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UNFOLDING THE TURBULENT CENTURY: A RECONSTRUCTION OF CHINA'S HISTORICAL NATIONAL ACCOUNTS, 1840–1912[1]

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This paper reconstructs China's economic development between 1840 and 1912 with an estimation of Gross Domestic Product (GDP). It provides for the first time a time series of GDP (per capita) for the late Qing Dynasty (1644–1911), based on sectoral output and value added, in current as well as in constant prices. The present estimation of per capita GDP in the late Qing period comes out higher than previous estimations, but it still suggests low average levels of Chinese living standards. The economy during the late Qing Empire was characterized by a large and growing agricultural sector and displayed only minor structural changes. Only in the beginning of the twentieth century did the economy start to show signs of growth.

JEL Codes: E01, E23, N15

Keywords: 19th century, China, GDP, living standards

1. Introduction

This paper reconstructs total economy movements and changes in living standards in China during the late Qing Empire (1644–1911), i.e. between 1840 and 1912, and produces for the first time an estimate of annual Gross Domestic Product (per capita). The period is a crucial part of what has been coined by Brandt, Ma and Rawski as the "Turbulent Century," the hundred years between 1840 and 1939 (Brandt *et al.*, 2014, p. 80). The turbulence refers in particular to the combination of wars, reforms, and natural disasters that the country faced after the 1840s when a new social and economic order began to emerge. From the late 19th century onwards, China became more involved in international trade, began to open up its economy, and started to import new

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technologies from the rest of the world (Maddison, 2007). The historical literature on China commonly describes this era as a breakpoint in the country's long-run economic development.

Recent studies on China's modern economic performance have emphasized that developments in the late Qing period had a long-lasting impact on the national economy. China's post-1949 state-led industrial development can be traced to the early stages of industrialization in the late 19th century (Wu, 2011). The country's present trade performance can also be connected to its experience in the 19th century, and thus not only to the 1978 reforms (Keller *et al.*, 2012). Indeed, Brandt *et al.* (2014, p. 47) have wondered why potentially favorable changes in social and economic conditions did not produce immediate improvements in the economy during the late Qing period but only came more than half a century later—with an evident "delay of growth".

Although there are many detailed chronicles of the state of local economies, the picture of the total economy of China in the late Qing period remains rather elusive, which makes a reconstruction of GDP useful. Estimates of real wages have been used as a measure of standard of living, but these are mainly representative for the city population. Knowing that China had an economy with a large rural population and a large primary sector, GDP per capita seems to be a measure that captures far more than just wages. New data together with information from recent historical studies of economic activities in the Qing period will be used to facilitate a new reconstruction of GDP. As with all historical GDP estimations the present paper necessarily involves simplification and approximation, but we see it as an important step forward in the study of the Chinese economy in the Qing period.

The structure of the paper is as follows: Section 2 presents a short overview of the literature on China's long-run economic development and the late Qing period in particular; in Section 3 we introduce our estimation procedures and the underlying assumptions; in Section 4 the new historical reconstruction of GDP will be compared with the results from earlier studies; Section 5 provides a new interpretation of the economic stagnation in the late Qing period; and Section 6 summarizes the main findings. The Online Appendix includes references to all the data that have been used and a detailed exposition of all the steps that were taken in the estimation procedure.[2]

2. China's Growth in the Literature

Until recently, the general opinion in the literature has been that the pre-1945 Chinese economy experienced hardly any substantial improvements in income. Accordingly, the discussions about the late Qing period have often ended with the conclusion that the Chinese economy was trapped in a long-term low-income equilibrium. Recent studies have tried to challenge this traditional picture, mainly by looking from twentieth-century perspectives, but the jury is still out. Rawski (1989), for example, concluded that China experienced a substantial increase in per capita production during the interwar period. This would imply a lower level of per capita production in Qing China before WWI and we can

[2]More details can be found in Ma *et al.* (2014), Appendix B.

therefore ask whether the positive trend in the interwar period can be traced back to the Qing period. Maddison's estimation assumes that sectoral growth of industries and services in 1913–30 can be traced back to the 1890–1913 period, and his estimation of per capita GDP still supports the familiar view of economic stagnation. Development patterns may have been more complex. Wang (2005) studied the economic dynamics of China through the growth of industries and foreign trade only and derived a U-shaped path of the economy in the late Qing period.

Table 1 summarizes previous Chinese GDP estimates of the 19th and the early 20th century. Most of these figures are benchmark estimates for specific years or short periods. Moreover, these GDP estimates are difficult to reconcile with each other because the monetary units are not always expressed in the same currency: some are based on local currencies, while others use internationally-comparable monetary units. It is therefore difficult to get a good idea of the changes in living standards in 19th-century China. For the period that we want to investigate, the Maddison Data produces five estimates and the most recent study by Xu *et al*. (2015a) contains three estimates.[3] Accordingly, we can only generate a very rough picture of economic development in the late Qing period.

Recent studies suggest that the Great Divergence between the Asian and the advanced Western economies had taken root many decades or even centuries before 1800. For China, the late 19th century was a transitional period in between the relatively peaceful early 19th century and the fast industrialization of the 1920s and 1930s. Our new data make it possible to compare Chinese living standards with those of western and other Asian countries. The paper tries to establish whether the Great Divergence continued and even grew in the final part of the Qing Empire or whether China was able to catch-up with the fast growing economies in Europe and Asia.

3. A New Estimation of Historical GDP

This section presents our estimation of Chinese GDP (per capita) for the period 1840–1912. We will first briefly introduce the method and the general estimation procedure, and then discuss underlying assumptions and data sources. In general, it will apply the same methods and procedures as have recently been used in historical GDP reconstructions for other countries, in particular the large Asian economies of the 19th century, such as Japan (Bassino *et al*., 2015, Broadberry *et al*., 2015b), Indonesia (van der Eng, 1992), and India (Broadberry *et al*., 2015a, Broadberry and Gupta, 2010). Similar methods have also been applied for other periods of pre-modern China, such as the reconstruction of pre-1840 Chinese GDP by Broadberry, Guan and Li (2014), the estimation of 1914/18 Chinese NDP by Ma (2008), and Rawski's estimation of the average growth rate of the Chinese economy from the 1910s to the 1930s (Rawski, 1989).

The present reconstruction of the historical national accounts in late Qing China is based on an estimation of sectoral output and value added. Data quality and availability has not only been a central concern in historical GDP

[3]To avoid confusion, in the following text Xu *et al*. (2015a) is short for Xu, Shi, van Leeuwen, Ni, Zhang and Ma (2015).

TABLE 1
HISTORICAL GDP PER CAPITA ESTIMATES FOR CHINA, 1800–1936

	1800–1920							1930s				
	1800	1840	1840	1880s	1850–1913	1850–1911	1914/18	1933	1933	1933	1931–6	1934–6
	Liu, 1987	Liu, 2009	Broadberry *et al.*, 2014	Chang, 1962	Maddison Data	Xu *et al.*, 2015a[a]	Ma, 2008[a]	Ou, 1947	Liu and Yeh, 1965	Maddison Data	Ma, 2008[a]	Fukao *et al.*, 2007
Benchmarks Local Currency	6.7 1700 taels	10.8 taels, current prices	12.95 [c] taels, current prices	7.44 [b] taels, current prices			52.4 1930s yuan	46 yuan, current prices	59.8 yuan, current prices		57.4 1930s yuan	60.5 1930s yuan
Benchmarks or Averages		318 [d]	594 [e]		566	559				579		619
Internationally-comparable Currency		1990 int. dollars	1990 int. dollars		1990 GK dollars	1990 int. dollars				1990 GK dollars		1990 int. dollars

Sources: See references, collected by the authors. The Maddison Data can be found in Bolt and van Zanden (2014).

