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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 (GDP) during the period of 1661–1933. We found a persistent decline in the per capita GDP between the 17th and 19th 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.**

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## 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[2], economic catch-up and convergence[3], and factors driving growth.[4] It is therefore not surprising that attention was given to Chinese national accounting at a relatively early stage, with Colin Clark[5] being one of the first scholars to attempt a reconstruction of China's national income, based on real wage data for the period 1925–1934. 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.[6]

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 vs. 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.*[7] The estimates of Ou *et al.* were then revised by Liu and Yeh[8], 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. For example,

2 Van Zanden *et al.*, *Global Well-Being*.
3 Broadberry *et al.*, *China, Europe.*
4 Mokyr, *The Lever of Riches.*
5 Clark, *The Condition.*
6 Deng and O'Brien, *China's GDP per Capita from the Han Dynasty*.
7 Ou *et al.*, *National Income of China*; Ou, *Correction on National Income of China.*
8 Liu and Yeh, *The Economy of the Chinese Mainland.*

Maddison[9] used it in his famous work on Chinese long-term growth. 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 urbanization 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[10] examined national income in the 1880s and Perkins[11] and Rawski[12] examined national income during 1914–1918. Even more ambitious scholars, such as Liu, Broadberry *et al.* and Maddison[13], tentatively extended their historical GDP 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.

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[14]. However, this position was opposed by other scholars, who claimed that the Chinese economy had already been surpassed by

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9 Maddison, *Chinese Economic Performance*.

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

11 Perkins, *Growth and Changing Structure*.

12 Rawski, *Economic Growth*.

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

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

the economies of Europe centuries earlier.[15] The latter studies show trends roughly similar to those found in the earlier studies of Bairoch and Maddison[16], which suggested that the Chinese economy had entered a stagnating or downward economic trend sometime between the Sung and Qing dynasties. However, all of the studies mentioned above 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 20th century, in 2008 we launched a research project led by Prof. 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 industry archives, local and special gazetteers (*Xiangtuzhi,* 乡土志), stone inscriptions and private notebooks.[17]

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[15] 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 e.g. Liu, *Chinese GDP;* Ma and De Jong, *China's per Capita GDP*; Broadberry *et al.*, *China, Europe and the Great Divergence*.

[16] 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.

[17] 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*

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.[18] 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 organized as follows. In Section 2, we discuss population and urbanization. Sections 3, 4, 5 and 6 address agriculture, industry, services and total GDP, respectively. Consistent with Maddison[19], 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 18th century. This result is cross-checked in Section 7, using a demand approach that results in virtually identical estimates to that of the output approach used in the first sections. Finally, a brief summary and conclusions are presented in Section 8.

## POPULATION AND URBANIZATION

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 to the official figures by applying the

*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.*, *Urbanizaton in China*, on urbanization; and Ni *et al.*, A Study on the Historical Quantification.

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

19 Maddison, *Chinese Economic Performance.*

data of various researchers.[20] Cao (2001) and Shi (2012)[21] recently conducted highly detailed analyses of the Chinese population, and their adjusted numbers were for the years 1661, 1776, 1820 and 1911. The numbers of Liu and Yeh (which are similar to those of Maddison) were used for 1933.[22] The remaining benchmarks, in 1685, 1724, 1850 and 1887, were interpolated based on the population growth ratios of Cao.[23]

**Table 1. Adjusted population figures for 1661–1933 (in millions).**

| Year | 1661 | 1685 | 1724 | 1766 | 1812 | 1850 | 1887 | 1911 | 1933 |
|---|---|---|---|---|---|---|---|---|---|
| Population Size | 120 | 146 | 202 | 286 | 369 | 436 | 436 | 439 | 500 |
| Urbanization (%) | 10.5 | 9.8 | 8.6 | 7.3 | 7.0 | 7.0 | 7.0 | 11.3 | 15.0 |

Table 1 lists the population estimates used in this study, which, as noted above, are comparable to 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% during the period of 1661–1933, a figure comparable to growth rates in pre-Industrial England, excluding recurring population declines due to plagues and famines[24], which also affected pre-Qing China. 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, decreasing tax burdens and a decline in the total number of disasters, all of which were factors affecting population growth during the Qing dynasty.[25]

[20] For example Deng, *Unveiling China's True Population Statistics*; Liang, *Chinese Historical Population*; Maddison, *Chinese Economic Performance.*
[21] Cao, *Chinese Population History;* Shi, *Re-estimation of Yields*.
[22] Liu and Yeh, *The Economy of the Chinese Mainland.*
[23] Cao, *Chinese Population History.*
[24] Broadberry *et al.*, *British Economic Growth.*
[25] Deng, *China's Population Expansion*.

Rising population also likely generated a higher urbanization ratio, which is often used as a partial proxy for trends in income in non-agricultural sectors. The urbanization ratios reported in Table 1 are for cities of over 2000 inhabitants, a definition that was first used in the 1953 Chinese census to characterize a residential area as a city.[26] Our estimates for the years 1776–1893 were taken from Xu *et al.*[27], who based their data, with minor modifications, on Cao (2001).[28] These estimates are comparable to those of Skinner (1977)[29]; however, Cao is clearer about his sources, and his estimates are therefore preferred. For 1644, 1850 and 1918, Xu *et al.* (2014)[30] obtained their information from various gazetteers and from the 1918 countrywide Christian survey. For 1933, the most reliable countrywide survey on the size of the urban population was conducted by Notestein and Qiao Qiming.[31] 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)[32], we arrived at a non-agricultural urban population ratio for 1933.

## AGRICULTURE

Historically, agriculture has been by far the largest sector in the Chinese economy. In 1933, agricultural output made up ~60% of the total GDP[33], and its share was even higher in preceding centuries. During the Qing dynasty, 65% of the GDP in China was attributable to agricultural produce, and close to 80% 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

[26] Rozman, *Urban Networks*, is in this case an exception: he used 3,000 inhabitants as the lower limit.
[27] Xu *et al.*, *Urbanization in China*.
[28] Cao, *Chinese Population History.*
[29] Skinner, *The City.*
[30] Xu *et al.*, *Urbanization in China*.
[31] See Buck, *Land Utilization in China.*
[32] National Bureau of Statistics, *The Compilation of Historical Statistics of All Provinces, Autonomous Regions and Municipalities Directly Under The Central Government, ca.1949-1989*.
[33] See e.g. Liu and Yeh, *The Economy of the Chinese Mainland;* Ou, *National Income of China.*

remains about the absolute land area (see Table 2), as the available statistics refer to tax units rather than actual amounts of land in production. Therefore, various authors 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[34], who, in turn, followed the approach of Zhang.[35] 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, 1735–1795). 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[36] and Guo[37] for the amount of agricultural land are much lower than those obtained by most other scholars. 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 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[38], is to work backwards from a "solid" modern benchmark. 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. 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

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[34] Guo, *Food production*.
[35] Zhang, *Re-estimation of Population Size*.
[36] Zhang, *Re-estimation of Population Size*.
[37] Guo, *Food Production*.
[38] Perkins, *Agricultural Development.*

**Table 2. Total area of cultivated land (units of 10,000 mu).**

| | This study | Ho | Perkins | Zhang | H. Wu | Guo Songyi | Wang | C. Wu | Wu & Xu |
|---|---|---|---|---|---|---|---|---|---|
| 1661 | 71,737 | | | | | | | | 57,500 |
| 1685 | 82,339 | | 74,000 | | | | 74,000 | | |
| 1724 | 99,749 | | | | 89,000 | | | | |
| 1750 | | | | | | | 90,000 | | |
| 1766 | 107,062 | | | | | 103,611 | | | |
| 1770 | | | 95,000 | | 95,000 | | 95,000 | | |
| 1784 | | | | | | 100,935 | | | |
| 1812 | 117,746 | | | 105,026 | | 105,044 | | 79,150 | 78,893 |
| 1850 | 132,042 | | | | | | 121,000 | | |
| 1851 | | | | 107,685 | | | | | |
| 1873 | | | 121,000 | | | | 121,000 | 114,510 | |
| 1887 | 138,939 | 73,691 | | 112,596 | | 112,596 | | 94,570 | 92,488 |
| 1893 | | | 124,000 | | | | 124,000 | 118,890 | |
| 1911 | 145,823 | | | | | | | | |
| 1913 | | | 136,000 | | | | 136,000 | 126,790 | |
| 1914 | | | | 125,927 | | | | | |
| 1933 | 153,400 | | 147,000 | | | | 153,400 | 140,470 | |
| 1929–1946 | | | | 141,696 | | | | | |

*Sources:* Datasets (from Appendix A) include data from Guo, *Food Production;* Ho, *Study and Evaluation of Land Figures;* Perkins, *Agricultural Development;* Wang, *Land Taxation in Imperial China;* Wu, *Study of Agricultural Productivity*; Wu, *Grain Yield per Mu*; Wu and Xu, *History of Capitalist Development;* Zhang, *Re-estimation of Population Size*.

benchmark, he used Buck's land classification for the early 1930s[39] and figures provided by the State Statistical Bureau for 1957.

In our study, we utilized the work of Shi[40], who started from nineteenth and twentieth century benchmarks using a method similar to that of Perkins. 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 three years after

[39] Buck, *Land Utilization in China.*
[40] Shi, *Estimate of Arable Area*; Shi, *Re-estimation of Cultivated Land*; Shi, *Re-estimation of Yield and Output*; Shi, *Estimation of Production Indicators*.

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[41], which we took as our point of departure. 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.[42] Our results are presented in Table 3, along with the 1933 data obtained by Liu and Yeh.[43]. We found an increase of ~8% of land under cash crop cultivation in 1661 to 15% in 1933, with most of the increase occurring near the turn of the nineteenth century.

**Table 3. Amount of land cultivated for food and cash crops during 1661–1933 (in mu).**

| | Total cultivated land | Food crop cultivation | Cash crop cultivation |
|---|---|---|---|
| 1661 | 717,824,000 | 660,398,080 | 57,425,920 |
| 1685 | 823,296,000 | 757,432,320 | 65,863,680 |
| 1724 | 997,376,000 | 917,585,920 | 79,790,080 |
| 1766 | 1,070,962,759 | 963,866,483 | 107,096,276 |
| 1812 | 1,177,953,103 | 1,024,819,200 | 153,133,903 |
| 1850 | 1,319,900,690 | 1,148,313,600 | 171,587,090 |
| 1887 | 1,388,905,412 | 1,180,569,600 | 208,335,812 |
| 1911 | 1,458,296,471 | 1,239,552,000 | 218,744,471 |
| 1933 | 1,534,000,000 | 1,296,997,000 | 237,003,000 |

*Sources:* 1933 data obtained from Liu and Yeh, *The Economy of the Chinese Mainland*; remainder, this text.

