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Measuring China's performance in the world economy: A Benchmark Comparison between the Economies of China and the UK in the Early Twentieth Century

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Abstract

This paper provides the first estimates of purchasing power parity (PPP) converters from the production side between China and the UK for the early 1910s. It gives a new starting point to evaluate the economic development in pre-modern China during early industrialization since the late 19th century. The estimated PPPs for manufacturing industries provide relative levels of producer prices in China, necessary for the calculation of comparative output and labor productivity. These producer prices are calculated by the authors from an official Chinese industrial census. The 1910s estimate will also be used to obtain a better understanding of the industrial development during the first four decades of the 20th century. By bringing in prices for the agricultural sector we present a new estimate of the welfare level for the total economy.

JEL classification codes: E23 E30 N15 N9

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1. Introduction

Recent studies of China's development in the late 19th century support the long-lasting influence of this era on China's modern economy. Particularly, China's post-1949 state-led industrialization can be traced back by a development path that began in the late 19th century (Wu 2011; Wong 2014). Proper measures of the pre-modern economic conditions in an internationally comparative framework help to understand the rapid economic growth of modern China. The best-known international comparison of long-run economic performance is the work of Angus Maddison. His per capita GDP estimation indicates countries' relative stage of economic development in general; however, a specific measurement for industrialization is necessary to investigate implicit linkages between the modern Chinese industrialization and its initial stage in the 19th century. For this purpose, Yuan, Fukao, and Wu (2010) constructed production-side PPPs for manufacturing industries and measured pre-WWII comparative output and labor productivity for three Asian economies, China, Japan and Korea, setting the US as the benchmark country. Their comparisons focus on the year 1935. Although this year is believed to be a representative year to measure pre-WWII levels of economic development, their study only captures part of the process of China's industrialization, which was in fact initialized in the 1860s.

This study intends to directly compare China's early industrialization level on the eve of the First World War (WWI) relative to that of the highly-developed economy of the UK, by estimating manufacturing purchasing power parities (PPPs) and calculating the comparative levels of labor productivity between both countries. We attempt to quantitatively position China's industrialization level at its early stage, relative to the contemporary leading international economies. Comparative China/UK labor productivity measures not only the absolute difference between Chinese and UK manufacturing, but also the relative development of China's manufacturing from the 1900s to the 1930s, with the development of UK manufacturing as the reference. This makes it possible to estimate China's industrial level since its first efforts toward industrialization before the end of the Qing Empire and analyze movements of convergence and divergence in the Chinese manufacturing sector between the 1900s and 1930s. The new manufacturing PPP estimated in this study will finally help us to obtain a more-detailed comparisons of welfare and productivity for earlier periods, particularly for the pre-WWI era (Fukao, Ma, and Yuan 2007; Woltjer 2013)

Understanding China's industrialization has broader implications. As the world's largest economy in the past and the second largest today, China always had the power to affect the rest of the world, but it also has been influenced by global developments. To obtain a complete understanding of world economic development since industrialization, China's economic situation in the late 19th century is important. In general, the uniqueness of China's industrialization can be used as a special case to show the important role of the manufacturing sector at the early stage of industrialization and to investigate the role of the state in promoting industrialization (Wu 2011; Wong 2014).

After we have given a short introduction of the historical context of China's industrialization in this section, the paper proceeds as follows. Section 2 provides general information on the Chinese economy in the first three decades of the 20th century, relative to the UK economy in 1907, in terms of output, employment, and foreign trade. Section 3 presents the standard industry-of-origin PPP approach applied in this study (Fremdling, de Jong, and Timmer, 2007). Data and sources are provided in Section 4, in

which we introduce the Chinese official yearbook of 1912 in detail. In Section 5, we report the estimated PPPs and discuss the resulting comparative levels of China/UK labor productivity. Section 6 contains concluding remarks.

1.1 China's path of industrialization before the 1930s

An important motivation of this study is to evaluate the development of Chinese industrialization in the period 1840s-1930s. We roughly separate this historical period into two parts, according to the political regimes. In the first period between the 1840s and 1911, when the country was still ruled by the Qing Empire, Chinese industrial development was initially motivated by a series of military defeats, such as the first and second Opium War (1839–42 and 1860, respectively), and severe regime-threatening domestic uprisings, such as the Taiping Rebellion (1850–64). The second period between 1911 and the 1930s started with the establishment of the Republic of China in 1911. After a decade of social chaos and recovery, the Chinese economy experienced a so-called "golden decade" of industrialization between 1927 and 1937 (Yuan, Fukao, and Wu 2010; Wu 2011).

The uniqueness of China's industrialization is the role that the state played in driving and shaping the course of economic development (Wu 2011; Wong 2014). Industrialization in the first period was promoted by the government's self-strengthening movement (1861-95) which aimed at catching up with the more-developed western countries and reinforcing its national defense. This movement was characterized by the establishment of state-owned factories in capital-intensive industries, such as China's first iron and steel factories and the first modern textile factories, together with new infrastructural outlays, such as the railway- and telegraph system. Government interventions remained an essential part of the industrialization in the second period, which was even more characterized by various government plans for industrialization. As summarized by Wu (2011), "Chinese governments, under different regimes in the past over one and a half centuries intervened, engineered, and hence shaped the course of China's industrialization at almost every vital stage."

The government-directed investments before the 1930s may have been essential for China's industrialization in the long run, such as the development of public infrastructures and efforts to promote and adopt Western technologies and practices. However, its contemporary effect on the private sector of the economy may have been less so. This depended on the extent and speed of the spill-overs from the public to the private sector, which are still difficult to measure directly. By focusing on private manufacturing industry, this study aims to reveal one side of China's industrialization in its initial stage and evaluate the development of private industries under the clear policy orientation toward heavy and capital-intensive industries.

2. The Chinese economy in the early 20th century

Before we assess comparative labor productivity levels between China and the UK, we briefly compare the general economic conditions of the two countries and describe the development of the Chinese economy before the 1930s. Based on the comparisons between the Chinese economy and the US economy in 1935 given by Yuan, Fukao, and Wu (2010), this section compares the Chinese economy of

1912 with the UK economy of 1907, and then compares the 1912 Chinese economy with its own 1930s level. The UK economy of 1907, the 1912 Chinese economy, and the 1930s Chinese economy generally represent different stages of economic development and industrialization. Here we will look at the economic structure, the structure of manufacturing, and trade patterns.