[a]Here, the value represents net domestic product (NDP). For our new estimation please check the main text and Appendix Table 4. Our estimate for 1912 is 34.86 taels or 52.3 yuan in current prices. Note that 1 Qing tael= 37.3 grams of silver; 1 tael= 1.5 Chinese yuan in the 1930s (Perkins, 1969, p. 2).

[b]Our estimate is 12.91 taels for the 1880s. The lower figure of Chang results mainly from his lower estimate of cultivated land area.

[c]Our estimate is 13.00 taels on average for the 1840s and 14.24 taels for 1840.

[d]The monetary unit "1990 int. dollars" is comparable with the "1990 GK dollars" used by the Maddison Data. Our estimate is 528 int. dollars for 1840.

[e]Our estimate is 538 int. dollars for the 1840s.

reconstructions of the early modern period but also for non-market economies because of the lack of price information. To address this, we need to apply theoretical insights, proxy indicators, and assumptions that have been used in other historical studies. Even for widely-used GDP estimations of advanced western economies, estimation procedures have necessarily involved simplification and approximation, not only for the early modern periods but also for the 19th and 20th centuries. Consequently, for the sectors for which we have only limited data sources we have used methods that are comparable or even similar to those that have been used for England before 1700 (Broadberry *et al.*, 2012) and Holland before 1800 (van Zanden and van Leeuwen, 2012). Our sectoral approach is set up as an open and transparent system that allows for improvements whenever new data become available.

We included all economic activities and classified them into three major sectors of the economy: agriculture, industry, and services. For each sector, we focused on important products or on a major part of production, to guarantee representativeness. For 76 percent of total agricultural output value, we provide an "independent" estimation without referring to a constant sectoral share relative to an existing sectoral value, which covers food crops and three major cash crops, raw cotton, raw silk, and tea. For the major products in agriculture, we relied entirely on our own new annual estimations (see Appendix Table 1a). The remaining agricultural output value including beans, fruits, flowers, livestock, forestry, and fisheries is assumed to be a constant proportion of food crops and major cash crops.[4] Textiles and food processing are the "independent" part and cover 83 percent of manufacturing in our estimation; coal is the "independent" part in mining and takes up 27 percent. Similarly, public administration and a part of commercial activities together involve 49 percent of services. For the rest in the industrial and services sector we do not apply constant sectoral shares since we were able to make use of benchmark estimations of 1840, the average level of the 1880s, 1920, and 1933, which represent output or value added in both sectors (see Appendix Table 1e). The annual movements in between the benchmark years were estimated by log-linear sectoral GDP and population growth, such as in construction, finance and housing, and other professional work.

We assumed a fixed input/output ratio across time in our estimation. This assumption has been applied in many historical GDP estimations, in particular in time series of real output growth e.g. for China 1914/18 and 1661–1933, India 1600–1871, Indonesia 1880–1989, and the UK 1270–1870 (van der Eng, 1992; Ma, 2008; Broadberry *et al.*, 2012; Broadberry, Custodis and Gupta, 2015a; Xu *et al.*, 2015a). Linking levels of value added with the growth of total output value implicitly assumes a fixed input/output ratio across time. Especially in the estimation of China's historical agricultural value added, a fixed input/output ratio has been used in most previous studies, even in the generally-accepted 1933 GDP estimation (Ou, 1947).

[4]See Equation 1.4–1.6 in Ma *et al.* (2014), Appendix B, pp. 38–9. The assumption of constant sectoral shares in agriculture across time has often been used in estimating China's historical agricultural production, such as in the Qing period before 1840 (Broadberry *et al.*, 2014) and in the period 1850–1911 (Xu *et al.*, 2015a).

Combining value added of the three major sectors gives annual nominal levels of GDP. To adjust for price fluctuations in our estimation, we constructed new price indexes for both sectoral and total GDP. For this, we applied the framework in Appendix Table 1. The new general price level is based on rice and wheat prices, import and export prices of raw cotton, raw silk, tea, and coal, and domestic prices of gold. To better position China's pre-modern economy internationally, we also calculated a new benchmark GDP (per capita) for 1912 based on purchasing power parities (PPP).

3.1. *Agricultural Production*

A precise estimation of the agricultural sector is essential to understand the size of the pre-industrial economy of China. As a typical agrarian economy, the country concentrated on crop production, such as grains and textile fibers, rather than livestock products (Maddison, 2007, p. 32). The reconstruction of this sector covers major agricultural outputs that were central to agricultural production in late 19th-century China, such as food and cash crops, in particular, rice, wheat, raw cotton, raw silk, and tea (see Appendix Table 1a and Appendix Figure 1.1). Other agricultural outputs coming from forestry, livestock farming, and fisheries were assumed to move in proportion to crop production.[5] Textile products and tea do not merely represent cash crops but may also reveal the possible impact of a larger exposure of China to international trade after the mid-19th century and the effect of the early industrialization which started in cotton and silk manufacturing. The export share of raw cotton, silk products, and tea combined was more than 50 percent of the total export value in late 19th-century China (Yan, 1989). For most of the food and cash crops that were included, historical records on output and price were used to calculate gross output value (GOV). For example, to estimate total output of raw cotton we combined domestic consumption and net export and calculated GOV by multiplying the estimated total output with the average of export and import prices. Net output value was derived through input/output (i/o) ratios, which we took from previous studies on pre-modern agriculture.[6] To adjust for price movements a general price index for the agricultural sector was constructed, consisting of price series for rice, wheat, raw cotton, raw silk, and tea.

The estimation of the volume of food crops deserves a more detailed treatment since it was most relevant to living standards in China (Perkins, 1969). Land input and land productivity are the major factors affecting food production in our farm accounting model (see also Allen, 2009 for a similar estimation of agricultural productivity in England and China before 1820). Studies on China's agricultural history have provided us with ample information on arable land and crops yields, originally based on official taxation records and local archives on

[5]This assumption has often been used when estimating China's historical agricultural production, e.g. Liu (2009)'s estimation of the early Qing period before 1840, Broadberry *et al.*'s (2014) estimation of the Qing period before 1850, and Xu *et al.* (2015a)'s estimation of the Qing period 1850–1911.

[6]We assumed a fixed input/output ratio of 0.096 which is directly taken from Liu (2009)'s estimation for the early Qing period. The ratio in previous estimations for the Qing period is around 0.10. Please see Table B.5 in Ma *et al.* (2014).

crop production. Our new estimation makes use of these studies but provides new extensions to estimate historical agricultural output.

The first survey of arable land was organized by the People's Republic of China and recorded a level of 1.6 billion mou in 1950.[7] For the period 1850–1911, existing estimates range from 1.2 to 2.0 billion mou (see Ma *et al.*, 2014, Table 4). The most recent estimation for the late Qing period gives a level of 1.4 billion mou (Shi, 2015). Using two levels based on benchmark estimates for respectively 1840 and 1914, our estimation of arable land varies with an average of 1.2 billion mou (Shi, 1989; Zhang, 1991). Although a sudden increase of cultivated land for crops in the central territory of the Qing Empire is not very likely, our estimation does take into account the 1860s immigration wave from middle China into Manchuria, which probably resulted in a slight increase of arable land in the late Qing period as shown in Wu (1985, p. 198) and Perkins (1969, p. 325).