As noted above, calculations of total agricultural output require information about cultivated

[41] Liu and Yeh, *The Economy of the Chinese Mainland.*
[42] 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.
[43] Liu and Yeh, *The Economy of the Chinese Mainland.*

land as well as yields. In general, yields can be determined using two methods. In one method, used by Perkins[44], one assumes the food consumption per person and multiplies this value by the total population. 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[45] have so far provided the most widely accepted historical average yield values for China. 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 1000 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 ~3,000 yield observations taken from Shi[46], representing yields of both rice and other crops, and covering ~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. The average yield was calculated by dividing the cultivated land of China into four categories, i.e. 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.[47]

Table 4 compares average yields obtained using different approaches. As mentioned above,

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[44] Perkins, *Agricultural development.*
[45] Wu, *Grain Yield per Mu*; Guo, *Food Production*.
[46] Shi, *Re-estimation of Yields*; Shi, *Estimation of Production Indicators*.
[47] For the late nineteenth century, we lack information on new high-yield food crops, such as sweet potatoes and corn. Fortunately, Wu Hui (1985) estimated that these new food crops increased the average yield by ~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.

Perkins' estimates, which were based on the first method, are lower than those obtained in this study and by Wu and Guo.[48] 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 4. 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 (from Appendix A) are from data of Perkins, *Agricultural Development;* Wu, *Grain Yield per Mu*; Guo, *Food Production and Living Standard.*

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[49] for 1933 gives the value added in food crops, expressed in 1933 prices. 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 allows us, based on the acreage of cash crops, to calculate an index for the cash crop sector for the period prior to 1850.[50] Of course, other agricultural products should also be added to the

[48] Wu, *Grain Yield per Mu*; Guo, *Food Production*.
[49] Liu and Yeh, *The Economy of the Chinese Mainland.*
[50] Shi, *Estimation of Production Indicators*.

total agricultural output, including those from livestock, forestry and fisheries. The contributions of these sectors to total production are given in Table 5[51] (based on Shi; also see Appendix A).[52] 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 (see Table 6).

**Table 5. Livestock, forestry and fisheries as a percentage of the total agricultural yield.**

| Year | Livestock | Forestry | Fisheries | Total |
|---|---|---|---|---|
| 1661 | 8.8 | 3.1 | 2.5 | 14.4 |
| 1766 | 7.7 | 2.9 | 2.2 | 12.8 |
| 1850 | 7.2 | 2.8 | 1.7 | 11.7 |
| 1911 | 7.1 | 2.7 | 1.9 | 11.7 |
| 1933 | 7.1 | 3.1 | 2.1 | 12.4 |

**Table 6. Index of total agricultural output (1933 = 100).**

| Year | Index |
|---|---|
| 1661 | 42 |
| 1685 | 49 |
| 1724 | 62 |
| 1766 | 73 |
| 1812 | 84 |
| 1850 | 94 |
| 1887 | 96 |
| 1911 | 98 |
| 1933 | 100 |

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.[53] However, with the exception of Bairoch[54], who calculated the value of industrial production for several large

[51] Ibidem.
[52] Ibidem.
[53] 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.*
[54] Bairoch, *International Industrialization Levels.*

economies for benchmark years back to 1750, none of these studies extends back before the end of the 19th century. 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% 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[55] have presented estimates of industrial output for periods prior to the twentieth century; however, due to source limitations, their estimates are only approximate.

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[56], 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.[57] Therefore, combining the classifications of Ou, Liu and Yeh, Peng, and Li and Xu[58], we arrived at a comprehensive classification of manufacturing in Qing China, which consists of 12 sectors, each of which includes various sub-types. As compared with the classifications of Ou and Liu and Yeh[59] for Republican china, we omit for the Qing dynasty electrical appliances, hydropower and gas, which were small to non-existent during that period (see appendix B, Table B1).

For each of these sectors, we calculated the total output and linked this output value to the value-added estimates of Liu and Yeh[60] for 1933, with two exceptions. First, for the construction subsector, we used the upgraded figures of Yeh.[61] 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.[62]

For 1911, we based our data on Guan[63], who provided an improved production value of industry subsectors reported in *the First Statistical Tables of Agriculture and Commerce* for 1912;

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55 Bairoch, *International Industrialization Levels*; Chang, *The Income of the Chinese Gentry;* Liu, *Chinese GDP.*
56 Bairoch, *International Industrialization Levels*.
57 For example Chang, *The Income of the Gentry;* Liu, *Chinese GDP.*
58 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*.
59 Ibidem.
60 Liu and Yeh, *The Economy of the Chinese Mainland*
61 Yeh, *China's National Income.*
62 Ou, *National Income of China*; Liu and Yeh, *The Economy of the Chinese Mainland.*
63 Guan, *Industrial Production of China*.

the 1912 data can also be used for 1911, as these statistics reported the data for the period from 1911 to 1912. 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[64]. Second, Guan[65] 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. Since 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.[66]

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 supplemental 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). More details of these estimates can be found in Appendix B.

By linking the resulting volume indices to the 1933 benchmark, we projected the data from the different industrial subsectors backwards (see Appendix B for details). Table 7 compares the results for total industry obtained in this study with the results of three other studies. The results reported by Chang (1962) and Liu (2010)[67] are much lower than those of the two other studies, because their datasets were more limited. On the other hand, the pre-1800 estimates of Bairoch are more than twice as high as ours, while his post-1800 estimates are lower than ours.

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[64] Ou, *National Income of China.*
[65] Guan, *Industrial Production of China*.
[66] Xu and Zhang, *Re-estimate of Production*.
[67] Chang, *The Income of the Chinese Gentry;* Liu, *Chinese GDP.*

**Table 7. Comparison of estimates of industrial output in China obtained in different studies (in 1990 GK dollars).**

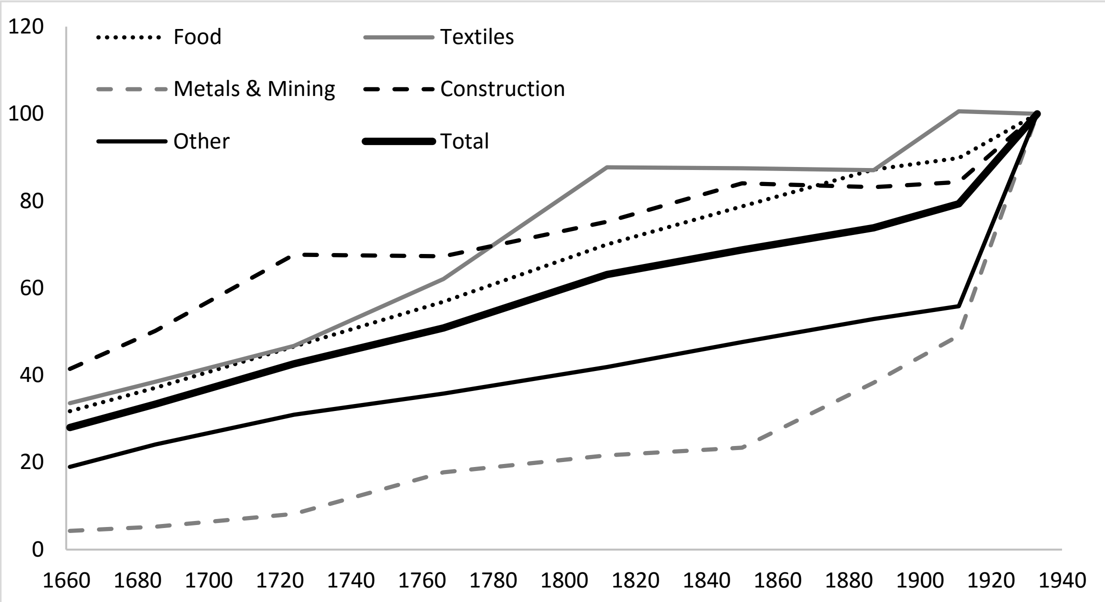
| Year | This text | Bairoch | Chang | Liu |
|---|---|---|---|---|
| 1660 | | | | 5,839,285,714 |
| 1661 | 7,448,857,175 | | | |
| 1680 | | | | 8,666,666,667 |
| 1685 | 8,860,102,090 | | | |
| 1720 | | | | 11,288,983,051 |
| 1724 | 11,322,586,958 | | | |
| 1750 | | 27,588,404,408 | | 12,537,500,000 |
| 1760 | | | | 11,800,481,928 |
| 1766 | 13,520,972,945 | | | |
| 1800 | | 13,702,106,081 | | 14,458,191,489 |
| 1810 | | | | 14,692,647,059 |
| 1812 | 16,787,047,633 | | | |
| 1840 | | 12,527,639,846 | | 16,636,111,111 |
| 1850 | 18,276,506,029 | | | |
| 1860 | | 7,690,778,441 | | |
| 1880 | | 7,690,778,441 | 8,685,131,517 | |
| 1887 | 19,641,790,403 | | | |
| 1911 | 21,094,637,590 | 5,480,842,433 | | |
| 1933 | 26,588,083,386 | 6,706,358,800 | | |

*Sources:* this study; Bairoch, *International Industrialisation Levels*; Chang, *The Income of the Gentry;* Liu, *Chinese GDP*.

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-17$^{th}$ century, a result which contradicts previous findings, such as those presented by Bairoch[68], who found a strongly declining level of industrialization during this period.

[68] Bairoch, *International Industrialization Levels*.

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




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 8 and Appendix C).[69]

**Table 8. 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.*

[69] 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, since neither his data nor his benchmark years match our study, we recalculated the service sector independently.

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 commercialized shares in agriculture and industry, taken from Xu and Wu.[70] 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.[71] 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.[72] 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 (see Table C1 and Appendix C).