2.1 Economic structure

[Table 1]

Table 1 presents the level and the structure of GDP for China and the UK in four different years before the 1930s. In this period, the UK economy left the Chinese economy far behind in per capita GDP, although the two economies were comparable in total GDP levels. Adjusted by market exchange rates, the level of per capita GDP for China was £3.5 in 1907 and £5 in 1912, while the level for the UK was £48.3 in 1907 and £49.2 in 1911, respectively. China's GDP per capita level was 7.3 percent and 10.4 percent of the UK level in 1907 and 1911, respectively. Using just market exchange rates we may underestimate the level of per capita GDP for China relative to the UK level. The official exchange rate is determined by capital flows and by tradable goods, but is not necessarily a good converter for domestic production and consumption. It is more appropriate to use a PPP-based comparison of per capita GDP; however, this requires a new estimation of PPP for the whole economy between the two countries. Based on the manufacturing PPP constructed in this study and prices for agricultural products, we will provide a general PPP for China and the UK and a new GDP estimate for China in the year 1912.

[Figure 1]

Figure 1 illustrates the difference in GDP structure between the two countries. For both 1912 and 1935, China had a share in agriculture of more than 60 percent. By contrast, UK GDP in 1911 was produced mainly in the industrial and service sectors, over 80 percent. As shown in Figure 1, the agricultural share in total GDP in China decreased substantially in the period 1907-1935. Nevertheless, the size of the industrial and service sectors was still extremely low compared with the economic structure of the UK in 1911. Yuan, Fukao, and Wu (2010) also stressed China's relative inferior position in industrialization in 1935, as indicated by a low share of utilities and transportation in total GDP, notwithstanding the government-directed investment in public infrastructure.

2.2 Manufacturing structure

[Table 2]

Table 2 and Figure 2 indicate the manufacturing structure for China and the UK in three different years, which illustrate different stages of industrial development. In general, for both 1912 and 1935, China was still in the early stage of industrialization, compared with UK manufacturing in 1907. Similar to Yuan, Fukao, and Wu's (2010) comparison with the US and Japan, we also regroup manufacturing roughly into labor-intensive and capital-intensive industries. Chinese manufacturing in both 1912 and 1935 largely concentrated in the production of agricultural or primary resource-based goods, such as

food and textiles; the two manufacturing branches took up more than 60 percent of gross output and absorbed over 70 percent of total manufacturing employment. In UK manufacturing over 50 percent of gross output and employment was created by mechanical engineering and the production of mineral-based intermediate materials, mainly including chemicals, building materials, metals and machinery.

[Figure 2]

Figure 2 shows significant structural changes in China's manufacturing sector between 1912 and 1935. In 1912, the food-processing industries produced more than 80 percent of gross output, while in 1935 the level was less than 20 percent. The employment share of food-related production also decreased from more than 40 percent to less than 10 percent. Absolute and relative expansion took place in the textile industry. In 1912, textiles created around 10 percent of gross manufacturing output but it employed more than 30 percent of the manufacturing labor force. This industry had expanded in 1935 to a level of around 40 percent of gross manufacturing output with around 60 percent of manufacturing employment. The structural shift toward intermediate goods production, such as chemicals, basic metal, and building materials, however, indicates the growth potential of the industrial sector already before WWII (Nishimizu and Robinson 1984). But the metal and engineering industries were still significantly smaller than the UK level of 1907, the Japanese level of 1935, and the US level of 1935. The share of iron and steel industries in total manufacturing was 12.6 percent in China in the year 1935, but 37.9 percent in Japan, and 32.7 percent in the US in the same year (Yuan, Fukao, and Wu 2010, Table 2, p. 328). Despite the intention of the state to promote capital-intensive production, the textile industries expanded the most during the period 1912-1935.

2.3 Trade pattern

[Table 3]

Table 3 and Figure 3 present the trade patterns for China and the UK in three different years before the 1930s. In Figure 3.1, we regroup the industries in Table 3 into three categories, following Yuan, Fukao, and Wu (2010, p. 329): (1) "primary goods", (2) "(relatively) simple manufactured goods", and (3) "sophisticated manufactured goods".[2] The shares for the three categories of products also indicate stages of economic development. With a much higher level of industrialization, the UK in 1907 exported mainly manufactured goods, such as textiles, metals, and machinery, and imported primary goods, such as food products and raw materials. The UK export share of manufactured goods was 81 percent in 1907, while the import share of primary goods was 72 percent. Both in 1912 and 1935 China presented the opposite case of the UK. Around 70-80 percent of Chinese exports were primary goods, while the import share of manufactured goods was around 50-70 percent. The contrasting structures between the Chinese and the UK trade may also imply different national characteristics of production, such as the Chinese specialization in silk production.

[2]According to Yuan, Fukao, and Wu (2010, p. 329), (1) "primary goods" includes "foodstuffs and live animals" and "raw materials, minerals, fuels"; (2) "(relatively) simple manufactured goods" includes all manufactured goods except "machinery and transport equipment", and (3) "sophisticated manufactured goods" includes "machinery and transport equipment".

The change of trade patterns for China between 1912 and 1935 is in conformity with classical theories on trade patterns and economic development. As a country concentrates more on industrial production, its exports will shift more towards manufactured goods and its imports more towards primary goods.

[Figure 3]

Compared with its trade shares in 1912, Chinese exports of primary goods decreased by 10 percentage points, while the import share of primary goods increased by 20 percentage points. Figure 3.2 displays an industrial classification of the products traded and shows the changes of trade structures in detail. Food products and raw materials were still the main export goods for China in both 1912 and 1935. Table 3 also indicates some important export goods in 1912, such as seed oil, hides, raw silk, and cotton, which all belong to the category of primary goods. Compared with the trade shares in 1912, Chinese imports of textiles decreased significantly in 1935, while the imports of other manufactured goods increased, in particular for machinery and transportation equipment.

3. Calculating Purchasing Power Parities

This study follows the standard approach of constructing industry-of-origin PPPs developed by the International Comparison of Output and Productivity program (ICOP) at the University of Groningen (Maddison and van Ark, 1988; van Ark, 1993). Recently, the ICOP approach has also been applied to the period before WWII (Fremdling, de Jong, and Timmer 2007; Yuan, Fukao, and Wu 2010; de Jong and Woltjer 2011) and also to the period before WWI (Woltjer 2013; Veenstra 2014). These studies not only prove that it is feasible to apply modern techniques for historical periods, but they also stress the advantages of the price-based method over the quantity-based method in productivity comparisons.

This study combines the methods used in three studies to estimate a new manufacturing PPP for China in the 1910swith the UK as a base country: Fremdling, de Jong, and Timmer (2007) give a Germany/UK comparison for 1935/1936; de Jong and Woltjer (2011) provide a US/UK comparison for 1935; Yuan, Fukao, and Wu (2010) present a CN/US comparison for 1935. Two extensions are made in this study, based on the new price relatives. First, we will compare (gross) labor productivities between China and the UK for 1912/1907, using a single deflation procedure. Second, we will construct a general PPP for the whole economy and then derive a GDP estimate for China in 1912. We can only give a rough estimation here for the whole economy, by combining the new manufacturing PPP with market price ratios for agricultural products between China and the UK.