The next step is to calculate total land productivity as the weighted average of unit yields of the different food crops. The weights are determined by the specific use of arable land for various crops per year. Since some crops were harvested twice a year, we took account of multiple cropping and assumed a fixed multiple cropping ratio of 1.32.[8] We also assumed constant shares of land inputs for the eight food crops that we included in our estimation.[9] Following Chang's 1880 estimation, we justified this assumption by stating that the food crop cultivation for the late Qing period was mainly aimed at direct consumption (Chang, 1962, p. 290). Note that we do not apply the same assumption to cash crops. Unit yields for each food crop were constructed for the period 1840–1912 according to the yield levels of the 1930s and an index reflecting fluctuations in annual harvest over the period 1840–1940. Thus, our estimation of land productivity combines unit yields with constant weights and mainly reflects exogenous shocks to unit yields. Besides exogenous factors such as weather conditions and social and political circumstances, technological progress could in principle have a major influence on both land use and unit yields. According to the literature, however, levels of agricultural technology in late 19th-century China did not experience significant changes and did not generate any improvements in agricultural productivity comparable to the agricultural revolution between 1620 and 1820 as described by Bozhong Li (Allen, 2009). Therefore, in our estimation the real change of food crop output is driven only by land input and exogenous fluctuations in unit yields.

The assumption of technological stagnation in the late Qing period in our estimation of output is based on the widely-held opinion that pre-modern China's agriculture was essentially static (Allen, 2009, pp. 529–30). The *Cambridge History of China* mentions that "... the technology and organization of Chinese agriculture differed little in 1911 from what it had been in 1870 (Even into the 1930s it remained largely unchanged)" (Fairbank and Liu, 1980, Chapter 1, p. 2). A

[7]1 mou = 666.5 square metres = 0.1647 acres. 1 Qing mou=0.1518 acres (Perkins, 1969, p. 294).

[8]Multiple cropping ratio = Sown area in one year / Total cultivated area, from Maddison (2007), p. 114, Table A.10. Here we rely on two estimates mentioned in the literature, 1.24 and 1.4 (Wu, 1985, p. 180, Maddison, 2007, p. 36, respectively). We applied the average level of 1.32 for all food crops and for the country as a whole.

[9]The shares of land uses for food crops in our estimation are based on Buck (1930, 1937), Chang (1962), Perkins (1969), and Liu (1987). Please see Table B.3 in Ma *et al.* (2014).

study on pre-modern China's agricultural technology concludes that the improvements in the late Qing period were taking place using traditional technology; new technical breakthroughs were mainly put into use after 1900 (Guo and Cao, 1989). Technological stagnation was also visible in the tendency among farmers to insist on traditional methods (Zhang, 1957, p. 578). Although 19th-century agricultural activities diversified through the adoption of new food crops like maize and sweet potatoes, the spread of the newly imported food alternatives was relatively modest in the last part of the 19th century (Wu, 1985). We therefore believe that in the late Qing period the rise in output from new food crops had only limited impact on total food crop output, which mainly consisted of widely-cultivated products like rice and wheat.

The new indicator that we use to estimate unit yields in Qing China is the so-called harvest ratio. It is a score of the quality of summer or autumn harvests recorded in the semi-annual official reports from the provinces to the central government. In these reports, a bumper harvest is set at 100 percent and a normal harvest at around 75. We interpret the score as a proxy for general agricultural productivity in a specific harvest year relative to an ideal situation, which allows for a consistent long-term comparison of agricultural production.[10] The *Cambridge History of China* has used the harvest ratio to show that there was a downward trend of agricultural production in the course of the 19th century (Fairbank and Liu, 1980, Chapter 1, pp. 6–7). Similar downward trends in provincial levels have also been found in other studies (Zhang, 1957, pp. 755–70, Zhao *et al*., 1995). This primary harvest record contains direct information on year-to-year circumstances that is extremely valuable for revealing annual changes in agricultural output.

We have used the national average harvest ratio calculated by Zhang (1996, pp. 415–9).[11] This study links the time series of the average harvest ratio with the long-term historical climate change in China for the period 1730–1978 and concludes that weather circumstances played a dominant role in agricultural activities and harvests in pre-modern China. From this series, we first constructed an annual harvest index for the late Qing period with the average of the 1930s set at 100. We then calculated unit yields for each food crop that is included in our estimation for the period 1840–1915. For example, the unit yields of rice and maize are supposed to move along the autumn harvest ratio series, and that of wheat followed the summer harvest ratio series.[12] With this procedure, we try to capture

[10]A careful reinterpretation might raise the question of whether the reported harvest data actually reflects subjective observations on agricultural production, which could be affected by the reporters' limited memory of previous harvest conditions. As a test we assumed two alternative possibilities of recollection and checked how much the reported trends will be affected by these alternatives. The first assumption is that the reporter can only remember the maximum level of harvests in the previous 10 years (or 20 years). The new trends are very similar to the original one. The second assumption is that the reporter can only remember the average level of harvests in the previous 10 years (or 20 years). The new trends show a slightly more downward slope than the one of the reported trend in the early 19th century. After the 1870s, the new trends are similar to the original one however.

[11]We did not use regional harvest ratios mainly because we did not have a complete regional dataset that covers all the regions. Moreover, the national harvest ratio we used in this paper has already been calculated from existing regional harvest ratios.

[12]The harvest ratio is not recorded for a specific crop but indicates the aggregate of agricultural productivity that may cover a range of crops in the same harvest season.

the aggregate change in unit yields and circumvent the problem of representativeness that may emerge when estimations are based on one specific region only.

The result of our estimation is a general decline in unit yields and land productivity in the late Qing period, which confirms the findings of early studies (Yan, 1989, p. 949; Wu, 1985, p. 197; Zhao *et al.*, 1995; Shi and Ma, 2010). More specifically, our result shows a continuous decline of land productivity through the 1850s–60s and sharp drops in around 1874 and 1898, which probably reflect not only negative climate changes but also other adverse exogenous shocks, such as the Taiping Rebellion (1851–64) and the first Sino-Japanese war (1894–5). Only after 1900 do we find the annual growth of agricultural production of 1.2 percent, which is roughly in line with Rawski's estimation of 1.4–1.7 percent for the period from the 1910s to the 1930s. The relatively fast improvement in China's agricultural sector as indicated by Rawski may have had its roots in the last decade of the Qing Empire. Our new estimation of land productivity based on the harvest ratio contributes to the on-going debate on the level of agricultural productivity in the Qing period. The present estimation of land productivity gives an average of 126 kg per mou for the period 1840–1915. This falls within the range of 120 and 150 kg per mou that was reported in previous studies (Perkins, 1969; Wu, 1985; Guo, 1994, 1995). If we extend our calculation to include the period 1914–8 the total level of gross food crop output in China reaches 142.8 billion kg, which is very close to Xu and Wu's earlier estimation of 141.7 billion kg (Xu and Wu, 2003, Vol. 2, p. 1078).