Finally, the government sector is based on the deflated government expenditure, the housing sector is based on estimates of house rent by Ou[73] for cities and countryside (projected backwards using the urban and agricultural populations as reported in Section 2) and the personal services sector, as in the approach of Chang[74], 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

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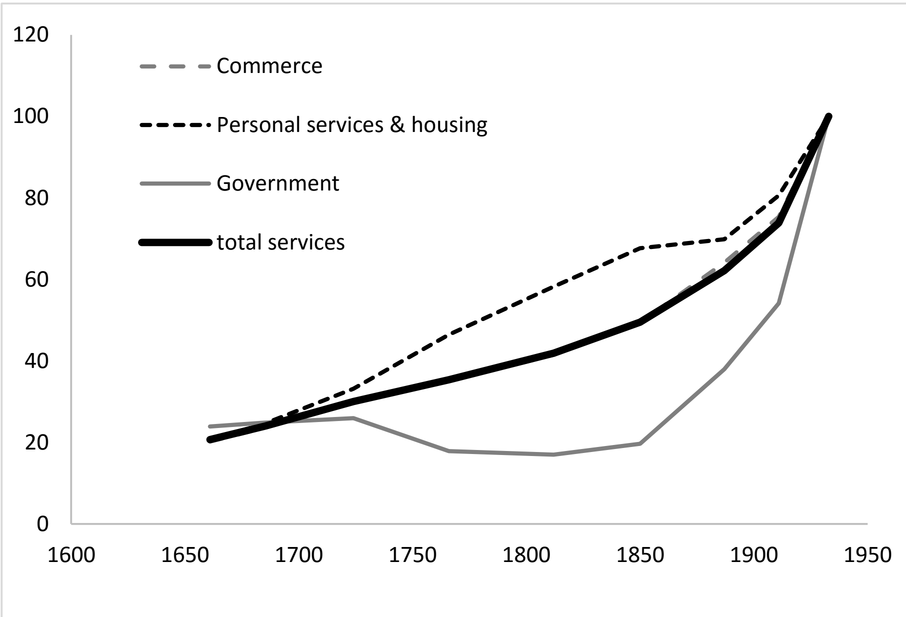
[70] Xu and Wu, *History of Capitalism Development in China*.
[71] Chang, *The Income of the Chinese Gentry*; Liu*, A Study of the A*ctivities *Forms of Usurious Loan Capital in Early Qing*; Liu, *The Usurious Loan Capital of the Ming and Qing Dynasties*.
[72] Cameron, *England, 1750–1844*; Mayhew, *Population, Money Supply*.
A similar method was also applied by Broadberry *et al.*, *British Economic Growth,* for England.
[73] Ou, *National Income of China*.
[74] Chang, *The Income of the Chinese Gentry.*

lawyers).

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 9, 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.[75]

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




[75] Chang, *The Income of the Chinese Gentry.;* Liu, *Chinese GDP.*

**Table 9. Value added of services, as reported in different studies (in 1990 dollars).**

| year | This text | Chang | Liu |
|---|---|---|---|
| 1660 | | | 13,285,714,286 |
| 1661 | 13,528,711,912 | | |
| 1680 | | | 18,333,333,333 |
| 1685 | 15,651,138,784 | | |
| 1720 | | | 21,925,423,729 |
| 1724 | 19,618,154,996 | | |
| 1750 | | | 25,181,250,000 |
| 1760 | | | 23,371,084,337 |
| 1766 | 23,079,438,672 | | |
| 1800 | | | 28,949,468,085 |
| 1810 | | | 29,627,647,059 |
| 1812 | 27,355,226,059 | | |
| 1840 | | | 34,891,666,667 |
| 1850 | 32,303,695,027 | | |
| 1860 | | | |
| 1880 | | 38,614,538,366 | |
| 1887 | 40,543,493,393 | | |
| 1911 | 48,185,873,862 | | |
| 1933 | 65,257,997,590 | | |

*Sources:* this study; Chang, *The Income of the Gentry*; and Liu, *Chinese GDP.*

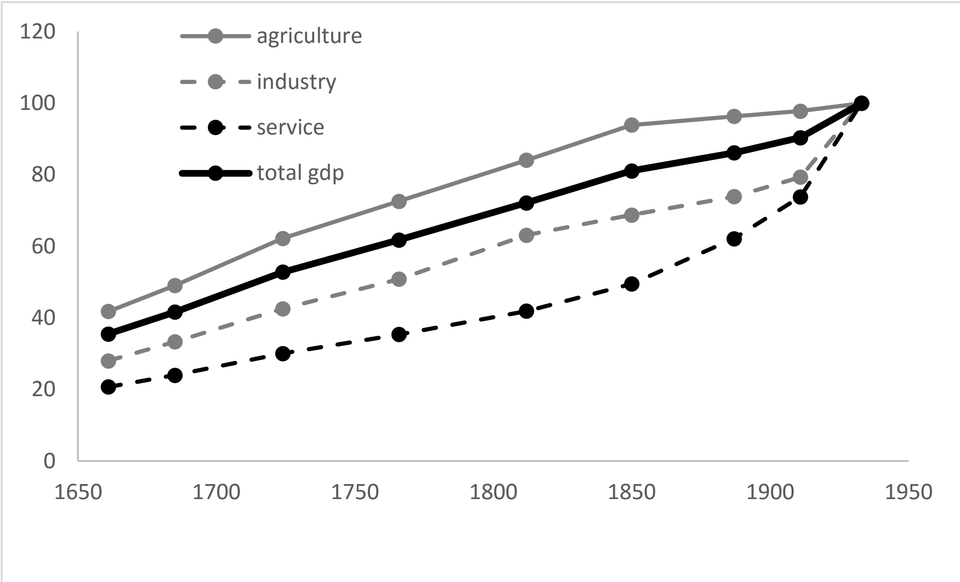
## GDP AND PER CAPITA GDP

To determine the GDP, we linked our indices of agriculture, industry and services to the 1933 benchmark of Liu and Yeh.[76] 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 (the prices are given in Appendix D). However, the use of different weighting factors did not significantly change the results. The results, presented in Figure 3, show that agriculture grew more slowly than the GDP, services grew much faster than the GDP and

[76] Liu and Yeh, *The Economy of the Chinese Mainland.*

industry grew at about the same rate as the GDP.

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




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% probability. The error margins are based on Feinstein and Thomas'[77] subjective margins of error, which have been applied in various studies, among them Van Zanden and Van Leeuwen's[78] calculation of the GDP for Holland. The basic approach to calculating the error is to attach subjective margins of error (i.e. 3% for 'firm estimates', 10% for 'good estimates', 20% for 'rough estimates', and 35% for conjectures) to each sub-series within agriculture, industry and services. Since these error margins are based on 95% 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 (2001) suggested use of the following equation to arrive at the overall error margin:

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

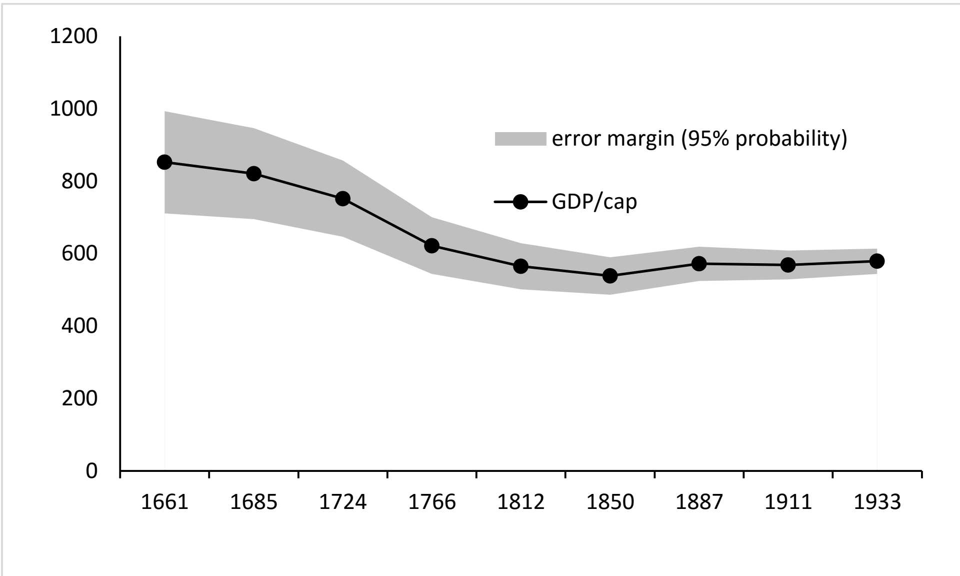
That is, the standard error of the overall series is equal to the standard error of each sub-series plus the correlation coefficient of each series. Doing this multiplicatively for all sub-series, we

[77] Feinstein and Thomas, *A Plea for Errors*.
[78] Van Zanden and Van Leeuwen, *Persistent But not Consistent*.

arrived at the overall error margin; the result is reported in Figure 5. 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.

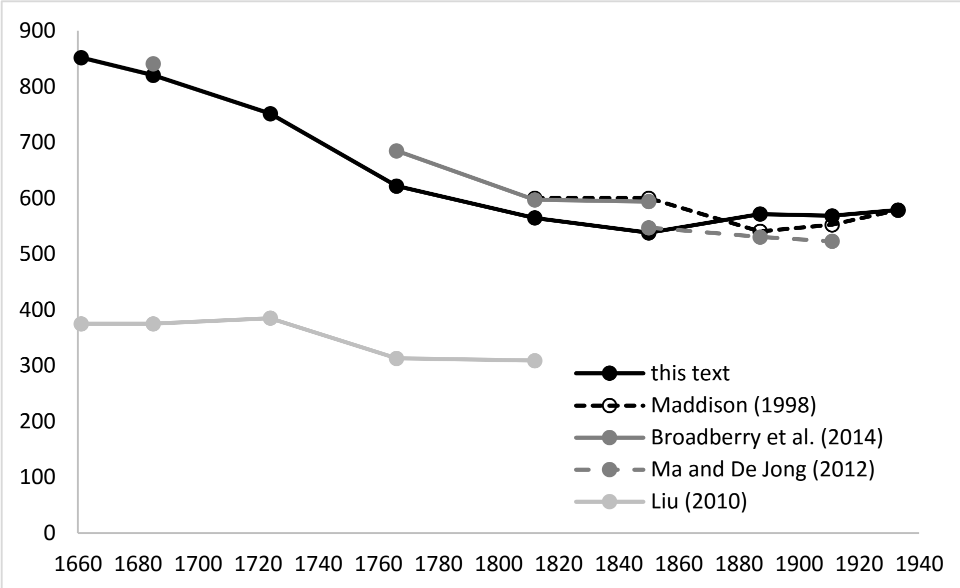
Another way of reviewing the data is by a cross-check. For example the pre-twentieth century data seem to confirm the human height data of Baten *et al.*, as well as the findings of Broadberry, Guan and Li.[79] Indeed, Figure 5 indicates a decline in all per capita GDP estimates. However, controversy 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. 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 18th century (see e.g. Table 11 for Spain).[80]

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




[79] Baten *et al.*, *Evolution of Living Standards*; Broadberry *et al.*, *China, Europe*.
[80] The exception is Italy, which had higher levels of per capita GDP than those of other southern European countries.

**Figure 5. Comparison of estimates of the per capita gross domestic product (GDP) (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.*

For the post-1900 period, our compound annual growth rate between 1911 and 1933 was 0.09%, which is lower than the estimate of 0.33% of Yeh, and certainly lower than Rawski's estimate of 1.1%.[81] Since growth rates in 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% (see Table 6), while population grew by almost 14% (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 (2008) 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.[82]

[81] Yeh, *China's National Income*; Rawski, *Economic Growth*.

[82] 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

The decline in the per capita GDP up to the 19th century, followed by stagnation, is a pattern that is common in other Asian countries as well, with the exception of Japan. Tables 10 and 11 show 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 18th 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 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.[83] 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.