A later improvement for this study is to use double deflation instead of single deflation, which is considered to be the preferred approach for productivity comparisons, especially for the early 20th century (Fremdling, de Jong, and Timmer 2007; de Jong and Woltjer 2011). The double deflation approach helps to capture differences in the technical input-output coefficients for an industry between two countries, which might be due to, for example, differences in production methods, the type of materials used, and the amount of imported material. All these differences are essential to understand the early stage of industrialization in the 1910s Chinese economy. However, both quantity and price information for inputs is not widely available in the early 20th century production statistics of China,

when the newly-established government of Republic China started to organize the first nationwide census. Another improvement is to adjust for differences in hours worked between the two countries, instead of only using employment data.[3]

We first introduce the basic procedure to calculate a new manufacturing PPP. Unit values (*uv*) are derived by dividing gross output values (*o*) by quantities (*q*) for each matched product *i* in each country.

$$uv_i = \frac{o_i}{q_i}$$

For each matched product, the unit value ratio (*UVR*) is given by the following equation.

$$\mathrm{UVR}_i^{\frac{CN}{UK}} = \frac{uv_i^{CN}}{uv_i^{UK}}$$

In this study, the UK is taken as the base country. The product's *UVR* indicates the relative producer price for the matched product in the two countries. UVRs of individual products need to be aggregated to derive relative prices for sub-industries, for branches, and for the manufacturing sector. We take sub-industry *j* as an example and label the relative price with a superscript *j*. In general, the PPP for industry *j* is given by the following equation.

$$PPP_i^{\frac{CN}{UK}} = \sum_{i=1}^{I} w_{ij} UVR_{ij}^{\frac{CN}{UK}}$$

, where $i=1,\ldots,I$ denotes the matched products in industry *j*; $w_{ij} = o_{ij}/o_j$ denotes the output share of the *i*th product in industry *j*; and $o_j = \sum_{i=1}^{I} o_{ij}$ denotes the total value of matched output in industry *j*. The weights of either the base country (the UK) or the other country (China) can be used, which provide a Laspeyres and a Paasche type PPP, respectively. The Fisher index, the geometric average of the Laspeyres and Paasche indices, will be used in the single deflation process, denoted by $F^{CN/UK}$.

In this study, the aggregation of the UVRs are weighted in multiple steps, first according to their output shares in the sub-industry (Weight III), then according to the industry's shares in the manufacturing branch (Weight II), and finally according to the branch shares in manufacturing as a whole (Weight I). Thus, the new manufacturing PPPs are derived using a "pyramid" type of approach, which consists of three steps (Yuan, Fukao, and Wu 2010). The first step derives industry-specific PPPs, using Weight III. The second step aggregates these industry-specific PPPs to yield branch level PPPs, using Weight II. The final step aggregates these branch-level PPPs to derive a single PPP for the whole manufacturing sector, using Weight I. For the last step, we use the branch shares directly from the census data. As a result, the aggregated PPP in the final step will reflect the actual share of each branch for which UVRs are available and taken as representatives for their branches. Appendix A shows the detailed calculation procedure.

[3] For state-owned factories in 1912 China, average weekly hours worked were ca 55 hours.

Now we can measure the difference in (gross) labor productivity between China and the UK, as the PPP-adjusted gross output value per worker in China relative to the gross output value per worker in the UK.

$$GO_{LP}{}^{\frac{CN}{UK}} = \frac{\frac{O^{CN}}{L^{CN}} / F^{\frac{CN}{UK}}}{\frac{O^{UK}}{L^{UK}}}$$

, where GO_{LP} denote the ratio of (gross) labor productivity between the two countries; $O = \sum_{j=1}^{J} o_j$ denotes the gross output values for the manufacturing sector, *j=1, …, J* denotes the matched branches in the manufacturing sector; *L* denotes the labor force involved in the matched branches.

4. Sources and data

This section introduces the data and sources that are used in constructing PPPs and labor productivities, including data structures, concepts and definitions, industrial classification, coverage, and problems in using the data sources. Details on the sources and data matching are provided in Appendix A and Table 4.

Four types of data have been used in this paper: (1) product data for the calculation of unit values (UVs) and unit value ratios (UVRs), (2) industrial output data to arrive at a weighted and aggregated PPP estimation for industrial sectors and total manufacturing, (3) employment data to calculate productivity levels, and (4) market price data to estimate a price converter for the whole economy. Our dataset is constructed mainly from two official surveys: for the UK we have used the *First Census of Production* of 1907 (Board of Trade 1912); for China the *Agricultural and Industrial Statistical Yearbook* for the Republic of China of 1912 (Agriculture and Industry Department 1914). The Chinese industrial census will be treated in more detail, since the census has rarely been used in studies measuring industrial performance.

4.1 The industrial census of China

The *Agricultural and Industrial Statistical Yearbook* for the Republic of China of 1912, published in 1914, is the result of the first nationwide survey organized by the government of the new Republic of China. The survey summarizes the economic situation for the first year after the overthrow of the 270-year-old Qing Dynasty and the establishment of the Republic of China. It is actually based on local economic reports made at the end of the year 1912 and combines also the survey of the textile industry of 1896, the survey of the silk industry of 1901, and the industrial survey of the period 1907-1908. This survey was conducted annually until 1921.

The Chinese census of 1912 contains information on more than one hundred products and 36 sub-industries for the manufacturing sector, but includes also data on mining and on the financial sector. Information on manufacturing was collected from individual plants or industrial units. They were then organized just by sub-industries, rather than general industrial branches. The census gives information

on gross output (quantities and values of products) for many individual products and on employment for sub-industries. The national aggregates in the census are based on provincial information covering 21 provinces and the capital city. Although it has several drawbacks, the Chinese census of 1912 is still the most important archival record for studying early industrialization in the pre-modern Chinese economy. It provides not only first-hand information but also a comprehensive and detailed coverage of Chinese industry in the 1910s.

Chang (1969) and Xu and Wu (2003) question the reliability of the early Chinese industrial census in the 1910s. They specifically mention the decrease in census coverage from 26 provinces to 10 provinces after 1914 because of domestic social unrest. This decrease leads to a serious underestimation of total industrial output. But even with declining coverage, the use of the data source is still possible according to Xu and Wu (2003). In the present paper we only use the census of 1912. There are a few shortcomings connected with this census. First, some products were not registered in the records. For instance, the census provides the numbers of factories and employment for the production of machinery, ships and vehicles, metal, and electricity power, respectively, but no corresponding information on output is given. Second, the census misses information about three southwestern provinces, Tibet, (Inner) Mongolia, and Qinghai which, however, were not heavily industrialized in the 1910s. A recent re-estimation shows that the census already covered around 65 percent of the total output value in 1912 (Guan, 2011). Thus, the problem of coverage in the census 1912 is in our view not that serious as previously expected. We therefore believe that the census is suitable to compare real output and productivity with the UK.[4] It is essential to use one and the same source for prices, output and employment to guarantee internal consistency of the calculation. By matching products in the two censuses, we were able to include 28 products and 6 branches to estimate PPPs between the countries. Of course we may underestimate the relative production costs between China and the UK due to the four missing sub-industries mentioned above. These sectors were mainly newly-established capital-intensive industries. On the other hand, their impact on the total outcomes is rather small due to the limited size of their total output.