3.2. *Industrial Production*

There are only a few official sources available for a direct quantitative reconstruction of the industrial sector of the late Qing period, in particular for the period before the 1860s. Previous studies on pre-modern China's traditional industries and early industrialization allow us to obtain a general picture of the secondary sector in the late Qing period. The *Cambridge History of China* points at an "undoubted disruption" of the domestic cotton industry in the late Qing period due to increased openness to international trade (Fairbank and Liu, 1980, p. 26). In contrast to the collapse of the cotton industry, there is also mention of the expansion in the production of silk goods and tea in response to export demand. But many other domestic industries were probably not affected by 19th-century globalization. We assume these industries to have grown in line with population development, such as rice milling in food-processing and traditional handicrafts like the production of bamboo tools.

For the industrial production of the period 1890–1913 Maddison applied the same rates of industrial growth as were found for the period 1913–33 (Maddison, 2007, p. 156). Ma calculated sectoral value added for the period 1914–8 by projecting backward 1931–6 sectoral levels of value added on the basis of Rawski (1989)'s estimation of sectoral growth rates (Ma, 2008, p. 367, Table 3). The present study improves on these estimations by providing a new time series of industrial production for the period 1840–1920. Levels of gross output value are derived through a backward projection of the time series from the level of industrial output in the benchmark estimation of 1920 in Xu and Wu (2003). To obtain value added, the i/o ratios of handicraft industries in Chang's 1880 estimation and in Ou's 1933 estimation are used for the period 1840–1920 (Chang, 1962; Ou, 1947).[13] Finally, the current price series was deflated by a new general price index for the industrial sector, based on price indexes of raw cotton, raw silk, coal, and the estimated agricultural price index above.

The estimation of industrial growth comprises manufacturing, mining, and construction (see Appendix Table 1b and Appendix Figure 1.2). Figures on manufacturing come from three industries: cotton goods, silk goods, and food-processing. We have used coal production as a proxy for mining. According to previous estimations, manufacturing and mining in the late Qing period together accounted for more than 80 per cent of total valued added in industrial production (Chang, 1962; Liu and Yeh, 1965; Liu, 2009). Textiles and food processing took up more than 50 percent of manufacturing output (Chang, 1962; Xu and Wu, 2003). Other industries in manufacturing and mining were assumed to grow in line with the four proxy industries and with the population. The construction sector in our estimation is assumed to grow in line with population. By combining the movements of the four proxy industries and population growth, we can derive the general growth pattern of the industrial sector in the late Qing period.

China's industrialization started in the late 19th century. Artisans' workshops and other traditional production coexisted with newly-established mechanized factories with machinery or new energy inputs. Chang (1962) tried to measure the size of mechanized industrial production in his 1880s GDP estimation and concluded that the share of new production was still negligible in the 1880s. Xu and Wu (2003) also distinguished between the traditional and the new sector in their estimate for 1920. Using these two estimations as benchmarks, Appendix Table 2a gives the calculation procedure of mechanized factory output for the period between the 1880s and the 1920s. After subtracting the estimated GOV of mechanized production from the estimated GOV of the entire industrial sector, we obtained the GOV of traditional production.

For the estimation of new mechanized industrial production, we have used a growth accounting model under the assumption that in the late Qing period the growth of labor productivity of the new industrial sector was dominated by capital deepening. For simplicity, we assumed the change of technological efficiency (TFP growth) to be zero. Note that we do not assume zero TFP growth for the entire industrial sector; this assumption is only applied to a small part of industrial production. This does not mean that we assumed zero technological progress in mechanized industrial production; however, we assumed that new technology was operated in the form of (imported) capital goods. After the 1860s China's economy experienced a rapid increase in imports of capital goods and energy inputs, such as machinery, coal, and iron. And after the 1870s there was a fast increase in the construction of infrastructure and utilities, such as the railway and the telegraph. Using different TFP growth rates other than zero, however, does

[13]We assumed fixed input/output ratios in manufacturing and mining of 0.667 and 0.200 respectively. Our input/output ratio in manufacturing is directly taken from Chang's 1880 estimate for the input/output ratio, which is smaller than the 1933 estimate of 0.758 in Ou (1947). Our input/output ratio in mining is set between Chang's 1880 estimate of zero and the 1933 estimate of 0.35 (Ou, 1947; Chang, 1962).

not significantly alter our estimations of the growth of the mechanized industrial sector (see Appendix Table 2b).

Applying a zero TFP growth rate and an estimated average capital income share of 47.8 percent in our growth accounting model we find a rapid and constant expansion of new mechanized production in the early stage of China's industrialization. For the period 1885–1920 the GOV of mechanized production increased annually at 8.7 percent. We can compare our preferred combination of the capital income share and zero TFP growth with figures for other Asian countries in the same period. For instance, the capital income share in Meiji Japan was around 47 percent and with the given growth rates of GDP and labor, the resulting TFP growth in 1891–1920 was 1.08 percent per annum (Broadberry *et al.*, 2015b, p. 30, Table 13). To reach a similar rate of TFP growth in Qing China, the corresponding capital income share in the mechanized industrial sector would be around 35 percent in the period 1885–1920, which would indeed tend to underestimate the capital income share in Qing China compared with other Asian economies. A capital income share at 40 percent has been used for pre-World War II India and accordingly the resulting TFP growth for the period 1890/91–1900/01 was −0.8 percent per year (Broadberry and Gupta, 2010, p. 271, Table 8). For the case of Indonesia, van der Eng (2010) derives a level of TFP growth at 0.4 percent for the period 1881–99 by assuming a capital income share at 50 percent (van der Eng, 2010, p. 300, Table 2). In the final decade of the Qing Empire, annual growth of mechanized industry production had already reached 9 percent. Previous estimations resulted in annual growth rates of 10–12.6 percent for the period 1912–25 (Chang, 1969; Kubo, 2005).

The fast growth of mechanized production did not lead to immediate reinforcement of other parts of the industrial sector. Although the share of mechanized production in total industry increased from 6.1 percent in the 1880s to 21.5 percent in 1920, traditional production was still dominant in the late 19th century (Chang, 1962; Xu and Wu, 2003). Our estimation shows that traditional industrial production in Qing China decreased through the entire late 19th century, which is consistent with the historiography of pre-modern handicrafts (Peng, 1957). Only after 1900 did total industrial production start to expand, accompanied by an improving performance of traditional industry (see Appendix Figure 1.4). Rawski (1989) concludes in his study on China's pre-1945 growth that the mutual reinforcement of traditional and new economic sectors contributed to economic growth between the 1910s and the 1930s. Again our estimation reveals that this mutual reinforcement within the industrial sector can be traced back to around 1900.