**Table 10. Per capita gross domestic product (GDP) in Asian countries (in 1990 GK dollars).**

| | China | India | Java | Indonesia | Japan |
|---|---|---|---|---|---|
| 1661 | 852 | 638 | | | 557 |
| 1685 | 820 | 630 | | | 592 |
| 1724 | 751 | 598 | | | 615 |
| 1766 | 622 | 573 | | | 596 |
| 1812 | 565 | 519 | 507 | | 641 |
| 1850 | 538 | 556 | 462 | | 681 |
| 1887 | 572 | 526 | 548 | 696 | 952 |
| 1911 | 568 | 691 | | 836 | 1,356 |
| 1933 | 579 | 700 | | 938 | 2,122 |

*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*.

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.

[83] See for example, Carmichael and Van Zanden, *Towards an Ethnographic Understanding*.

**Table 11. Per capita gross domestic product (GDP) in Europe (1990 GK dollars).**

| | England/GB/UK | Holland | Netherlands | Italy | Spain |
|---|---|---|---|---|---|
| 1661 | 1,030 | 1,978 | | 1,398 | 687 |
| 1685 | 1,350 | 2,250 | | 1,437 | 751 |
| 1724 | 1,586 | 2,239 | | 1,505 | 799 |
| 1766 | 1,806 | 2,718 | | 1,533 | 783 |
| 1812 | 2,012 | 2,408 | 1,800 | 1,433 | 916 |
| 1850 | 2,718 | | 2,371 | 1,481 | 1,079 |
| 1887 | 3,713 | | 3,277 | 1,751 | 1,585 |
| 1911 | 4,709 | | 3,863 | 2,199 | 2,017 |
| 1933 | 5,277 | | 4,956 | 2,565 | 2,486 |

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

*Sources:* 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*.

CROSSS CHECK: THE DEMAND SIDE

As noted above, 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.[84] We therefore applied a similar demand-side approach to cross-check our results.

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.[85] 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

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

[85] See for example, Allen, *Economic Structure*.

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 normalizing 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; i.e. if incomes declined, people worked more, or women had to increase levels of commercial activity.[86] 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; i.e. 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.[87] However, because of their cross-sectional nature and focus on food rather than staples, these values are probably slightly high. Therefore, Allen (2000) defined the own price, income and cross-price elasticity values as –0.6, 0.5 and 0.1, respectively.[88] Malanima[89], 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. On the other hand, Alvarez-Nogal and Prados de la Escosura (2013) for Spain, and Kaneda for Japan, defined income elasticity as 0.3 and own price elasticity as –0.4.[90] For China, we prefer a lower elasticity value, since rice as a staple is unlikely to have a high elasticity, and since comparable Asian

86 Dasgupta and Bishwanath, *Female Labour Supply*; Malanima, *The Long Decline*.
87 Lluch *et al.*, *Patterns in Household Demand*.
88 Allen, *Economic Structure*.
89 Malanima, *The Long Decline*.
90 Alvarez-Nogal and Prados de la Escosura, *The Rise and Fall of Spain*; Kaneda, *Long-term Changes*.

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.*[91] We used the subsistence basket as the consumer price index (CPI). Agricultural prices were based on the prices of wheat, sorghum and rice, where rice prices were weighted at 50%. For non-agricultural prices, we used, soap, candles, lamp oil, fuel and cloth, where cloth prices were weighted at 50%. The above 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 urbanization rate. We followed the same approach, using the urbanization values of Xu *et al.*[92], and weighting these values by the share of services and industry in the total GDP for the benchmark year 1933. However, using urbanization 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 urbanization rate. In both of these cases, the circumstances imply that use of the urbanization 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[93] and cause an underestimate in the weighting of urbanization. In summary, it seems reasonable to assume that the biases in the use of urbanization balance themselves out; thus, we used the 1933 weighting of industry and services and linked this to the urbanization ratio.

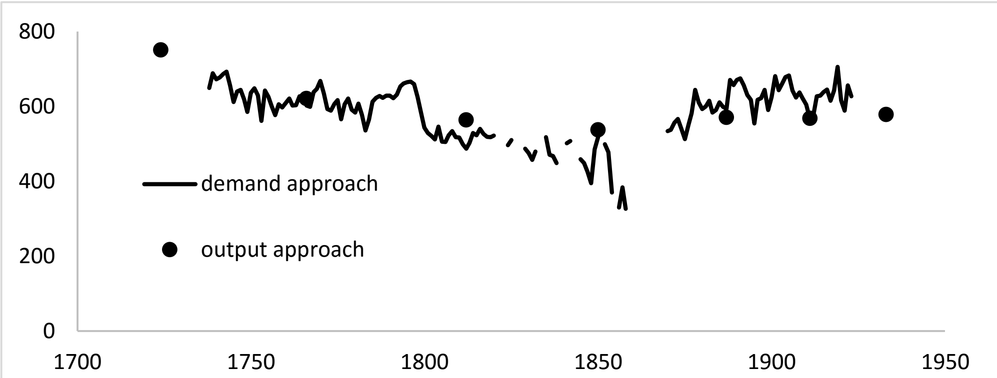
Our results are presented in Figure 6. The benchmarks seem to match our data well, with the largest deviation is preferable to view them as an approximate mean of previous and future years. As such, we are occurring in 1812. We must emphasize, however, that output-based benchmarks are only approximations 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 ~23%. This decline, which took place during the Taiping Rebellion (1850–1864), 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[94] pointed

[91] Allen *et al.*, *Wages, Prices and Living Standards*.
[92] Xu, *et al.*, *Urbanization in China*.
[93] See for example, Rosenthal and Bin Wong, *Before and Beyond Divergence.*
[94] Peng, *Change of Prices and Wages in Modern Beijing*.

out, one may speculate that the rebellion nevertheless affected prices of foodstuffs and caused serious currency inflation in Beijing as well.

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.

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




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.[95] Yet, few estimates of Chinese historical GDP values are available, mainly due to 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[96], as well as with height and wage studies, the per capita GDP declined from the mid-17$^{th}$ century onwards. 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

[95] Foldvari and Van Leeuwen, *Comparing per Capita Income*.

[96] Broadberry *et al.*, *China, Europe*; Ma and De Jong, *China's per Capita GDP*.

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 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, etc.[97], but no decisive conclusion has yet been reached, because of a lack of evidence on the growth patterns of the Chinese economy. 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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[97] See for example, Broadberry, *Accounting for the Great Divergence*; Pomeranz, *The Great Divergence;* Landes, *Why Europe and the West*.

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**Appendix A: Agriculture**

Because of the data structure, we are able to subdivide the arable sector in both food and cash crops. In addition to the direct estimate of arable sector outputs of Liu and Yeh (1965) for 1933, we required two additional types of data to calculate our agricultural output series for the earlier years: (1) the amount of cultivated land and (2) agricultural yields.

***Cultivated land***

The amount of cultivated land can be obtained from government publications such as *Daqing Huidian* (*Code of Great Qing Dynasty,* 《大清会典》), *Qingchao Wenxian Tongkao* (*Comprehensive Examination of Literature in Qing Dynasty,* 《清朝文献通考》), *Daqing Yitongzhi* (*Comprehensive Geographic Gazetteer of the Great Qing Unification,* 《大清一统志》) and *Hubu Zeli* (*Regulations and precedents of the Ministry of Revenue*, 《户部则例》). These publications provide official figures for the amount of cultivated land in the entire country for the years 1661, 1685, 1724, 1766, 1812 and 1887. However, the official figures only represent the amount of taxed land, and are therefore considered to be an underestimate of the true cultivated area. The official figures for the early Qing (1661–1724) do not deviate too much from actual values, but those from the later period (benchmarks in 1766 and later) increasingly do. Hence, we have corrected the official figures based on a variety of methods.

To arrive at the total cultivated area, we first estimated the actual area of cultivated land in 1724, 1850, 1887 and 1911. For 1724, we used an adjustment coefficient based on various factors to modify the data taken from the official registry for this year (Shi 2011, 2015). For calculating 1850, 1887 and 1911, we first obtained the area of cultivated land in 1952, as published by the National Bureau of Statistics, and then used the cultivated land area index sheet for the late Qing and the Republic (pre-Sino–Japan war) established by the Central Agricultural Laboratory, and the University of Nanking during the Republic period, to estimate the cultivated land area in these three years using a backwards projection approach.

Sources allow us to subdivide the resulting estimates of total acreage in food crops and cash crops. For 1933, these values are taken from Liu and Yeh (1965). Xu and Wu (1990) provided a breakdown of the amount of cultivated land planted in the main cash crops, such as cotton, mulberry, ramie, sugar cane and others, for 1840, 1894 and 1919, while Perkins (1984) provided comparable figures for 1914–1918. Combining these estimates with data from sources such as *The First Statistical Tables of Agriculture and Commerce* and local gazetteers, we estimated the share of cash crop land for 1850, 1887 and 1911. For the benchmark years before 1850, as trade is positively correlated with the amount of cash crops, we used that index to project the share of cash crop land back to 1661 (Shi 2015).

***Yields***

Yields vary with time, place and type of crop. Liu and Yeh (1965) provided a benchmark for 1933. Based on a large number of primary documents, including official archives, local gazetteers, private account books and title deeds, Shi (2015) derived ~3,000 observations that could be used to calculate yields of food crops in the Qing dynasty. Tables A1 and A2 list the yield observations of both rice and dry crops across China for different periods.

**Table A1.** Distribution of rice yield observations in south China.

| Province | Number of counties | Number of observations | Distribution of observations | | |
|---|---|---|---|---|---|
| | | | 1644–1812 | 1812–1850 | 1850–1911 |
| Jiangsu | 34 | 89 | 79 | 30 | 10 |
| Anhui | 35 | 247 | 228 | 135 | 19 |
| Zhejing | 45 | 98 | 79 | 34 | 19 |
| Jiangxi | 56 | 187 | 140 | 42 | 47 |
| Fujian | 35 | 146 | 132 | 33 | 14 |
| Guangdong | 52 | 237 | 212 | 67 | 25 |
| Guangxi | 40 | 195 | 116 | 58 | 79 |
| Hunan | 41 | 275 | 209 | 96 | 66 |
| Hubei | 45 | 368 | 218 | 80 | 150 |
| Sichuan | 48 | 211 | 136 | 101 | 75 |
| Yunan | 58 | 175 | 170 | 7 | 5 |
| Guizhou | 30 | 93 | 83 | 55 | 10 |
| Total | 519 | 2321 | 1802 | 738 | 519 |

*Source:* Shi (2012, 2015).