The Chinese census of 1912 defines a factory as an enterprise that hired at least 7 workers, which is similar to the definition in the Japanese *Census of Factories* of 1935.[5] However, the Chinese census actually combines factories with family workshops that hired less than 7 workers. Output data in this census cover both factories and family workshops. For now, we do not try to separate the output of family workshops from the total output given by this census. Thus, we may underestimate labor productivity levels in Chinese manufacturing, if labor productivity in family workshops indeed was lower than in factories. The UK census excluded "domestic workshops" that hired only family members. An accurate performance comparison at industrial level depends on how the "modern" and "traditional" sectors are defined in the official statistics for each country and how we can separate the two. There is a chance that our comparison overestimates the productivity difference between China and the UK around the 1910s, because (1) the "traditional" component of the Chinese manufacturing still

[4] We have used Xu et al (2015)'s industry GDP estimation to solve the coverage problem. The value shares of sub-sectors in manufacturing were estimated by this study rather than the shares from the census. This substitution does not affect the final results in a significant level, however.

[5] The Japanese census of factories of 1935 defined a factory as an enterprise that hired five or more workers and used machine power (Yuan, Fukao, and Wu 2010). The definition of a factory in the Chinese census of 1912 was preliminary and temporary. Later, China's first Factory Law, passed in 1929, defined a factory as an enterprise that hired at least 30 workers and also employed machine power (Lieu, 1955).

dominated in size over the "modern sector" in the 1910s; (2) the productivity of the "traditional" sector was on average lower than that of the "modern" sector; (3) only the "modern" sector is well recorded in the UK census.

Official surveys may differ in their definitions and concepts, such as gross output and employment, which can lead to bias in a productivity comparison. We do not find notable differences between the Chinese census and the UK census on this matter. For instance, the UK census defined employment as "the average number of persons employed on the last Wednesday in January, April, July, and October in the factories, together with the number ordinarily employed in the workshops", while the Chinese census defined employment as "the average number of persons employed in one year". The Chinese census only includes gross output, while the UK census provides data on intermediate inputs and net output as well.

The census years for the comparison between China and the UK differ by five years; thus, we measure the productivity level of Chinese manufacturing in 1912 relative to the UK level in 1907. Although the choice of benchmark years is partly determined by the availability of data sources, we still need to take account of changes of productivity levels in Chinese manufacturing and to assess the possible effects of business cycles and of differences in capacity utilization. During the period 1907-1912, Chinese real GDP did not change significantly, but industrial production might have experienced a rapid increase driven by inputs of capital and labor and by increasing returns, in particular in this early stage of development. If we assume that the increase of Chinese manufacturing was faster than that of UK manufacturing in the period 1907-1912, we may underestimate the gap between the two economies and this will result in a lower comparative China/UK labor productivity. For now, we do not adjust for the year difference. By comparing these two census years, we still capture the nature of Chinese industrial development on the eve of the First World War.

4.2 Data matching and coverage

The starting point for matching products and industries is the industrial classification. This study follows the classification of the UK census of 1907. We try to reclassify the Chinese manufacturing sector into 11 branches as presented in Table 4. The Chinese census gives detailed product and industry information on a lower level of aggregation, which makes it easy to fit the Chinese industries into the classification used in the UK census. We have moved the seed-crushing industry into the branch *Food, Drink and Tobacco*, away from its original branch, *Chemicals*, in the UK census. Future improvement on the classification will be based on the two-digit industries as defined in the ISIC (*International Standard of Industrial Classification*).

[Table 4]

Following the standard "industry-of-origin" PPP approach, as explained in the methodology section, we need to match similar products between China and the UK and then derive prices per unit of product, or unit values (UVs), in the national currency of each country. It would be impossible to match products shared between two countries, without having detailed information about their characteristics. The Chinese census of 1912 used in this study lacks detailed explanations on products and industries. Hence,

other explanatory sources have been used. For this study we relied on two data sources for the Chinese industry: (1) D.K. Lieu's *Report on a Survey of China's Industry* (NRC 1937) and (2) Zhen Chen's *Study Materials of Industrial History in Contemporary China*, vol. 4 (Chen 1961). In the UK census, there is a wealth of information on the product level.

This study presents 30 matches of products and classifies them into 7 branches. The sample of products ranges from cotton piece goods to various chemical products. A complete list is presented in Appendix A. Table 4 gives the range of coverage in terms of gross output and employment, which shows to what extent the Chinese and the UK economies shared similar manufacturing products. We use the number of matches and the coverage ratios to indicate the range of coverage. The calculated coverage ratios are the share of total gross output value or employment being covered by products matched in each country. This study covers 80 percent of the Chinese and 20 percent of the UK manufacturing output. In the various branches, the ratios for China are generally over 50 percent, while the ratios for the UK are around 20 percent. There are three branches for which the coverage ratio is higher than or close to 30 percent for both countries: (1) food, drink, and tobacco, (2) textile industries, and (3) leather and leather products.

The coverage ratios for the manufacturing sector and for each matched branch are quite different between China and the UK. The differences in coverage ratios are significant in this study, compared with the coverage ratios in pre-WWII productivity studies (Fremdling, de Jong, and Timmer 2007) and also pre-WWI productivity studies (Woltjer 2013; Veenstra 2014), in which the differences are usually below 20 percentage points. However, these are comparisons between developed countries. The coverage ratio between a less developed country and a more developed country can vary greatly due to differences in industrial structure and in phases of industrial development. In a China/US manufacturing comparison for the 1930s, 35.7 percent of Chinese products and 17.2 percent of US products were covered (Wu 2001). In a China/Japan comparison for 1935, about 72 percent of Chinese products and 30 percent of Japanese products were covered (Yuan, Fukao, and Wu 2010). In the 1910s, China was still in an early stage of industrialization, compared with the UK, and was slowly recovering from previous internal wars. The number of matches also indicates that the industrial structure in China in the 1910s was still quite basic compared to the UK. As mentioned before, most of the manufacturing production and employment in China centered on simple food-processing activities.