3.3. *The Service Sector*

The reconstruction of the service sector includes four sub-sectors: public administration, finance and housing, commercial activities, and other professional services (see Appendix Table 1c and Appendix Figure 1.3). We have used public spending as the central indicator for public administration and brought in a new data source to estimate the current value of public spending in the late Qing period. The calculations that were made are based on data published by Shi

TABLE 2

Annual Growth of Real GDP Per Capita for Various Countries and Regions, 1840–1910

a. Economic growth in some regions, 1840–1910 (%)

	12 W. Europe	W. Offshoots	30 W. Europe	7 E. Europe	L. America	16 E. Asia	Qing China	Qing China (Total GDP)	Qing China (Population)
1840–1860	1.35	1.47	1.05	0.46			0.17	−0.27	−0.44
1860–1880	0.88	1.68					0.36	0.24	−0.12
1880–1900	1.54	1.90	1.51	1.38	1.32	0.44	−0.16	0.25	0.42
1900–1910	1.02	1.88	1.27	1.32	2.34	0.69	0.51	1.07	0.56

b. Economic growth in some countries, 1840–1910 (%)

	Italy	Holland/ Netherlands	England/ GB	India	Indonesia (Java before 1880)	Japan	Qing China	Qing China (Total GDP)	Qing China (Population)
1840–1860	−0.24	0.17	0.70		−0.28	0.41	0.17	−0.27	−0.44
1860–1880	0.45	1.06	1.01	0.31	0.99	1.31	0.36	0.24	−0.12
1880–1900	0.74	0.82	1.32	0.40	0.63	1.68	−0.16	0.25	0.42
1900–1910	1.67	1.06	0.24	1.56	1.06	1.16	0.51	1.07	0.56

Sources: Calculated by the authors. Per capita GDP for other countries and regions is from the Maddison Data (Bolt and van Zanden, 2014). The Chinese population is also from the Maddison Data.

(2009). This study has data from the Qing archives containing records of revenues, expenditures, and inventories of the Silver Treasury.[14] We combined the spending recorded by the Silver Treasury with its relative share in total public spending. Shi argues that the share was around 13 percent before 1894 and around 15 per cent after that year, which is much lower than the share of 30 per cent in the early Qing period (Shi, 2009, p. 102). This may signal a declining influence of the central Qing state on political affairs. For missing data in the period 1840–1912, we referred to previous estimations for public spending of the Qing Empire in Shi and Xu (2008). Total public spending in the late Qing period (so including provincial spending) was rather low. The per capita level was 0.27 taels on average, and the average share in GDP was only 1.3 percent. In 1933 the per capita level had increased to 1.1 taels, a mere 2.7 percent of GDP (Liu and Yeh, 1965).

For other sub-sectors within services there is only limited primary information and we therefore had to rely on the assumptions and benchmark estimations of previous studies. We assumed that commercial activities, e.g. commerce, transportation, and communication, developed in line with agricultural and industrial production. For the late Qing period, the commercial ratio (e.g. the part of output that went through the market) was estimated on average at 15 percent for agricultural products and 73 percent for industrial products, according to previous estimations such as Xu and Wu (2003), Broadberry *et al*. (2014), and Xu *et al.* (2015a).[15] Our estimation of the abovementioned commercial ratio includes the increase in the share of marketed products in both agricultural and industrial products. For instance, the marketed products in food crops increased from 10.5 percent before 1840, to 15.8 percent in 1894, and to 21.6 percent in 1920 (Xu and Wu, 2003, vol. 1, p. 289, vol. 2, p. 989). The marketed product in textiles increased roughly from 60 percent to 70 percent (Xu and Wu, 2003). These new estimations of the agricultural and industrial sector enable us to derive levels of value added in commercial activities. For the sub-sectors of finance, housing, and other professional services we assumed a development that was in line with population growth. The years in between the benchmark levels of 1840, the average of the 1880s, 1920, and 1933 were thus filled by population growth in log-linear trends (details of the four benchmark estimations are presented in Appendix Table 1e). To deflate the new levels of value added in current prices we constructed a general price index for the service sector on the basis of the new agricultural and industrial price indexes since our estimation of commercial activities was derived from agricultural and industrial production and commercial activities accounted for around 60 percent of value added in the service sector. The new price index also includes domestic prices of gold as a rough indicator of changes in earnings of

[14]The main archives used in this book are the Yellow Registers ("*Huangce* 黄册,") specifically the registers for aggregate revenues and expenditures ("*Dajin Ce* 大进册" and "*Dachu Ce* 大出册").

[15]The estimation of the commercial ratio of the late Qing period includes two steps: the difference between the producer price and the market price, and the share of marketed product in total output. Details can be found in Xu *et al*. (2015a). Here, we use the five-year average of rice price difference between Shandong province and the Yangzi delta. The price difference decreased from 93.2 percent in the 1870s to 45.5 percent in the 1900s. Rice prices in Shandong province are from the Grain Price Table 1821–1912 published by the Institute of Economics, Chinese Academy of Social Science (2009).

financial activities. Liu (2009) has used the price of gold to represent the general price level of non-agricultural products in the early Qing period.

3.4. *Real GDP and GDP Per Capita*

Adding the three sectors together we are able to derive an annual series of nominal and real GDP (per capita) for the late Qing period (see Appendix Table 1d). Our GDP deflator is an aggregation of the price indexes of the three sectors that we mentioned before. To calculate real GDP per capita we used the population estimation in the Maddison Data.[16] Population growth derived from this data series is consistent with other studies on pre-modern China before ca. 1910 (Perkins, 1969; Cao, 2001; Hou, 2001; Deng, 2004; Xu *et al*., 2015a).

To facilitate an international comparison of living standards, our work also includes an independent and new benchmark estimate of GDP (per capita) for 1912 expressed in current purchasing power parities (see Appendix Table 3). Here follows a short explanation of the procedure. The PPP converter between China (for the year 1912) and the US (for the year 1909) was calculated indirectly from a PPP between China (1912) and the UK (1907). For the agricultural sector, three products were included: rice, wheat, and maize. Price data for these products allowed us to calculate market price ratios between China and the UK. The estimated agricultural PPP between China and the UK is 9.10 yuan/£, which is actually quite close to the market exchange rate in 1912, i.e. 9.99 yuan/£. For the industrial sector, a manufacturing PPP was used from Ma, De Jong and Xu (2016). This comparison covers more than 30 manufactured products resulting in a China/UK PPP of 6.61 yuan/£. Because of the lack of price information in services we implicitly assumed that service PPP is similar to the whole economy PPP and in our calculation equals the average of the agricultural and industrial PPP. The resulting PPP for the whole economy is 8.07 yuan/£ and lower than the 1912 official exchange rate of 9.99 yuan/£. Combining this estimate with the US/UK PPP estimate from Woltjer (2013) of 6.1 $/£, we can now indirectly calculate a new PPP between China and the US of 1.32 yuan/$ (8.07/6.1 = 1.32). Applying the new China/US PPP to our GDP (per capita) estimate of China for 1912, we obtain a level of 551 dollars, which is only a fraction lower than Maddison's 1913 estimate of 552 GK dollars. Both estimates are totally independent. Using this new level a backward projection can be made of Chinese GDP (per capita) both in local currency (in current and constant prices) and in international dollars (int. dollars) for the period 1840–1912 in prices of ca. 1910.

4. Plausibility of the New Results

The present reconstruction of historical GDP of the late Qing period has resulted in new estimations for both levels and trends of real per capita GDP. Appendix Table 4 presents the details, including price indexes and GDP deflators. The level of GDP per capita in current prices is 14.2 taels for 1840 and 34.9 taels

[16]For 1380 to 1930 the Maddison Data provides population estimates at ten year intervals and filled the gap in-between with log-linear growth (Maddison, 2007).