**Table A2.** Distribution of dry crop yield observations in North China.

| Province | Number of counties | Number of observations | Distribution of observations | | |
|---|---|---|---|---|---|
| | | | 1644–1812 | 1812–1850 | 1850–1911 |
| Hebei | 32 | 92 | 38 | 9 | 54 |
| Shandong | 48 | 140 | 104 | 33 | 36 |
| Henan | 29 | 57 | 36 | 5 | 21 |
| Shanxi | 34 | 74 | 62 | 6 | 12 |
| Shaanxi | 58 | 128 | 104 | 26 | 24 |
| Gansu | 26 | 53 | 46 | 6 | 7 |
| Xinjiang | 20 | 24 | 24 | 0 | 0 |
| Manchuria | 14 | 39 | 16 | 10 | 23 |
| Total | 261 | 607 | 430 | 95 | 177 |

*Source:* Shi (2012, 2015).

The yields of cash crops for 1850, 1887 and 1911 were obtained from the official publication *Fuyi Quanshu* (*The Complete Book of Tax and Labor Service*,《赋役全书》), local gazetteers and private account books. For the pre-1850 period, we calculated a ratio of 1.9 for the average income per mu of cash crop to the average income per mu of food crop. This ratio was kept constant for the entire period before 1850.

***Livestock, forestry and fishery sectors***

For 1933, Liu and Yeh (1965) estimated the value added and output in livestock, forestry and fisheries. For 1887, Chang (1962) estimated the value of output in livestock and fisheries, and Ou (1947), Perkins (1969) and Wu (1990, 1993) presented analyses of these sectors in the late Qing and the Republic. Otherwise, few data are available for these metrics. Combining the evidence above with scattered evidence regarding non-arable sectors in earlier centuries, Shi (2015) arrived at a set of estimates of total output in these three sectors.

## Appendix B: Industries

We start by subdividing the industries into various sub-sectors. We do this by combining the classifications of Ou (1947), Liu and Yeh (1965), Peng Z (1957), Li and Xu (2004). The resulting classification consist 12 sectors each of which includes various sub-types (see Table B1). We will deal with most sectors in this appendix consecutively.

**Table B1.** Comparison of classification for industry in different authors

| Modern classification | Ou and Liu | Chuang-li Chang | Di Liu | This text |
|---|---|---|---|---|
| Mining manufacture | Mining | Mining | Mining | Mining |
| | Food Processing | Food Processing | Food Processing | Food Processing |
| | Textile | Textile | Textile | Textile |
| | Leather & rubber | Ceramics | Ceramics | Leather |
| | Clothing & Attire | Leather | Manufacture and Repair of Transportation equipment | Clothing & Attire |
| | Paper Manufacturing & Print | Metal | Miscellaneous | Paper Manufacturing & Print |
| | Metal | Furniture | | Metal |
| | Manufacture and Repair of Transportation equipment | Manufacture and Repair of Transportation equipment | | Manufacture and Repair of Transportation equipment |
| | Lumber & Wood products | Clothing & Attire | | Lumber & Wood products |
| | Stone, clay & glass products | Instruments | | Stone, clay & glass products |
| | Chemicals | Accessories | | Chemicals |
| | Accessories and instruments | Woven fabric | | Accessories and instruments |
| | Machinery | Miscellaneous | | Miscellaneous |
| | Electric Appliances | | | |
| | Hydropower and Gas | | | |
| Building | Construction | Construction | Construction | Construction |

*Sources:* Ou, *National Income of China;* Liu and Yeh, *The economy of the Chinese mainland;* Chang, *The income of the gentry;* Liu, *Chinese GDP.*

***Food processing***

This sector consists of subsectors such as rice milling, flour, brewing, sugar, tea, tobacco and edible oils. For 1933 and 1911, output and value added are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming), respectively. Using inputs as a proxy, the pre-1911 data were brought backward from 1933 using an index of agricultural output. This was done separately for food- and cash crops. Food processing was split into grain processing, such as rice milling, flour and brewing, was assumed to move in line to grain outputs. Cash crops, such as sugar, tea, tobacco and food oil were assumed to parallel the index of the amount of cultivated land planted in cash crops.[98]

***Textiles***

The textile sector consists of subsectors such as cotton ginning, cotton yarn, cotton cloth, silk thread, silk weaving and linen. Output and value added for 1933 and 1911 are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming). For the benchmark years 1850–1887, with the exception of silk weaving, textile subsector data were based on volume indicators of key raw material inputs, such as cotton for cotton yarn and cotton cloth (for the cotton sector) and ramie (Chinese grass) for linen and woollens (for the wool sector). For the years 1850–1887, we first subtracted net raw material exports of the respective series. For silk weaving, as based on gazetteers, modern countrywide surveys and other sources, Xu (2014) provided data on silk fabric output in 1850, and Peng (1957, vol. 2, pp. 64–100) for 1887. Applying a constant ratio of raw silk to silk fabric, we arrived at the silk thread output for both benchmarks above. Unfortunately, such direct observations are unavailable for the period before 1850. Therefore, we assumed that textile output, except for woollens, moved in line with the acreage of textile-related cash crops, while woollen output was assumed to be parallel to the livestock output.

***Leather and rubber***

The leather and rubber sector consists of distinct leather and rubber subsectors. For the leather

[98] The percentages of cultivated land under food-related cash crops in different benchmark years is taken from agriculture section. (see Appendix A)

and rubber sector, output and value added for 1933 and 1911 are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming), respectively. For the pre-1911 period, almost no significant rubber industry existed. Since raw materials in this subsector were taken from livestock and poultry, the leather index was assumed to parallel the index of livestock and poultry products.

***Clothing and attire***

The output and value added figures for the clothing and attire sector are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming), respectively, for 1911 and 1933. For benchmarks before 1911, as textiles and leather are the raw materials for clothing and attire, the output of the sector was assumed to parallel the aggregate output of the textile and leather industries.

***Paper manufacturing and print***

The paper and print sector consists of paper, paper goods and printed matter. The value added of the paper manufacturing and printing industries for 1933 is given by Liu and Yeh (1965). For benchmark years before 1911, we relied on an index of newly engraved book titles. During the Qing period, book engraving in China was generally classified in terms of three types of publishers: government (gazetteers, official publications, etc.), gentry (private notebooks, genealogies, etc.), and booksellers (novels, dramas, poems, etc.). During the Qing period, officials, scholars, booksellers and clans tended to amass libraries of books and to compose book catalogues containing rich information, especially on engraved books, such as the print year, author, publisher and location of the publisher. Some of these catalogues still exist, and we used these to create the following indices of engraved books.

(1) Using three catalogues (the *Collection of Engraving Books by County and Province in the Qing Dynasty* (《全清分省分县刻书考》; Du 2009), the *Collection of Chinese Imprinted Books*（《中国版刻综录》 1987） and *Chinese Local Histories: A Collection of 8577 Annotated Titles* (《中国地方志总目提要》 1996)), we obtained the number of new official book titles during the Qing. Since provincial government publishers were established across China after the Taiping Rebelling (in the late Qing), we applied the provincial government publishers' catalogues (Zhang 1957) to supplement the new official book titles between 1887 and 1911.

2) Using another three catalogues (*the Collection of Engraving Book by Counties and Province*

*in the Qing Dynasty* (《全清分省分县刻书考》2009), the *Collection of Chinese Imprinted Books* (《中国版刻综录》 1987) and the *Comprehensive Catalogue of Chinese Genealogy* (《中国家谱综合目录)1997)), we obtained the number of new gentry book titles over the course of the Qing dynasty.

(3) As books in the third category (private novels) were engraved by booksellers for marketing, few countrywide catalogues were prepared for these books, with the exception of novels and Christian books. Using the *Catalogue of Chinese Popular Novels* (《中国通俗小说书目》) and the *Supplemental Catalogue of Chinese Popular Novels* (《增补中国通俗小说书目》), we obtained the number of new novel titles over the course of the Qing dynasty. Xiong (2011, pp. 105, 122, 129, 131, 135) provided a catalogue of Christian books printed by missionaries in the Qing dynasty. Although records of the proportion of novels and Christian books to the total number of private books are scarce, according to recent research on *Sibao,* one of the most important book production centres in the Qing dynasty, novels and Christian books constituted ~12% of the annual book production (Zhou 2000). Assuming that booksellers in the remainder of China printed the same percentage of novels and Christian books as did the *Sibao* booksellers, we arrived at the total number of privately published book titles.

(4) The summation of categories (1)–(3) provided us with an index of new book titles over the course of the Qing dynasty.

For the Republican period, the *Publishing Catalogues Compilation in the Republic of China* (《民国时期出版书目汇编》 2010) provided us with a relatively complete number of book titles published in 1933. As a result, we linked the number of books in 1933 to those in benchmark years in the Qing dynasty as a proxy for the paper manufacturing and print sector as a whole in benchmark years before 1933.

***Mining, metals and metal products***

The mining sector consists of large-scale mining operations, such as those for iron ore, pig iron, steel, coal, coke, copper, gold, silver, lead, zinc, tin, sulphur, saltpetre, mercury and salt, and small-scale mining. Estimates for each benchmark and for each product were obtained from a variety of sources. Neither countrywide annual production statistics for each mineral product nor annual mining output estimations of previous scholars are available for the Qing dynasty. Thus, we relied heavily on archival materials to arrive at estimates of the outputs of different mineral products.

Coal and iron were not considered as important minerals by the Qing government until the Self-Strengthening Movement of the 1860s. This movement led to the establishment of modern iron and steel work, and a few modern coal mines. Annual output data for these modern companies are available. However, most of the companies were not in operation until the 1890s. Thus, the Qing government did not record the actual output of coal and iron during most of the dynasty, with the exception of output in certain areas, such as for coal in Xinjiang, Mongolia and Manchuria, and for iron in Guangxi and Guangdong; in these areas, coal and iron were taxed, and some tax records remain. However, the tax records are not directly related to output. Moreover, these areas were not major producing areas. Guangdong was an important producing area, but it had already fallen into decline in the 1800s.

Other mineral products, such as copper, gold, silver, lead, zinc, tin, mercury, sulphur, saltpetre and salt were more important for the Qing government, and as opposed to coal and iron, these products were all taxed, such that numerous records of tax and output are available. Series data were obtained from the Qing dynasty archives of the First Historical Archives of China and The Academia Sinica in Taiwan. These records form a solid basis for our estimations of mining activities.

*Benchmark years 1933, 1911 and 1850*

For large-scale mining, outputs and prices for 1933 were recorded by *The Geological Survey of China* (Hou 1935), which provided a series of reports by the *General Statement of the Mining Industry* (1921–1945, Issues 1–7) of *The Geological Survey of China, Ministry of Agriculture and Commerce.* The reports were based on field investigations performed by the Geological Survey. Sources such as reports from companies, mines and local governments, as well as other contemporaneous material, were also used. Thus, this series of reports provided statistical data on large-scale mining reserves, output and prices, by province as well as countrywide. The reports are widely cited as a fundamental source of statistical data regarding the Republic of China's mining industry.

