based and output-based approaches (in 1990 GK dollars).

Even though the demand side approach does allow us to track the general pattern of per capita GDP, one must use these data with care, as wage and price data are obtained from records kept in Beijing, which may or may not have incurred the effects of specific events, such as the rebellion, or perhaps incurred the events at a later time.

CONCLUSIONS

In recent decades, GDP calculations have been increasingly used as a measure of economic performance and well-being, even for civilizations that existed over two millennia ago.⁸⁶ Yet, few estimates of Chinese historical GDP values are available, mainly because of a lack of data. In this study, we contributed to the body of GDP estimates, not only by gathering a large amount of secondary information, but also by supplying new historical evidence related to the Chinese economy.

While the quality of the data remains limited, we nevertheless found that, in line with a variety of other studies, as well as with height and wage studies, the per capita GDP declined from the mid-seventeenth century onwards.⁸⁷ This decline, which is confirmed by a demand approach, also occurred in other Asian countries (except for Japan) and was driven mainly by population growth during the Qing dynasty. The circumstance is similar to that in pre-modern England, which also witnessed population growth accompanied by a stagnating or even declining per capita GDP. The main difference between the two is that England emerged from this deadlock during the industrial revolution, but China did not.

An important question, which is not answered by this study, is why China did not emerge from this period of stagnation in the nineteenth century. Indeed, rather than

⁸⁶ Foldvari and Van Leeuwen, *Comparing per Capita Income*.

⁸⁷ Broadberry *et al.*, *China, Europe, Ma and De Jong*, *China's per Capita GDP*.

being caused by increasing industrialisation as was the case in England, the decline in per capita GDP in China halted in the middle of the nineteenth century, mainly on account of declining population growth rates. The reason that this led to stagnation rather than growth of the per capita income was that the decline in population growth was accompanied by a significant decline in the growth of agricultural production. Various arguments for this growth pattern have been proposed, related to climate shocks, lack of capital accumulation, lack of market efficiency, culture, and the like, but no decisive conclusion has yet been reached, because of a lack of evidence on the growth patterns of the Chinese economy.⁸⁸ The per capita GDP estimates provided by this study therefore contribute to resolving some of the larger questions related to the history of economic growth, both in China and worldwide.

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88 See for example, Broadberry, *Accounting for the Great Divergence*; Pomeranz, *The Great Divergence*; Landes, *Why Europe and the West*.

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Appendix I

There are various alternative estimates of the yield of food crops. As mentioned in the text, Perkins' estimates, which were based on the correction-method method, are lower than those obtained in this study and by Wu and Guo.⁸⁹ While both Wu and Guo's yields present the same trends as those detected in this study, the yields obtained in this study are higher than those obtained by Wu but lower than those obtained by Guo. These differences are attributable to different numbers of yield observations collected in the different studies.

Table A1. Average yield of food crops (jin/mu)

Year	This study	Perkins	Wu	Guo Songyi
1661	258			
1685	266			
1724	281		369	
1750			385	
1766	310			310
1770		203		
1784				315
1812	326			319
1850	326	243		
1887	310			287
1911	295			
1933	280	242		

Sources: The datasets are from data of Perkins, *Agricultural Development*; Wu, *Grain Yield per Mu*; Guo, *Food Production and Living Standard*.

89 Wu, *Grain Yield per Mu*; Guo, *Food Production*.