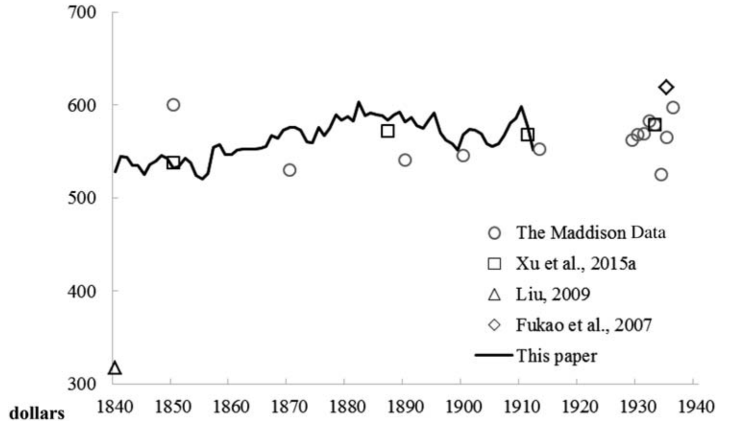

Figure 1. Estimations of per capita GDP in China, 1840-1940, in 1990 international dollars

Sources: See the text, collected by the authors. The Maddison Data can be found in Bolt and van Zanden (2014).

for 1912. The level in international dollars is 528 for 1840 and 551 for 1912. Taking an average across the entire late Qing period, we arrive at a level of 563 int. dollars and of 35.6 taels in 1912 prices. The real growth of GDP per capita is on average 0.06 percent annually for the period 1840–1912, with a peak in the 1880s. Real GDP per capita increased annually at 0.32 percent before the peak and decreased annually at 0.30 percent after the peak.

Figure 1 compares our results with other estimations for the late Qing period and shows that the present estimates of GDP per capita are generally higher.[17] The only exception is Maddison's estimate for 1850, which is assumed to be equal to his 1820 GDP estimate and suggests a higher level of living standards in the early Qing period before the Taiping Rebellion. Instead, we obtain our GDP estimation from quantitative information from the sectoral level, by using archival data and recent historical studies. Our estimates are very close to the most recent GDP per capita estimation in Xu *et al.* (2015a), especially for 1850 and 1911. Our estimation of total GDP is actually lower than in Xu *et al.* (2015a) since the population figures that we use are slightly lower than theirs. We can also compare our 1912 benchmark estimate of GDP per capita with other estimates for the 1910s. It is possible to combine the new 1930s China/US PPP in Fukao *et al.* (2007) with

[17]Our GDP estimates are also higher in terms of silver taels and in current prices. Table 1 shows three other estimates of per capita GDP in current prices and in taels. Our 1840 estimate of 14.24 taels is about 32 percent higher than Liu's estimate of 10.8 taels (Liu, 2009, p. 153). Chang (1962) arrived at a level of 7.4 taels for the 1880s, whereas our estimation is 12.91 taels. The lower figure of Chang results mainly from his low estimate of the area under cultivation. Another recent GDP per capita estimate for 1840 is 12.95 taels in Broadberry *et al.* (2014), which is around 10 percent lower than our estimate of 14.24 taels for the same year. The difference stems mainly from the applied assumptions of the input/output ratio for grain crops. They assume a ratio of 18 percent, which in our view is abnormally high (Broadberry *et al.*, 2014, p. 38). We base our calculation on a ratio of about 10 percent, which is more in line with existing studies. If we use their input/output ratio of 18 instead of 10 percent, the new 1840 estimate would decrease to 13.32 taels. This difference in the assumed i/o ratio explains more than half of the difference.

1914/18 GDP per capita in 1930 prices estimated by Ma (2008). The resulting level of GDP per capita for 1914/18 is 515 int. dollars, which is close to our 1912 estimate of 551 int. dollars independently derived from our new China/US PPP for the 1910s.

To test the reliability of the new estimates of per capita GDP, two cross checks were made. One concerns food crop output, which formed the most important part of the family budget in late Qing China. According to our estimation, the potential daily energy consumption from food crops could reach a level of 2,600 kcal for the late Qing period, with a range between 2,377 and 2,791 kcal, taking account of an energy loss of ca. 20 percent.[18] This level is higher than the overall minimum energy requirement of 1,680 kcal/day estimated by the FAO (2008). However, the daily energy intake recommended by the FAO is around 3,100 kcal for males aged 20–25 years, with a mean body weight of 68 kg and a moderately active lifestyle. For the female population under similar conditions, the recommended daily energy intake is around 2,410 kcal (FAO, 2001). Therefore, the production of food staples in late Qing China could barely support a healthy and well-nourished population, if this were the major energy source of food supply. From this, we can conclude that a large portion of the Chinese population was living at subsistence level during the late Qing period.

Secondly, we can compare our results with alternative measures of living standards, such as average consumption budgets and wages. Here we refer to the average household budget in the Qing Dynasty as an indicator for consumption. The estimated per capita consumption in a five-person family in the late Qing Empire is 12.7 taels in the relatively wealthy Jiang-Zhe region (63.31 taels divided by 5).[19] Our estimation of per capita GDP from the output side is generally higher than this estimated consumption level, except for the 1850s and for particular years in the 1870s–1880s when major disasters happened. As recorded previously, the annual salary of a farm laborer in 1888 was 13 taels in the Shandong province (Zhang, 1957, p. 692). Our estimated per capita GDP of 1888 is 12.89 taels, which is close to this annual salary. As a proxy for a daily wage, we calculated GDP per capita/day and derived an average of 0.044 taels in current prices. This derived average daily wage is close to the baseline wage for the early Qing period calculated by Allen *et al*. (2011, Figure 1, p. 16). Again, this signals low living standards in Qing China during the turbulent late 19th century.

These new estimations result in a different growth path of the economy compared with the Maddison Data for the late Qing period (see Figure 1). Maddison's estimation of per capita real GDP considers the Taiping Rebellion as an important breakpoint in long-term Chinese economic development. His estimation is based on several data points and presumably indicates a stagnation of living standards

[18]Increasing the energy loss to 40 percent will lead to an estimated average of potential daily energy consumption of 1,950 kcal. According to Buck's survey data, the range of daily energy consumption in the 1930s was 1,823–4,434 kcal (Buck, 1930, 1937).

[19]Fang (1996) estimated an average consumption basket in the Qing Dynasty for a farmer family with five members living in the Jiang-Zhe region. It covers food, clothing, rent, and fuel. He concluded that in the early Qing Empire the level of annual household consumption was 32.6 taels and in the late Qing Empire 58.31 taels. Following Zhang (2005), we have added per capita educational expenses to this estimation at an amount of 1 tael per person on average or 5 taels per family.

for the entire Qing period with a sharp decline in 1850–70 that reflects the adverse impact of the Taiping Rebellion. Our estimation of real per capita GDP provides a time series with more fluctuations: a period of relative stability in the 1840s-50s, a first round of increasing levels in the 1860s–80s, a decrease in the 1880s-90s, and a second phase of rising levels from 1900. Table 2 shows annual growth rates of per capita GDP for these four periods respectively, which in general confirms the stagnation of living standards for the late Qing period.