Based on these statistics, Ou (1947) not only modified the price data and added the output of coke, but also gave an estimate of the ratio of cost to value added for all mining products. This report was followed by Liu and Yeh (1965), who re-processed Ou's (1947) original data in a more general way. Hence, the estimates on the mining sector provided by Ou (1947) are more complete than those provided by Liu and Yeh (1965), who missed or omitted direct observations on several important types of mining, such as pig iron, steel, coke and cement, in their 1933 estimates for the mining sector. Therefore, we relied on Ou (1947) for both output and value added data for 1933.

For 1911 and 1850, estimates were derived from Xu and Zhang (2015 and 2016 forthcoming). These two studies are based on a wide array of sources, as the authors presented not only output data, but also calculated the number of mining factories and the numbers of iron furnaces and coal mines in the entire country.

*Benchmark year 1887*

The output of some large-scale mining operations in the 1880s, including coal, iron ore, pig iron, gold, silver, copper, tin and salt, are available from Chang (1962). However, these data are incomplete. Therefore, we upgraded the datasets as follows. The output of coal and iron was estimated via labour productivity data for each province. The labour productivity was assumed to be fixed during this period; this is an important precondition. In fact, many records indicate that traditional production tools and processes were in use during this period, indicating that there were no major technical breakthroughs in the coal and iron industries during the Qing dynasty (Wu 2007; Yang 1982). Some large modern companies with Western equipment were indeed founded in the late 19th century. However, only the *Kaiping* Coal Mine was in operation in the 1880s, while others, such as the *Hanyang, Daye* and *Pinxiang* mines did not go into operation until the 1890s. Thus, we modified the output of coal and iron for the year 1887 from Chang (1962), by grouping all producing provinces into three groups, based on their output in 1916 (large, midsize, and small production centres) (Ding and Weng 1921). For each group, we chose provinces for which production could be traced back to 1887, and then used data from these provinces as indices for calculating the overall coal and iron production for that year.

For coal, we selected 6 of 23 producing provinces as examples. These included two provinces with large-scale mining operations, *Zhili* and *Liaoning*. For *Zhili* Province, we determined the total output in 1887 by summing the output of the *Kailuan* Mines Bureau (which formed from a merger between the *Kaiping* Coal Mine and the *Luanzhou* Coal Mine) and that of western Beijing, which had been in production since the 10$^{th}$ century (*Memorial to the Throne in the 1st Historical Archives* *of China;* Hou 1935; Wu 1985). Production from the *Liaoning* was calculated based on government publications, such as the *Veritable History of the Qing* (*Daqing lichao shi lu*,《大清历朝实录》), *Political Notes of the Northeast Provinces* (*Dong san sheng zheng lue,*《东三省政略》), document collections of ministers like *Li Hongzhang* (Gu and Dai 2008) and *Zeng Guoquan* (Liang 2008), the government document collection *Comprehensive Mirror of Shengjing* (*Sheng jing tong jian,*《盛京通鉴)) and the British consulate's reports and news report (Sun 1957).

*Jiangxi* and *Shanxi* are two examples of midsize producing provinces. For *Jiangxi*, the *Pingxiang* Coal Mine, part of the *Han-Ye-Ping* Company, was one of the largest modern factories in the late Qing. The mine went into operation in 1898, but was founded on previously existing mines. Thus, based on the archives of the *Han-Ye-Ping* Company (*Hubei* Provincial Archives 1992), documents from high-ranking officials (Xia 2004), local gazetteers, surveys from the Jiangxi Province Government (1935), company gazetteers of the *Pingxiang* Mines Bureau (1998) and Japanese reports of years around 1911 (Li 2011), we estimated the output of these older mines in Jiangxi. The *Shanxi* coal mining operations can be dated to the Song dynasty (Datong Mines Bureau 1989). Our estimates for Shanxi are based on a survey of the German geographer Ferdinand von Richthofen (Peng 1957), *Shanxi Coal Industry Gazetteers* (1991), records of the Datong Mines Bureau (1989) and local gazetteers.

As for small-producing provinces, we chose *Anhui* and *Jiangsu* as representative of a total of 15 provinces. The output of Anhui was estimated from custom export data (Wang 1991), Memorials to the Throne by the Viceroy (Liu 1966; Sun 1957) and custom reports of the news press (Sun 1957). *Jiangsu's* output was estimated using data from previous studies (Sun 1957; Yu 1991), contemporary news reports (Sun 1957), officials' reports to ministers (*The Complete Works of Zuo Zongtang* 1996; *The Complete Works of Li Hongzhang* 2008) and mining archives of the Qing (The Academia Sinica 1960) and the Republic of China (The 2nd Historical Archives of China 1991).

Similarly, for iron, we chose *Shanxi* as an example of a major producing province. The particular smelting method used in Shanxi started at least from the 1660s, and was still in use in the 1950s. We estimated Shanxi's output based on the surveys of von Richthofen in 1870 and W. H. Shoekley in 1899 (Peng 1957), data from Tegengren (1923), a metallurgy report conducted in 1957 (Fan 1985) and other sources (e.g. Ministry of Industry and Commerce 1937).

We chose Hunan as an example of a midsize producing province. We estimated Hunan's output in 1887 based on data from surveys (Tegengren 1923; An 1941), local gazetteers and government reports (Ministry of Industry and Commerce 1935). Since Hunan's local iron and steel production were strongly impacted by imported iron, especially in the 1880s, we also used statistics on iron imports (Yao 1962) to obtain the final estimated output of iron ore, pig iron and steel.

Guangxi is considered representative of 12 small-size provinces. Its output in 1887 was estimated using data from local gazetteers, the Memorial to the Throne by the Viceroy (The Complete Works of Zhang Zhidong 1998) and archives of The 1st Historical Archives of China.

Copper and silver productions in 1887 were calculated as follows. Most of China's copper production took place in Yunnan (Yan 1948). Although Chang (1962) argued that Yunnan's production was equal to that of China as a whole, this is a misconception. Therefore, we obtained the total number of copper and silver mines in 1880 from Peng (1962). The product of these values and the average output per factory in 1850, as obtained from Xu and Zhang (2014), yielded a value for the total copper and silver output.

Lead and zinc factories in 1887 were located mainly in Guizhou Province. Using the output and number of factories in Guizhou in 1887, obtained from local gazetteers, we calculated the average output per factory. Then, we used the ratio of the number of factories in Guizhou to the national total in 1850 to obtain the total output of lead and zinc in 1887.

The remaining products include gold, tin, mercury, sulphur, saltpetre and salt. Gold output in the 1880s was taken from the China Gold Association (2006). Tin output in the 1880s, most of which was from Yunnan, was taken from Zhang (1942). The producing region for mercury was limited; we identified only one mercury factory in 1887, from data of the archives in The 1st Historical Archives of China. Sulphur and saltpetre are used to produce gunpowder. Thus, the output must have been exactly equal to the amount approved by the emperor. We used a method similar to that used for gold and copper to estimate the amounts of sulphur and saltpetre. Salt output was obtained from Chang (1962).

*Benchmark years before 1850*

For pre-1850 benchmarks, we used volume indices linked to 1850. Peng (1957, 1962) established annual quantity statistics for "mining factories" between 1644 and 1880 using a variety of Qing archives and local gazetteers. Some data, however, are missing due to Peng's lack of sources. We filled in missing data (if any) for 1661, 1685 and 1724 with data for the previous year, also provided by Peng, or when available, data from other sources.

For example, Peng found silver output data for the years 1754 and 1800 from the Qing Archives. For gold there is a scale problem. According to Xu and Zhang (2014), output of the two largest gold factories in 1850 was almost 30 times higher than that of the other 10 factories combined. However, these two factories had just started operations in the 19$^{th}$ century. Therefore, our index of gold factories for 1850 is linked to data from the 10 smaller factories, thus excluding the output of the two recently established large factories. Steel and coke were produced from pig iron and coal, respectively, so they are assumed to parallel values for these commodities. We assumed that salt values were parallel to population size, since consumption of salt was relatively constant over the Qing dynasty (Xu and Wu 1985). Other small-scale mining outputs were assumed to be parallel to those of large-scale mines. Finally, since mining supplied the main raw materials for metal products, metal products were assumed to follow the mining index.

***Manufacture and repair of transportation equipment***

This sector consisted of the construction and repair of water transportation equipment (e.g. ships and boats) and land transportation equipment (e.g. carriages, wheelbarrows, sedan chairs and oxcarts). The former subsector was of particular importance during Qing dynasty, as well as in Republican China. For both 1933 and 1911, output and value added are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming). For 1776, 1850 and 1887, Matsuura (2010), Fan (1985) and Chang (1962) provide the total number of boats and ships for the entire country. As these boats generally yielded 10 years of service (Chang 1962, pp. 312), we estimated the number of boats replaced per year; i.e., the annual production of boats in 1776, 1850 and 1887. By assuming that the manufacture and repair of boats paralleled that of population, figures can be obtained for the pre-1776 period. Land transportation equipment was assumed to follow water transportation equipment for the period 1661–1933.

***Lumber and wood products***

This sector consists of sawn timber and furniture, as well as rattan, bamboo and willow products.

For both 1933 and 1911, output and value added are given by Liu and Yeh (1965) and Xu and Zhang (2016 forthcoming). For the benchmarks before 1911, output in these sectors was assumed to be parallel to the index of wood products taken from the Agriculture section (see Appendix A).

***Stone, clay and glass products***

This sector is subdivided into two subsectors: construction materials (e.g. brick, stone, clay and glass) and ceramics (e.g. pottery and chinaware). For construction materials, output and value added in 1911 and 1933 are given by Xu and Zhang (2016 forthcoming) and by Liu and Yeh (1965), respectively. For benchmarks before 1911, the output was assumed to parallel the output of wood, as obtained in the Agriculture section (see Appendix A).

For ceramics, the output and value added in 1911 and 1933 for the entire country are given by Xu and Zhang (2016 forthcoming) and by Liu and Yeh (1965), respectively. These were projected back in time using output data from *Jing Dezheng*, the most important production centre in China, which are reported in the *Ceramic Narrative History in Jing Dezheng* (1959). Unfortunately, the share of *Jing Dezheng* of the total Chinese output of ceramics is not constant over time; we calculated that it constituted 8% and 32% of the total output in 1911 and 1933, respectively. Since the official records claimed that output of *Jing Dezheng* in post-Taiping years was half of that in pre-Taiping years (as the industry had been damaged by the Taiping Rebellion) (*Qing Chao Xu Wenxian Tongkao*, vol. 383, pp. 11302), the share of Jing Dezheng of the total Chinese output is assumed to have been 8% in 1887 and 16% between 1661 and 1850.

***Chemicals, accessories and miscellaneous***

For 1911 and 1933, output and value added in this sector were taken from Xu and Zhang (2016 forthcoming) and Liu and Yeh (1965), respectively. For benchmarks before 1911, outputs in the three sectors were assumed to be parallel to population numbers.

***Machinery, electric appliances, hydropower and gas***

As these sectors started production at the beginning of the 20$^{th}$ century, we only used output and value added data for these sectors for 1933, as obtained from Liu and Yeh (1965).