The difference in coverage ratios can also be explained by the availability of data on products, heterogeneity of products and of quality across countries, the unique national character of tastes and output, and differences in quantity specifications (units of measurement). Our China/UK comparison provides various examples. In Chinese manufacturing, mats and matting production was an important industry, which can also be found in the Chinese export reports, but the UK census of 1907 only gives the production value. The Chinese census records gross output of gloves made from textiles, while the UK census only reports gloves made from leather. We have to leave these two products or sub-industries out of our comparison. Silk production is another case. The Chinese census of 1912 lists nine different types of silk products, while there is only one entry of silk products in the UK census of 1907. Thus, we have to use the aggregated silk output in China and compare this with the total silk output in the UK. Similar procedures have been used to compare oil, liquor, and sugar production between the two countries. For paper production, we classified the nine different types of paper listed in

the Chinese census into two general types as used in the UK census: first-class writing paper and paper for printing.

5. Analyzing the new levels of prices, productivity and GDP

5.1 New manufacturing PPPs and a new estimate for total real GDP in China in 1912

Table 5 provides the gross output PPPs according to the methodology described above and presents the Laspeyres, Paasche, and Fisher PPPs from our binary comparisons for manufacturing as a whole and for all the matched branches. The estimated PPP for total manufacturing in China relative to the UK is 6.61 Yuan/Pound. Compared with the market exchange rate in 1912 (9.99 Yuan/Pound), the PPP-adjusted relative producer price level for Chinese manufacturing is 0.66. This suggests that the price for the matched products was 28 percent lower than the UK level than measured by the market exchange rate.

[Table 5]

The lower producer price for China relative to the UK is a reflection of the fact that non-tradable goods had a lower price level in China than in the UK. This is the standard Balassa-Samuelson effect. Productivity growth in the tradable goods sector will eventually raise the price of non-tradable goods, when an economy is more and more involved in foreign trade (Balassa 1964; Samuelson 1964). Therefore, the relatively lower manufacturing PPP results from different stages of economic development of the two economies. The UK economy was certainly more developed, industrialized, and involved in international trade than the Chinese economy in the early 20th century.

A further decomposition of the manufacturing sector offers additional insights into the price structure of these two economies. First, the relative price (UVRs) differences across manufactured products and sub-industries were quite substantial. For instance, the UVRs for sugar and oil are over 20, which is far above the branch average of 9.75 in food processing. In the same branch the UVRs for liquor and tobacco are below 5. Second, the specific pattern of industrial specialization for a country is reflected in the relative price structure between the two countries (See Table 2 and Figure 2 for more details). Chinese manufacturing in 1912 focused on food processing (85 percent), while UK manufacturing in 1907 was concentrated more on textiles (30.4 percent) and engineering (24.4 percent). Even within these branches considerable structural differences existed, again illustrated by the gap between the respective Paasche and Laspeyres PPPs for branches, especially for food processing. In China, edible oil was the main product within the food processing branch, in the UK it was liquor.

Following Yuan, Fukao, and Wu (2010), we can also ask the question how to interpret the gap between the PPP-implied price level and the market exchange rate. Table 5 shows that the gap is almost non-existing for the food processing industry, while for textiles, chemicals, and paper production the gap is quite high. The baseline is that manufactures are generally tradable goods and by nature their PPPs should be close to the market exchange rates (see Prasada Rao and Timmer 2003). Although it is still difficult to provide a comprehensive explanation for the gap, a comparison between the import and export value of products gives us some clues to understand it. Taking the trade of textile products in

China as an example, the import value of textile products was 1.67 times the export value in China in 1912. Figure 4 shows that cotton piece-goods and cottons yarn took up 88 percent of the total import value of textile products, while cotton materials and raw silk took up 80 percent of the total export value of textile products. Thus, in 1912 the Chinese economy exchanged intermediate materials for textile production for textile manufactures. We also find that the import/export ratios for the value of cotton piece-goods, paper, and chemicals in 1912 were 53, 2.3, and 44, respectively. In general, the Chinese economy in the 1910s tended to export intermediate inputs for manufacturing, such as cotton materials and raw silk, and to import final manufactured goods, such as cotton piece-goods . A stronger demand for imports in China than the foreign demand for exports may have driven up the exchange rate of foreign currencies. For instance, the PPP-adjusted relative producer price for Chinese textile industry was 0.64, relative to the market exchange rate in 1912.

[Figure 4]

Appendix B presents the calculation procedure to derive the level of per capita GDP for 1912 in China in terms of 1990 international dollars. Here we applied the method that has been used by Broadberry, Gaun, and Li (2014). For the industrial sector we relied on the already presented results. For the agricultural sector we have used three products, i.e. rice, wheat, and maize, and calculated the market price ratios between China and the UK for the three products. To estimate the weights for the three products in the Chinese agricultural sector, we combined market prices in 1912-1913 and output quantities in 1915 to derive their market value. The resulting agricultural PPP in China relative to the UK is 9.10 Yuan/Pound, which is actually quite close to the market exchange rate in 1912, 9.99 Yuan/Pound. Because we have no price and volume information on services we have assumed that the service PPP equals the average of the agricultural and industrial PPPs. Taking the economic structure for China in 1912 and the UK in 1911 as the weights for the three sectors, we derive the general PPP for the whole economy, which is 8.02 yuan/£ in the 1910s. With this new PPP our estimate of per capita GDP for China in 1912 is 545 international dollars (of 1990), which is lower than Maddison's 1913 estimate, 552 GK dollars. Applying the real growth rates estimated by Ma and De Jong(2016), we can back-project the level of per capita GDP for China in 1912 to its earlier 1840s level, which is 645 international dollars of 1990. This level is higher than Maddison's estimate of 600 dollars for 1850 and Broadberry, Guan, and Li's (2013) estimation of 594 for the 1840s.

5.2 Labor productivity

Table 6 gives our results of comparative gross labor productivity in China and the UK for different branches of industry using our industry-specific PPPs, and a total weighted average. Labor productivity, measured as gross output per worker, reflects the level of capital deepening and the level of efficiency, compared with the base country. In general, labor productivity in Chinese manufacturing in 1912 was around 16 percent of the UK level in 1907. For all the matched branches, Chinese labor productivity levels were substantially lower than the UK levels. We notice that the labor productivity level in the total weighted average is higher than levels for branches. This reflects the extremely large share of food-processing industries in total manufacturing in China, compared with the UK, and the high relative labor productivity level of this branch compared with other Chinese branches.

[Table 6]

Did the Chinese economy experience a catch-up phase in manufacturing during the first decades of the twentieth century, relative to UK manufacturing? To answer this question we constructed comparative labor productivity in 1935 between China and the UK, based on de Jong and Woltjer (2011) and Yuan, Fukao, and Wu (2010). The former provides a relative labor productivity level between the US and the UK (2.24), while the latter provides a relative level between China and the US (0.07). We can derive an indirect labor productivity level between China and the UK for 1934-35 of 0.1568. Relatively speaking, we do find catch-up in manufacturing of China against the UK after the 1910s. However, the catching-up effect is only in a relative form, taking into account the potential underestimation of the comparative China/UK labor productivity in the 1910s. Labor productivity in the UK manufacturing also increased during this period; thus, in absolute levels we can hardly see any catch up in manufacturing of China against the UK.