Surprisingly, we find in the new data no constant decline in real GDP per capita during the Taiping Rebellion, which deserves an explanation. Indeed, there was a clear drop of real per capita GDP but only from 1852 to 1855. According to our estimation, the Qing economy lost 6 percent in real terms in the 1850s. But in the same period the total loss of population was more than 8 percent, which by simple arithmetic leads to an increase in per capita real GDP of around 2.5 percent. Thus, the huge decline in population explains the seemingly unusual increase in per capita GDP before 1870. In contrast, the decrease in GDP per capita in the 1880s-90s was driven by an increasing population and a rather constant level of total GDP. Only in the 1870s and 1900s did the growth of the total economy surpass population increases. Figure 2 presents the population trends in our estimation and compares total GDP with per capita GDP. It is tempting to suggest that Malthusian forces were still responsible for the stagnation of living standards in late Qing China. Cha (2014) also emphasizes the role of population growth in 19th-century China by stating that the pressure on economic development "comes from nowhere but population growth;" he estimated a generally downward trend of living standards for the Qing period. According to Figure 2, the sudden liberation from the Malthusian trap in the 1860s–70s did not last; the population recovery in the 1880s-90s led to an immediate decline in per capita GDP.

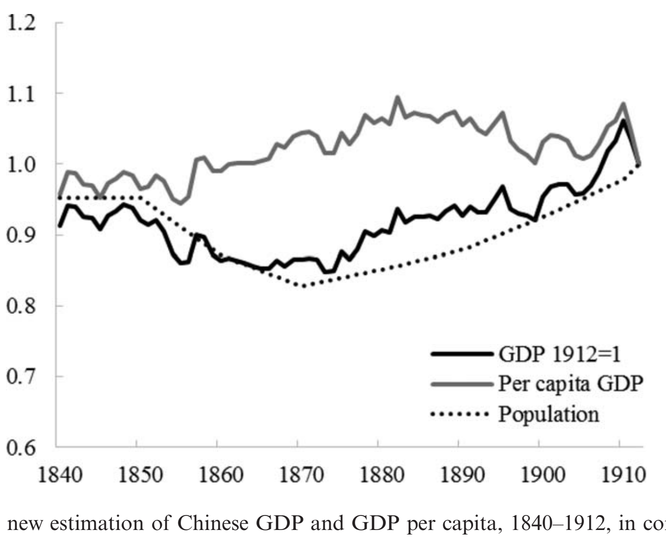

Figure 2. The new estimation of Chinese GDP and GDP per capita, 1840–1912, in constant prices, 1912=1

Sources: See the text, estimated by the authors.

According to our reconstruction of total GDP in Figure 2, the most serious economic decline of the late Qing period happened in the 1850s–60s, when both the economy and society were threatened by wars and natural disasters, such as the Taiping Rebellion in the south (1851–64) and the Nien Rebellion in the north (1852–68). We also find that in these two decades significant setbacks were actually happening in the industrial- and service sectors, more than in the agricultural sector (see Appendix Figure 2). A recovery in the 1870s-80s shows a total increase of real GDP by 7.3 percent. At the beginning of the 1890s, the Qing economy had recovered and returned to its pre-Taiping Rebellion levels. One could ascribe the better performance in the 1870s-80s to the politically-inspired "self-strengthening" movement (1860–94) which intended to incorporate new technologies from more advanced western economies. However, this is doubtful since economic growth, as we have seen, slowed down again in the 1890s. The growth path of real GDP in our estimation fits well into the general situation of the late Qing Empire that we know from the historiography.[20] Very different from Maddison's interpretation, our work views the period after 1870 generally as a period of recovery in the long-term economic development of pre-modern China, which to some extent supports the idea of a "resilience" of the economy in the face of the adverse economic and social conditions of the turbulent century as described in Brandt *et al.* (2014).

The decline of the total economy in the period 1895–9 deserves special attention. This decrease can be attributed to the first Sino-Japanese war, to the bad climatic conditions in the 1890s, and perhaps also to worsening trade conditions. Since the 1860s domestic cotton cloth production in Qing China had been negatively affected by large imports; the downward trend became significant in particular in the 1890s (Xu and Wu, 2003). Similarly, the export of tea reached a peak in the 1880s and started to decline thereafter. We also find a decline in the export of silk goods in the 1890s. The sudden drop in export demand may have led to a decline in domestic production. After being involved in globalization for over half a century, the Qing economy had become more and more vulnerable to shocks from international markets, in particular in the industrial and the service sectors. However, the impact of declining foreign demand was probably mitigated by increasing domestic demand; in the period 1890–1920 the share of marketed products increased. Figure 2 actually shows that after the war period 1894–5 the economy moved quickly back to a growth path. We therefore conclude that the influence of the first Sino-Japanese war was limited and transitory.

Earlier in this section, we compared the levels of GDP per capita with other measures of living standards. We can do the same again with the trends and compare them with trends in wages. Although wages declined sharply in the 1850s, Allen *et al.* (2011) find that real wages in Beijing (northern China) had risen back to their former level of the early Qing period by around 1870 and continued to increase until 1900. Demographic indicators in Baten *et al.* (2010) reveal a decline in living standards in South China from 1850 and a recovery from 1900. In contrast with these trends of partial indicators for specific regions in China, ours is a national aggregate and accordingly the economic fluctuations that we find are relatively mild.

[20]However, our work fails to capture some historical events, such as the four-year drought in northern China from 1876 to 1879.

In the previous section, we have linked the agricultural and industrial production of the 1900s with corresponding developments in the interwar period; we can do this also for total GDP per capita. Ma (2008) derived an increase in real NDP per capita of 0.53 percent per annum for the period from the 1910s to the 1930s. We find almost the same growth rate for the final years of the Qing Empire, with an estimated annual per capita real GDP growth of 0.51 percent for the 1900s.

Finally, we can put the economic performance of the late Qing period in an international perspective. Table 2 compares annual growth rates of real GDP per capita in Qing China with both advanced western and newly-industrializing Asian economies. The comparison shows clearly the divergence of growth paths between Qing China and Western Europe since the mid-19th century. From the second half of the 19th century, Asian economies such as Japan and Indonesia had entered a fast-growth trajectory and were able to catch up with western economies. But Qing China showed no growth acceleration in per capita levels; in the late Qing period annual growth of the economy was much lower than that in contemporary Asian countries. The growth of the Qing economy was still comparable with that of India in 1860–80; however, in the 1900s per capita real GDP of Qing China increased by 5.1 percent in contrast with a growth of 15.6 percent in India. We can also make international comparisons at sectoral levels. In the period 1850–74, the land productivity of food crops in Qing China declined annually by 0.42 percent, while in pre-Meiji Japan land productivity increased annually by 0.27 percent. Qing China's industrial sector started to grow at an annual rate of 2.3 percent in the 1900s, whereas the corresponding growth rate was 3.3 percent in India and 4 percent in Meiji Japan. These data suggest that Qing China was losing out to other Asian countries already in its early stage of industrialization.

5. Economic Stagnation in the Late Qing Empire

Our new estimation of per capita GDP confirms that the economy of the late Qing Empire was stagnant at low levels of living standards. This work focused on measurement and less on finding the mechanisms behind the development of the Qing economy and the Great Divergence with the more advanced Western economies. The new data, however, provide some explanations for the commonly accepted stagnation of the Chinese economy.