***Construction***

The 1933 estimate of value added for construction is from Liu and Yeh (1965). Unfortunately, few data exist for earlier periods. However, in the Qing dynasty and Republic of China, the main construction materials were wood, brick and stone. Based on a large number of local inscriptions across China between the Qing dynasty and the Republic of China, 47 observations were collected that report on the details of which materials were used in different construction projects, such as in temples, ancestral halls, drama stages, schools, dams and guild halls (see Table B1). Using these observations, we performed a regression analysis that showed the relationship between wood output and building remained constant over time. Hence, we used an index of wood output from the Agriculture section as a proxy for developments in the construction sector.

**Table B2.** Distribution of local inscriptions on construction across China.

| Period | Beijing | Shanghai | Henan | Shanxi | Jiangsu | Fujian | Guangxi | total |
|---|---|---|---|---|---|---|---|---|
| 1650–1750 | | | 1 | | | 1 | | 2 |
| 1750–1800 | 2 | 1 | 1 | | 1 | | 1 | 6 |
| 1800–1850 | | 2 | | 5 | 3 | | 6 | 16 |
| 1850–1910 | | 2 | | 3 | 5 | 5 | 8 | 23 |
| Total | 2 | 5 | 2 | 8 | 9 | 6 | 15 | 47 |

*Sources:* Beijing, Wang (2008), Li (1980); Shanghai, Shangha Museum (1980); Henan, Xu (2005); Shanxi, Zhang et al. (2007, 2009); Jiangsu, Jiangsu Museum (1959), Suzhou Museum et al. (1981), Wang et al. (1998); Fujian, Zheng et al. (1995), Huang (1995); Guangdong, Social Science Academy in Guangdong et al. (1987); Guangxi, Zeng (2010), Huang (2008), Du (2013) and Tang et al. (2012).

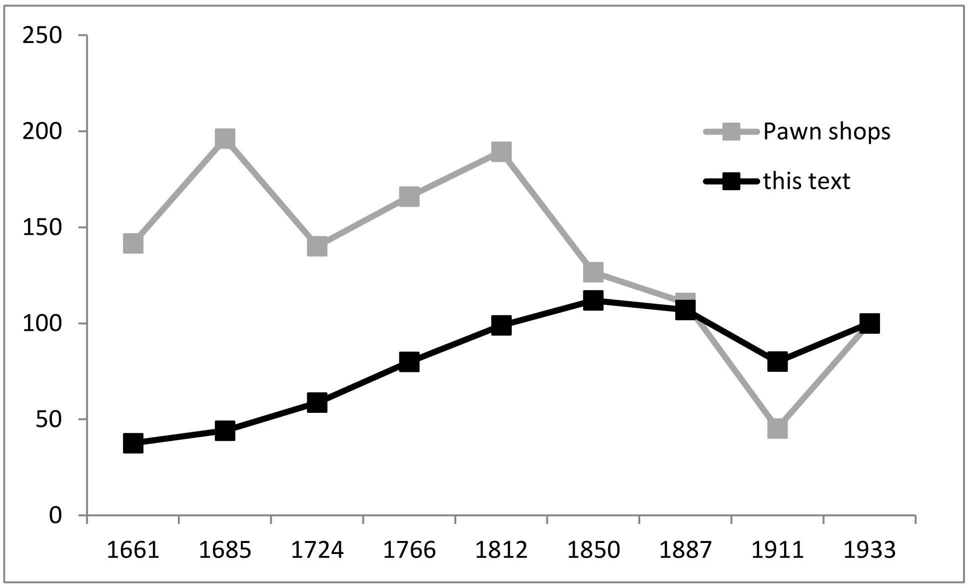
## Appendix C: Services

***Commerce***

Commerce can be subdivided into trade, transport and finance. For 1933, these estimates were obtained from Liu and Yeh (1965). Trade and transport were assumed to be parallel to the amount of marketed products. The share of marketed products in both industry and agriculture was obtained from Wu Chengming (2001) (including domestic and net import products) for 1840, 1869, 1894, 1908, 1920 and 1936. Before 1840, we assumed that marketed shares remained constant. The product of these shares and the total value added for agriculture (Section A) and industry, minus construction (Section B), yielded an index of trade and transport.

It is challenging to obtain data for the financial sector. During the early stages of the Qing dynasty (pre-1840), finance included three subsectors: pawn shops, *Qianzhuang* (local banks) and *Piaohao* (inter-regional banks established by Shanxi businessmen). The value added of the financial sector consisted of the personal revenue of professionals working in these subsectors

**Figure C1.** Index of the financial sector compared with the alternative "pawn shop" method (1933 = 100).




plus the profits accruing to the capital employed (Qiugen Liu 1995). However, the amount of capital only refers to the initial capital, meaning there is an increasingly large underestimation of the financial sector over time; also, the total number of pawn shops declined significantly, possibly compensated for by other financial institutions about which we lack information. Therefore, following Cameron (1967), who showed that a rise in the financial sector corresponded to a decline in the velocity of money, we used the inverse of the velocity of money as a proxy for trends in the financial sector (Chang 1962; Liu 2009, 2011; Rawski 1989; Yan 2011). To capture the scale-effect, this number was multiplied by the total population to arrive at an index of financial value added (see Figure C1).

Finally, the government sector was based on deflated government expenditures, the housing sector was based on estimates of house rent by Ou (1947) for cities and countryside, and projected back using the urban and agricultural populations (as reported in Section 2), and the personal services sector was based on population (for domestics) and jinshe, juren and shengyuan for doctors, teachers and lawyers, respectively.

***Government***

With the exception of the 1933 benchmark, which is given by Liu and Yeh (1965), we calculated the value added in the government sector during the Qing dynasty by using real government expenditures. Since the Qing government fiscal system consisted of formal and informal expenditure, we first derived the formal expenditure. Based on a large number of fiscal archives, official publications and other sources, Shi and Xu (2007, pp. 47–55) and Chen (2000) provided estimates (in current prices) of government expenditures between 1661 and 1850. Government expenditures in both 1887 and 1911 were provided by the *Accounting Record in the Guangxu Period* (Liu 1901; 《光绪会计录》) and the *Guangxu Chao Gonghua Lu* (Zhu, Vol.1, pp. 866, 1909; 《光绪朝东华录》). The latter source also provided total expenditures covering formal and informal expenditures in 1911.

After deriving the formal expenditure, and as few complete records on informal expenditures in both central and local governments exist in historical sources, we used the proportions of informal expenditures to total expenditures in governments of ~20% before the Taiping Rebellion and ~40% after the rebellion, based on Shi and Xu (2007, pp. 279), who based their data on an array of fragmented and scattered records. The results are reported in Table C1. To calculate the real total government expenditure, we applied the price index of Peng (1957, pp. 459).

**Table C1.** Government expenditures between 1661 and 1933 (in both millions of tael and millions of yuan).

| Year | Formal in tael | Total in tael (formal + informal) | Total in yuan |
|---|---|---|---|
| 1661 | 30.5 | 38.1 | 57.1 |
| 1685 | 32 | 40 | 59.9 |
| 1724 | 34 | 42.5 | 63.6 |
| 1766 | 42.2 | 52.8 | 79 |
| 1812 | 47 | 58.8 | 87.9 |
| 1850 | 40 | 50 | 74.8 |
| 1887 | 81 | 135 | 202.1 |
| 1911 | — | 300 | 449 |
| 1933 | — | — | 820 |

Note: the price ratio between 1850 and 1933 in the service sector was taken from Table D1 in Appendix D.

***Residential rent***

For residential rents, we followed the same method as that proposed by Ou (1947), who calculated rents per capita in 1933 to be 12 yuan for city residents who were required to pay a house tax, 4 yuan for city residents who were not required to pay a house tax, and 2.1 yuan for residents living in the countryside. By projecting backwards the number of people living in cities using the urbanization ratio, as presented in Section 2, we calculated residential rents back to 1661.

***Personal services***

The value added in personal services in 1933 is given by Liu and Yeh (1965). The number of domestic workers was assumed to parallel the urban population, as presented in Section 2. For other personal services, including notaries and teachers, we assumed the value added to parallel the number of Shengyuan candidates (Xu et. al 2012).

**Appendix D: Prices**

With the exception of grain prices, few annual or complete records on other kinds of prices exist for the Qing dynasty. However, since 1850 yields many more records on prices than other benchmark years in the Qing dynasty, we managed to collect 23 types of product prices from scattered sources; these are linked to comparable prices in 1933 (see Table D1).

**Table D1.** Prices of selected goods in 1850 and 1933.

| | 1850 | | 1933 | |
|---|---|---|---|---|
| Products | Price | Units | Price | Units |
| grain | 0.01092 | tael/jin | 0.02134 | yuan/jin |
| tea | 0.18360 | tael/jin | 0.28 | yuan/jin |
| sugar | 0.02579 | tael/jin | 0.0791 | yuan/jin |
| silk fabric | 5.4 | tael/picul | 27 | yuan/picul |
| reeling silk | 1.5 | tael/jin | 3.6 | yuan/jin |
| cotton cloth | 1.5. | tael/picul | 7 | yuan/picul |
| boat | 13.77 | tael/ton | 25 | yuan/ton |
| ceramic | 15 | tael/dan | 6 | yuan/dan |
| coal | 0.00034 | tael/jin | 0.00175 | yuan/jin |
| coke | 0.00074 | tael/jin | 0.00386 | yuan/jin |
| iron ore | 0.00123 | tael/jin | 0.0014 | yuan/jin |
| pig iron | 0.00838 | tael/jin | 0.0179 | yuan/jin |
| steel | 0.01643 | tael/jin | 0.0351 | yuan/jin |
| copper | 0.06133 | tael/jin | 0.20531 | yuan/jin |
| lead | 0.01634 | tael/jin | 0.06422 | yuan/jin |
| zinc | 0.01525 | tael/jin | 0.0737 | yuan/jin |
| tin | 0.03418 | tael/jin | 0.81667 | yuan/jin |
| mercury | 0.43675 | tael/jin | 1.13 | yuan/jin |
| sulphur | 0.02815 | tael/jin | 0.05264 | yuan/jin |
| saltpetre | 0.02949 | tael/jin | 0.10529 | yuan/jin |
| gold | 15.4431 | tael/liang | 100 | yuan/liang |
| silver | 1 | tael/liang | 1.4 | yuan/liang |
| salt | 0.01874 | tael/jin | 0.0118 | yuan/jin |

*Notes and sources:*

1) Grain price: for 1850, the unweighted average price is taken from the Grain Price Table Between *Daoguang*

and *Xuantong* periods of the Qing dynasty (2009). For 1933, Ou (1947, pp. 109) provided the modified price based on the countrywide grain survey in the 1930s.