[Table 7]

Finally we were able to construct comparative labor productivities between regions of China and the UK (see Table 7). This makes it possible e.g. to compare the labor productivity level in the Yangzi delta region with that of the UK in the early stage of China's industrialization. We already discussed that labor productivity for the whole manufacturing sector may average out extreme values among the different industrial branches. Likewise labor productivity for the whole country may also average out extreme values among regions. We regrouped the 21 provinces and the capital city into six larger regions and repeated the calculation of comparative labor productivity. For the sample comparison which only includes the matched products and sub-industries, the Guangdong region was the leading region for manufacturing in 1912; it had higher comparative labor productivity levels than the national level. For the textile industry, the Yangzi region was still one of the leading regions, but it had lost its status to the Guangdong region and even to the large middle region. For the food-processing industry, the middle region was the leading area in 1912, which had always been the main region for agricultural production. Note however, that the regional comparative labor productivity is only a preliminary indicator for the difference between a region of China and the UK, since we have not matched the specific products of the region with the UK but have applied the national manufacturing PPPs.

6. Final remarks

This study fits in the literature on long-term comparative economic performance by providing a new benchmark estimate between the Chinese economy and the more-developed UK economy in the period before WWI. The paper also wants to contribute to the general discussion of industrialization by stressing the importance of structural transformation in the early stages of industrialization. In this final section, we summarize our findings and point out some limitations that need to be taken up in future research on the topic.

The benchmark exercise has estimated a Chinese labor productivity level in manufacturing in 1912 that was around 16 percent of the UK level in 1907. A similar level of comparative labor productivity was

found between the two economies in 1935. This leads to the conclusion that the early industrialization in China during the years between 1912 and 1935 did not narrow the gap with the more-developed economies. However, one might as well conclude that the efforts towards industrialization at least stopped the widening of the gap. Second, during this period the focus of Chinese manufacturing shifted from food-processing to textile manufacturing. Because productivity levels in food production were much higher than in textiles, structural change in the manufacturing sector did not result in rapid growth. Third, comparative labor productivities between regions of China and the UK indicate a significant regional imbalance in the early stage of China's industrialization. Whereas the Yangzi region started to decline, the vast middle region and the south coastal region of China began to take off in the 1910s.

Data coverage remains a big challenge in this type of studies. In particular between less-developed and more-developed economies it is difficult to find large numbers of similar goods necessary to make a reliable labor productivity comparison. This study compares the Chinese and the UK economy on the basis of the matched manufactured goods and the matched branches. But there is no one-to-one relationship with total manufacturing. E.g. for China we also would like to include the productivity performance of state-owned factories and state-directed investments, which are not in the sample. This information would help us to get a complete understanding of China's early industrialization before the establishment of the Peoples' Republic of China in 1949.[6]

However, two major improvements are within reach. The first one is to perform a much closer investigation into the agricultural sector in the context of China's early industrialization and to provide a better PPP-estimator for the total economy. Secondly an estimate of regional manufacturing PPPs for each of the six regions of China will give a more accurate picture of productivity levels between the various regions of China which may be compared with the European core and periphery. The improved PPPs, on both the country and the regional level, may reveal the degree of regional imbalances in the early stage of China's industrialization. The degree of dispersion between the regional and country-level PPPs can tell us whether or not the country-level PPP is a representative indicator for the whole economy.

[6] In 1912 in China the proportion of the employment in state-owned factories to that in private manufacturing enterprises was 0.20 percent.

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Tables and Figures

Table 1 Economic levels and structure taken from the national accounts, China (1907, 1912, 1935) and the UK (1907, 1911)

		China, 1907	China, 1912	China, 1935	UK, 1907	UK, 1911
Total GDP (in mil.)[a]		10284	14918	1928	2113	2227
Per capita GDP, current prices (in national currencies)[a]		24.72	34.50	54.18	48.32	49.20
Structure of GDP (%) [b]		**100**	**100**	**100**	**100**	**100**
Agriculture		**69.6**	**72.3**	**62.5**	**11.8**	**11.8**
Industry		**7.8**	**6.8**	**12.7**	**43.5**	**44.1**
	Mining			0.9	6.3	
	Manufacturing			**10.1**	**32.1**	
	Construction			1.7	5.1	
Services		**22.6**	**20.9**	**24.8**	**44.7**	**44.1**
	Utilities			0.7		
	Transportation			5.7		
	Other services			18.4		

Sources: The first two columns are from Ma and de Jong (2016); The third one is from Yuan, Fukao, and Wu (2010), Table 1; The last two columns are from Feinstein (1976) and Officer and Williamson (2014).The former gives the economic structure for the UK in 1907 and 1911, which are the employment shares of the three sectors. The latter gives the levels of nominal GDP for the UK in 1907 and 1911.

[a] The levels of 1907 and 1912 China are in terms of silver taels. The levels of 1935 China are in terms of Chinese Yuan.

[b] The compositions of GDP are calculated in nominal terms of national currencies. For the UK, the employment shares for three sectors are used.

Table 2 The structure of manufacturing, China(1912, 1935) and the UK (1907)

	Shares in gross output value [a]			Shares in employment [b]		
	China, 1912	China, 1935[c]	UK, 1907	China, 1912	China, 1935[c]	UK, 1907
Structure of manufacturing (%)	100.00	100.00	100.00	100.00	100.00	100.00
Food, drink and tobacco	**85.32**	**14.90**	**19.50**	**44.05**	**9.06**	**8.17**
Textile, clothing, leather products	7.57	**43.10**	**30.93**	**37.79**	**64.41**	**36.89**
Chemicals	1.40	**13.40**	4.03	3.06	8.04	2.25
Iron, steel, engineering, and shipbuilding	1.59	7.80	**24.36**	2.66	4.85	**27.12**
Stone, clay, and glass products	1.36	6.50	7.58	5.85	3.83	12.78
Metal industries	0.00	4.80	6.07	0.00	2.93	2.02
Paper and printing	0.65	8.10	3.98	1.93	5.61	5.73
Lumber and wood products	0.00	0.20	3.01	0.00	0.26	4.21
Miscellaneous	2.11	1.30	0.54	4.66	1.02	0.83

Sources: The data for 1912 China and 1907 UK are from the two censuses used in this study. The data for 1935 China is from Yuan, Fukao, and Wu (2010), Table 2.

[a] Output shares are calculated in nominal terms of national currencies.

[b] Employment is defined as numbers employed rather than hours worked.