Qing China in the late 19th century was an agrarian economy. Figure 3 shows that on average around two thirds of total GDP (in current prices) was produced in the agricultural sector. The agricultural share in 1912 constant prices reached no less than 70 percent in the late Qing period, partly due to high agricultural price levels in the 1910s. One might suspect that the agricultural share may have been overestimated in our calculations. It is difficult to accurately estimate the agricultural share in a pre-modern economy that was characterized by high agro-industrial or agro-service activities. In our estimation, we have placed tea and raw silk in the category of agricultural products, but they can also be seen as processed products and thus manufactured goods. But even if we reclassify the two products into the secondary sector it will not reduce the agricultural share substantially. Other estimations for Qing China also arrived at agricultural shares in current prices above 60 and even 70 percent (Liu, 2009;

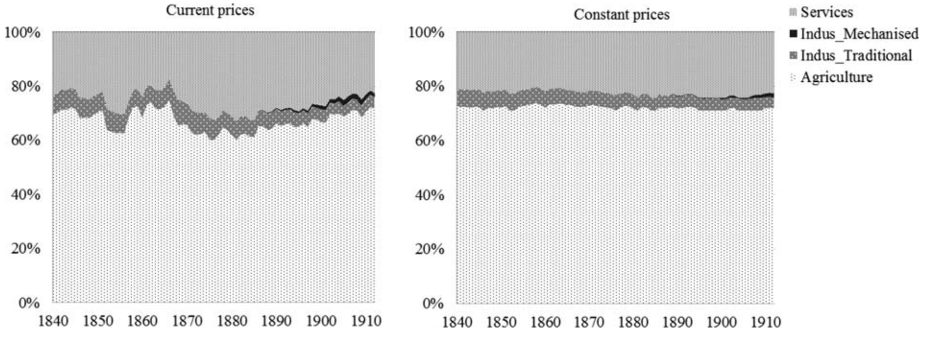

Figure 3. Chinese GDP by sector, 1840–1912, in current prices and prices of 1912

Sources: See the text, estimated by the authors.

Guan and Li, 2010). And in 1933, the share of agriculture still took up more than 60 percent of the total economy (Liu and Yeh, 1965). Compared to other Asian economies, the agricultural sector in Qing China was not exceptionally large; the agricultural share was 47.9 percent in 1880 Indonesia, 67.5 percent in 1881 India, and around 60 percent in pre-Meiji Japan (van der Eng, 1992; Broadberry *et al.*, 2015a; Bassino *et al.*, 2015).

Economic performance in pre-modern China thus largely depended on the growth dynamics of the agricultural sector (Rawski, 1989). The stagnation of the Qing economy in the late 19th century can therefore mainly be attributed to a problematic agricultural development (see Appendix Figure 2). Our results reveal a broad stagnation of land productivity and accordingly no significant improvements in agricultural output. Figure 4 illustrates that the movement in land productivity was

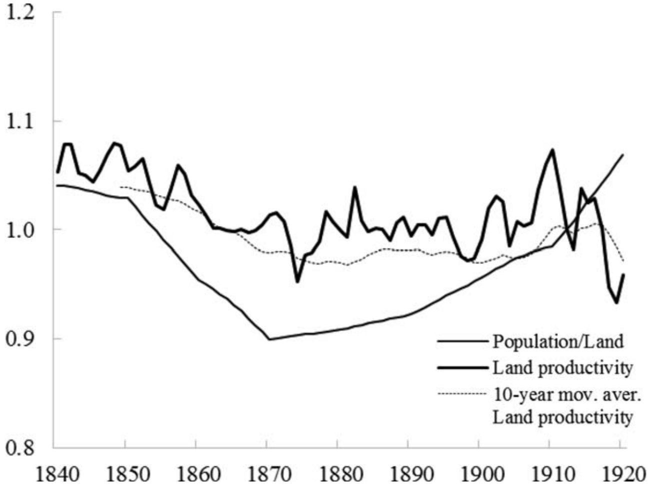

Figure 4. Land productivity for food crops and the population/land ratio, 1840–1920, 1912=1

Sources: See the text, estimated by the authors.

Data on population and cultivated land are from different studies.

Thus, our estimation does not presume any relationship between population change and cultivated land.

roughly similar to the development of the population/land ratio, which directly indicates a stagnation of per capita agricultural output for the late Qing period. Note that we estimated land productivity for food crops independently without referring to population and land data. One possible reason for the poor performance of the agricultural sector may have been the traditional labor-intensive agricultural production methods. Low technological development prevented the achievement of higher levels of land productivity after facing huge losses of labor caused by wars and natural disasters in the late 19th century. Our findings support the traditional view on economic performance in pre-modern China: although population expansion potentially produced high land productivity it resulted in a low per capita income, as stated in Wong's study on economic change in late imperial China between 1500 and 1900 (Wong, 1997).

Figure 3 gives an indication of the fixed economic structure in late Qing China. Regardless of all the efforts toward industrialization, the economy was even showing a growing agricultural sector. If we take Qing China's urbanization level as a proxy for non-agricultural production, new data seem to support our finding of structural stagnation; a recent study concludes that the urbanization ratio remained at 7 percent for the period 1850–95 and increased to 13 percent in 1918 (Xu *et al.*, 2015b). There are only minor shifts between the three sectors. With both the output value and the share of the industrial sector declining, we even find a mild de-industrialization from the 1870s onward, which generally confirms Williamson's (2008) finding on pre-modern China. Even though this was the period of China's early industrialization with the so-called self-strengthening movement (1860–94), the momentum of newly founded industries was overshadowed by the large sector of traditional production in agriculture and handicrafts.

As discussed in the previous section, agricultural output in late Qing China could barely support the population, which means that there was no room for any savings for reinvestment in the agricultural sector and capital formation in other sectors. Low levels of land productivity implied that there was hardly any release of labor to other sectors. More so, in the context of labor-intensive agriculture, efforts to increase the labor/land ratio are a rational way to increase land productivity. But this is not a guarantee of higher income per capita levels. In some cases, agricultural output may even have fallen below the subsistence level. Economic resources in this specific agrarian economy with a large population and with relatively limited access to international markets were still flowing into agricultural activities. In such an economy it may take a long time to move towards an economic structure favoring industrial production and modern economic growth (Broadberry and Gupta, 2006).

6. Conclusions

Although recent studies have provided new interpretations of the economic performance of late Qing China, the question of whether the economy of the "Turbulent Century" was indeed stagnant remains open. Our new estimation provides for the first time annual output data that uncover total-economy trends and fluctuations in both nominal and real terms for the period 1840–1912.

Several new contributions distinguish the present reconstruction from previous estimations. Our estimation focuses on agricultural production and applies the so-called harvest ratio to measure changes in land productivity. The development of the industrial sector is studied by taking into account the early industrialization of pre-modern China by isolating the fast-growing new mechanized industries from the declining traditional production. For services, new data on public expenditure were added. Problems of inconsistency in previous estimations were solved by providing a current PPP estimation for the year 1912 and time series GDP estimation expressed in international dollars.

The present annual estimations of per capita GDP in the late Qing period reveal income levels that are higher than in most other studies, but they nevertheless point at low levels of living standards. Characteristic of the economy was a large and growing agricultural sector. There were no significant structural changes for most of the late Qing period. GDP per capita growth was restrained; and only at the beginning of the 20th century were there signs of progress. But even this positive economic performance seems to be insignificant in comparison with the fast industrialization among neighboring Asian countries. A systematic quantitative investigation into the regional and sectoral components of the Qing economy may provide additional explanations for the missed opportunity to catch up, and for the impact of globalization on the economy.

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Supporting Information

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ONLINE APPENDIX

Appendix Figures 1–2
Appendix Tables 1–4