2) Tea price: for 1850, since the domestic price for many products in the middle of the 19th century was half that of the export price (Xu and Wu 1985, pp. 325), the domestic average tea price was taken as half the export price, which was derived from Yao (1962). For 1933, Ou (1947, vol. 2, pp. 131) provided the average price of tea based on price surveys from 10 tea production centres in the 1930s.

3) Sugar price: for 1850, the domestic average sugar price was taken as half of the export price, which was derived from Yao (1962). For 1933, the sugar price was taken as a weighted average of the different types of sugar prices, which were reported in the *Sichuan* Sugar Production and Selling Survey (Ou 1947, vol. 2, p. 139). The weight of output of different types of sugar was taken from the sugar production survey compiled by the Guangxi provincial government (Ou 1947, vol. 2, p. 138).

4) Silk fabric: for 1850, the domestic average price was weighted by both silk fabric and pongee. The former price was taken as half of the export price, which was derived from Yao (1962, p. 618). The later price was taken from the *Daoguang Tongzhi Jixiang Xianzhi* vol. 10 (道光、同治《綦江县志》卷 10). The weight of output of both silk fabric and pongee was taken from Xu (2014). For 1933, Ou (1947, vol. 2, p. 104) obtained the price of silk fabric from the Industry Survey in China, conducted by Lieu (1933). Reeling silk: for 1850, the domestic average price was taken as half of the export price, which was derived from Yao (1962, pp. 553). For 1933, Ou (1947, vol. 2, p. 103) provided the average price of reeling silk in the handcraft sector based on industry statistics for both *Shangdong* and *Zhejiang* provinces.

5) Cotton cloth: for 1850, the domestic average price was ~0.3 tael per picul, as obtained from Xu and Wu (1985, p. 325). Since a picul of cloth in 1850 was equal to one third of a picul of cloth in 1933 (as mentioned by Ou 1947), the price of cloth in 1850 in the same units as that 1933 was assumed to be 1.5 tael per picul. For 1933, Ou (1947, vol. 2, p. 100) provided the modal price based on a large number of price observations across China in the 1930s.

6) Boat price: for 1850, we obtained the weighted average price of boatbuilding for three types of boats. The price for a river boat weighing more than 50 ton was averaged from different records on boatbuilding prices, such as in Li and Jiang (1995, p. 206) and Bao (1826, vol. 49). The price for a river boat weighing less than 50 ton was averaged from gazetteers, such as *guangxu dinghai xianzhi* vol. 20 (光绪《定海县志》卷 20) and *jiaqing denghai xianzhi* vol. 6 (嘉庆《澄海县志》卷 6). The price for ships weighing more than 50 ton was averaged from records on historical sources such as from Wang (1826, vol. 49), Bao (1846, vol. 1), Nie

(1983, p. 53) and *daoguang xiamengzhi* vol. 15 (道光《厦门志》卷, 15). The weighted output of the three types of boats was taken from our estimates of the manufacture and repair of water transportation in 1850 (see Appendix B). For 1933, Ou (1947, p. 51) used the transportation survey to arrive at the average price of boatbuilding in the handcraft sector.

7) Ceramic price: for 1850, the domestic average price was taken as half the export price, which was derived from Yao (1982, p. 258). For 1933, the domestic average price was taken as half the import price, which was derived from the *Ceramic Narrative History in Jing Dezheng* (1959, p. 328)
8) Coal price: for 1850, the price was taken from the Qing archives (1st Historical Archives of China: Memorial to the Throne, No. 02-01-07-11825-002). The price in 1933 was taken from Hou Defeng (1935).
9) Coke: the price in 1933 was taken from Ou (1947). The price in 1850 was estimated from the coal/coke price ratio of 1933 and the coal price of 1850.
10) Pig iron: the price in 1850 was taken from *Hubu Zeli* (1874) and Peng (1957). The price in 1933 was taken from Ou (1947).
11) Iron ore: the price in 1850 was taken from Peng (1957). The price in 1933 was taken from Hou (1935).
12) Steel: the price in 1933 was taken from Hou (1935). The price in 1850 was estimated from the pig iron/steel price ratio in 1933 and steel prices in 1933.
13) Copper: the price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21438-016, 02-01-04-21577-018 and 02-01-04-21439-003). The price in 1933 was taken from Ou (1947).
14) Lead: the price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21457-021, 02-01-04-21457-030, 02-01-04-21606-044, 02-01-04-21489-040, 02-01-02-3158-009, 02-01-04-21526-016, 02-01-04-21489-044, 02-01-04-21432-032 and 02-01-04-21457-022). The price in 1933 was taken from Ou (1947).
15) Zinc: The price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21508-002, 2-01-04-21489-011, 02-01-04-21576-020, 02-01-04-21507-042, 02-01-04-21671-014, 02-01-04-21489-044 and 02-01-04-21420-021; and Academia Sinica, no. A366-035). The price in 1933 was taken from Ou (1947).
16) Tin: the price in 1850 was taken from the Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21489-033 and 02-01-04-21508-003) and *Hubu Zeli* (1874). The price in 1933 was taken from Ou (1947).

17) Mercury: the price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21489-035 and 02-01-04-21489-035) and *Hubu Zeli* (1874). The price in 1933 was taken from Ou (1947).
18) Sulphur: the price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21435-026, 03-3025-006 and 04-01-01-0861-031), *Shengjing Tongjian* (1962) and *Guangxu Hunan General Gazetteer* (1885). The price in 1933 was taken from Hou (1935).
19) Saltpetre: the price in 1850 was taken from Qing archives (1st Historical Archives of China: Memorial to the Throne, Nos 02-01-04-21484-026, 02-01-04-21332-005 and 04-01-01-0861-031) and *Guangxu Hunan General Gazetteer* (1885). The price in 1933 was taken from Hou (1935).
20) Gold: the price in 1850 was taken from Zhang (1925) and the price in 1933 was taken from Hou (1935).
21) Silver: the prices in 1850 (1 tael is equal to 1 liang) and 1933 were taken from Hou (1935).
22) Salt: the price in 1850 was taken from Xu and Wu (1985, pp. 328) and the price in 1933 was taken from Ou (1947, vol. 2, pp. 18).

**Appendix E: Per capita gross domestic product (GDP/cap) in 1990 GK dollars, calculated using the demand approach.**

| Year | GDP/cap | Year | GDP/cap | Year | GDP/cap | Year | GDP/cap |
|---|---|---|---|---|---|---|---|
| 1738 | 670 | 1789 | 648 | 1840 | | 1891 | 696 |
| 1739 | 710 | 1790 | 649 | 1841 | 517 | 1892 | 677 |
| 1740 | 693 | 1791 | 642 | 1842 | 523 | 1893 | 650 |
| 1741 | 699 | 1792 | 651 | 1843 | | 1894 | 637 |
| 1742 | 708 | 1793 | 674 | 1844 | | 1895 | 572 |
| 1743 | 714 | 1794 | 681 | 1845 | 474 | 1896 | 637 |
| 1744 | 676 | 1795 | 685 | 1846 | 463 | 1897 | 641 |
| 1745 | 631 | 1796 | 687 | 1847 | 438 | 1898 | 664 |
| 1746 | 660 | 1797 | 680 | 1848 | 408 | 1899 | 609 |
| 1747 | 665 | 1798 | 644 | 1849 | 501 | 1900 | 645 |
| 1748 | 638 | 1799 | 600 | 1850 | 535 | 1901 | 702 |
| 1749 | 604 | 1800 | 561 | 1851 | | 1902 | 664 |
| 1750 | 656 | 1801 | 545 | 1852 | 515 | 1903 | 680 |
| 1751 | 668 | 1802 | 538 | 1853 | 493 | 1904 | 699 |
| 1752 | 649 | 1803 | 528 | 1854 | 382 | 1905 | 704 |
| 1753 | 579 | 1804 | 563 | 1855 | | 1906 | 662 |
| 1754 | 663 | 1805 | 522 | 1856 | 340 | 1907 | 643 |
| 1755 | 645 | 1806 | 521 | 1857 | 396 | 1908 | 657 |

| Year | GDP/cap | Year | GDP/cap | Year | GDP/cap | Year | GDP/cap |
|---|---|---|---|---|---|---|---|
| 1756 | 619 | 1807 | 540 | 1858 | 337 | 1909 | 640 |
| 1757 | 594 | 1808 | 551 | 1859 | | 1910 | 624 |
| 1758 | 625 | 1809 | 534 | 1860 | | 1911 | 586 |
| 1759 | 616 | 1810 | 533 | 1861 | | 1912 | 593 |
| 1760 | 628 | 1811 | 514 | 1862 | | 1913 | 647 |
| 1761 | 640 | 1812 | 503 | 1863 | | 1914 | 649 |
| 1762 | 621 | 1813 | 518 | 1864 | | 1915 | 658 |
| 1763 | 622 | 1814 | 545 | 1865 | | 1916 | 665 |
| 1764 | 646 | 1815 | 539 | 1866 | | 1917 | 635 |
| 1765 | 645 | 1816 | 557 | 1867 | | 1918 | 663 |
| 1766 | 621 | 1817 | 543 | 1868 | | 1919 | 728 |
| 1767 | 618 | 1818 | 535 | 1869 | | 1920 | 636 |
| 1768 | 658 | 1819 | 534 | 1870 | 550 | 1921 | 607 |
| 1769 | 667 | 1820 | 538 | 1871 | 554 | 1922 | 677 |
| 1770 | 689 | 1821 | | 1872 | 574 | 1923 | 647 |
| 1771 | 655 | 1822 | 529 | 1873 | 584 | 1924 | |
| 1772 | 611 | 1823 | | 1874 | 557 | 1925 | |
| 1773 | 607 | 1824 | 512 | 1875 | 529 | 1926 | |
| 1774 | 626 | 1825 | 526 | 1876 | 568 | 1927 | |
| 1775 | 637 | 1826 | | 1877 | 600 | 1928 | |
| 1776 | 583 | 1827 | 509 | 1878 | 664 | 1929 | |
| 1777 | 625 | 1828 | | 1879 | 630 | 1930 | |
| 1778 | 640 | 1829 | 502 | 1880 | 611 | 1931 | |
| 1779 | 609 | 1830 | 490 | 1881 | 619 | 1932 | |
| 1780 | 602 | 1831 | 471 | 1882 | 634 | 1933 | 579 |
| 1781 | 626 | 1832 | 495 | 1883 | 602 | | |
| 1782 | 595 | 1833 | | 1884 | 608 | | |
| 1783 | 553 | 1834 | | 1885 | 630 | | |
| 1784 | 583 | 1835 | 534 | 1886 | 618 | | |
| 1785 | 631 | 1836 | 486 | 1887 | 612 | | |
| 1786 | 643 | 1837 | 482 | 1888 | 691 | | |
| 1787 | 648 | 1838 | 463 | 1889 | 677 | | |
| 1788 | 642 | 1839 | | 1890 | 692 | | |

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