[c] For 1935 China, the table gives the structure of *factory* manufacturing. For 1912 China, the table also includes the output and employment of family workshops.

Table 3 Export and import values and shares, China (1912, 1935) and the UK (1907) in mil. of national currencies

	China, 1912						China, 1935				UK, 1907					
	Export	Shares	Shares	Import	Shares	Shares	Export	Shares	import	Shares	Export	Shares	Shares	Import	Shares	Shares
Total value	**555.50**		**100**	**709.29**		**100**	**520.13**	**100**	**669.42**	**100**	**426.04**		**100**	**488.67**		**100**
Food and animals	**206.81**	**100**	**37.23**	**141.55**	**100.**	**19.96**	**111.67**	**21.47**	**179.10**	**26.75**	**26.16**	**100**	**6.14**	**202.50**	**100**	**41.44**
Seed oil	53.40	25.82	9.61	4.60	3.25	0.65					3.43	13.11	0.81	19.05	9.41	3.90
Crude materials,minerals, and fuels	**88.18**	**100**	**15.87**	**68.06**	**100.**	**9.60**	**236.29**	**45.43**	**146.29**	**21.85**	**48.23**	**100**	**11.32**	**66.27**	**100**	**13.56**
Hides	18.52	21.00	3.33	0.94	1.37	0.13					1.82	3.77	0.43	5.66	8.54	1.16
Chemicals	**16.13**	**100**	**2.90**	**66.53**	**100.**	**9.38**	**10.54**	**2.03**	**53.88**	**8.05**	**19.40**	**100**	**4.55**	**15.59**	**100**	**3.19**
Leather	5.36	33.24	0.97	11.81	17.75	1.67					6.60	34.02	1.55	8.07	51.76	1.65
Paper	4.87	30.21	0.88	6.45	9.70	0.91					2.34	12.09	0.55	5.52	35.40	1.13
Textiles	**191.08**	**100**	**34.40**	**245.45**	**100**	**34.61**	**87.59**	**16.84**	**55.08**	**8.23**	**171.71**	**100**	**40.30**	**125.93**	**100**	**25.77**
Cottonmaterials[d]	25.86	13.54	4.66	9.27	3.77	1.31					0	0	0	67.99	53.99	13.91
Cotton goods	3.49	1.83	0.63	122.08	49.74	17.21										
Cotton yarn	0	0	0	93.95	38.28	13.25					110.44	64.31	22.60	9.31	7.39	1.91
Silk cocoons[d]	3.69	1.93	0.66	0	0	0										
Raw silk[d]	109.71	57.42	19.75		0	0										
Silk goods	25.51	13.35	4.59	0	0	0										
Others	22.82	11.94	4.11	20.16	8.21	2.84										
Manufactured products classified by materials[a]	**20.61**		**3.71**	**29.19**		**4.12**	**46.66**	**8.97**	**96.32**	**14.39**	**110.12**		**25.85**	**70.14**		**14.35**
Machinery and transportation equipment	**0**		**0.00**	**15.55**		**2.19**	**2.11**	**0.41**	**53.88**	**8.05**	**44.23**		**10.38**	**6.47**		**1.32**
Miscellaneous manufactured articles[b]	**32.70**		**5.89**	**142.96**		**20.15**	**24.98**	**4.80**	**84.88**	**12.68**	**6.28**		**1.47**	**1.77**		**0.36**
of which(total export or import value =1)																
Primary goods[c]		**0.78**			**0.31**			**0.67**		**0.49**			**0.18**			**0.72**
Simple manufactured goods[c]		**0.22**			**0.67**			**0.33**		**0.43**			**0.71**			**0.26**

Sophisticated manufactured goods [c]	**0.00**	**0.02**	**0.00**	**0.08**	**0.10**	**0.01**

Sources: The trade data for 1912 China is reorganized from Yang and Hou (1931). The trade data for 1935 China is from Yuan, Fukao, and Wu (2010), Table 3. The trade data for 1907 UK is reorganized from "*Annual Statement of the Trade of the United Kingdom, 1907*" (London: HMSO).Value shares are calculated in nominal terms of national currencies.

[a] Excluding textiles. Including metal industries

[b] Including other commodities and transactions not classified according to kind.

[c] "Primary goods" includes ''food stuffs and live animals", ''crude materials, minerals and fuels"; ''simple manufactured goods" includes all manufactured except "machinery and transport equipment"; ''sophisticated manufactured goods" includes only "machinery and transport equipment".

[d] These three items will be classified into primary goods when calculating the share.

Table 4 Product matches and coverage in a comparison of manufacturing sectors in China and the UK, ca. 1910

		Number of matched products	Coverage ratios (%)			
			In gross output value		In employment	
			China, 1912	UK, 1907	China, 1912	UK, 1907
	Total manufacturing	30	0.80	0.20	0.59	0.15
1	Iron, steel, engineering, and shipbuilding	0				
2	Metal industries	0				
3	Textile industries	7	**0.63**	**0.44**	**0.79**	**0.42**
4	Clothing industries	4	0.55	0.22	0.60	0.18
5	Food, drink and tobacco	7	**0.88**	**0.35**	**0.66**	**0.27**
6	Chemicals	8	0.39	0.15	0.28	0.11
7	Paper and printing	2	0.06	0.15	0.06	0.08
8	Leather and leather products	1	**0.92**	**0.45**	**0.89**	**0.28**
9	Lumber and wood products	0				
10	Stone, clay, and glass products	1	0.85	0.55	0.84	0.23
11	Miscellaneous	0				

Sources: Constructed by the authors. See Section 4.2 for more information. For the matched products, see Appendix A for more information.

Table 5 PPPs in manufacturing, China/UK ca. 1910

		Gross output PPP (Yuan/Pounds)			Relative to exchange rates[b]
		Paasche	Laspeyres	Fisher[a]	
	Total manufacturing	**6.67**	**6.55**	**6.61**	**0.66**
1	Food, drink, and tobacco	4.64	14.81	8.29	**0.83**
2	Textiles	6.27	6.68	6.47	**0.65**
3	Leather	11.98	11.98	11.98	**1.20**
4	Clothing	5.09	4.91	5.00	**0.50**
5	Chemicals	20.79	12.49	16.11	**1.61**
6	Clay	7.75	7.75	7.75	**0.78**
6	Paper and printing	9.91	8.87	9.38	**0.94**

Sources: Estimated by the authors. See Appendix A for more information.

[a] Fisher PPP is a geometric mean of Laspeyres and Paasche PPPs for manufacturing PPPs and for branch PPPs.

[b] Relative to exchange rates: Fisher gross output PPP/ the exchange rate in 1912.

In 1912, 1 pound =9.99 Chinese Yuan (Hsiao 1974, p. 187).

Table 6 Comparative labor productivity levels in manufacturing, China/UK ca. 1910[a]

	Sample [d]	Comp. LP 1912/1907[b]		Comp. LP ca. 1935[c]
		1 UK, 1907 =1	2 UK, 1907 =1	UK, 1935 =1
	Total manufacturing	**0.0820**	**0.0905**	**0.1568**
1	Food, drink, and tobacco	0.0612	0.0533	0.1520
2	Textiles	0.0267	0.0283	0.1152
3	Leather	0.0300	0.0487	0.1256
4	Clothing	0.1225	0.1531	0.1896
5	Chemicals	0.0236	0.0240	0.2630
6	Clay, stone, glass	0.1010	0.0734	0.3819
7	Paper	0.0343	0.0606	0.2780

Sources: Estimated by the authors.

[a] Employment is defined as numbers employed rather than hours worked.

[b] Fisher PPP in Table 5 is used here.

[c] For the comparative China/UK labor productivities in 1935, we combine two estimates, the comp. LP US/UK ca. 1935 calculated by de Jong and Woltjer (2011) and the comp. LP China/Us ca. 1935 calculated by Yuan, Fukao, and Wu (2010).

[d] Sample 1 only includes the 27 matched products. Sample 2 includes all the products in the 6 matched industrial branches, including both matched and non-matched products.

Table 7 Comparative labor productivity in manufacturing, regions of China /UK ca. 1910 (UK, 1907=1)

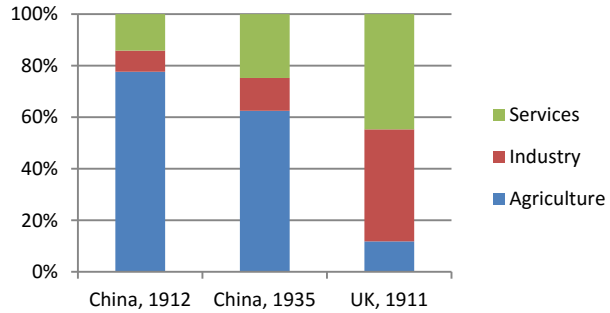
Sources: Estimated by the authors. See Section 5.2.

[a] Only matched products are included. We directly apply the national Fisher PPP to regions of China. "Capital region" covers the capital city, Zhili, Fengtian, Jilin, and Heilongjiang; "Yangzi region" covers two provinces: Jiangsu and Zhejiang; "Guangdong region" covers three south coastal provinces: Fujian, Guangdong, and Guangxi; "Sichuan region" covers Sichuan and Yunnan; "Xinjiang region" covers Xinjiang and Gansu; "Middle region" covers the rest seven provinces, mainly in the middle of China.

[b] Comparative labor productivities for China as a whole is directly from Table 6.

	China [b]	Manchuria	Northern China	Northwestern China	Lower Yangzi	Middle Yangzi	Upper Yangzi	Southwestern China	South China	Southeastern China
Manufacturing	0.0905	0.2259	0.0409	0.0318	0.0433	0.1250	0.0086	0.0489	0.0484	0.0130
Food	0.0533	0.0567	0.1482	0.0134	0.0246	0.1074	0.0049	0.0166	0.0216	0.0030
Textiles	0.0283	0.3768	0.0076	0.0162	0.0441	0.0502	0.0074	0.0353	0.0550	0.0566
Leather	0.0154	0.0625	0.0137	0.0102	0.0040	0.0183	0.0183	0.0055	0.0521	0.0282
Clothing	0.1531	0.3884	0.3046	0.0195	0.1438	0.2542	0.1562	0.3150	0.2396	0.4695
Chemicals	0.0089	0.0874	0.0074	0.0147	0.0070	0.0092	0.0057	0.0208	0.0200	0.0169
Clay products	0.0734	0.2113	0.0734	0.0581	0.1992	0.0771	0.1068	0.0503	0.0365	0.1014
Paper	0.0606	0.2705	0.1772	0.2080	0.0415	0.0804	0.0386	0.0215	0.1500	0.0832

Figure 1 Economic structure from the national accounts, China (1912, 1935) and the UK (1911)



Sources: Constructed by the authors, based on Table 1.

Figure 2 Manufacturing structures for China (1912, 1935) and the UK (1907)

Figure 2.1 Shares in the gross output value of manufacturing

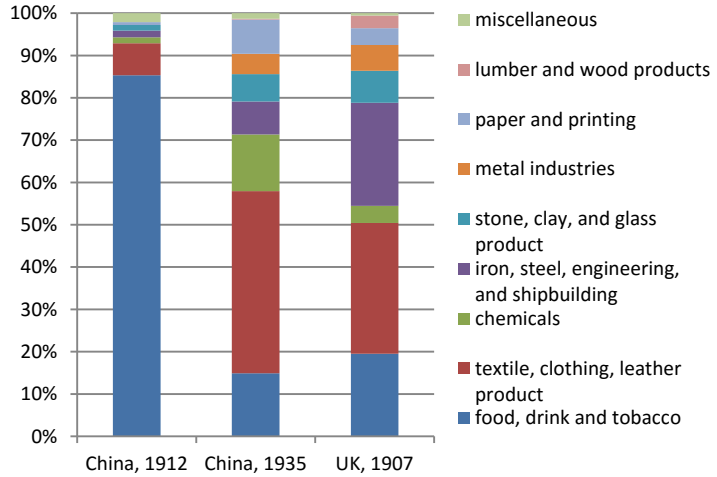
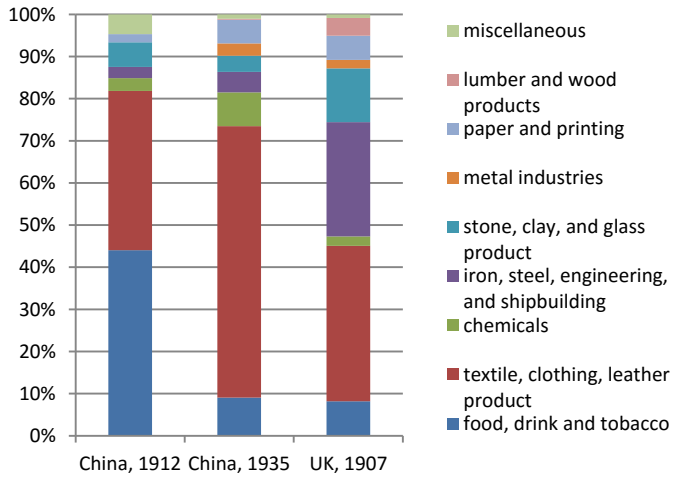


Figure 2.2 Shares in total manufacturing employment



Sources: Constructed by the authors, based on Table 2.

Figure 3 Export and import shares, China/UK various years

Figure 3.1 Shares of three major product classifications

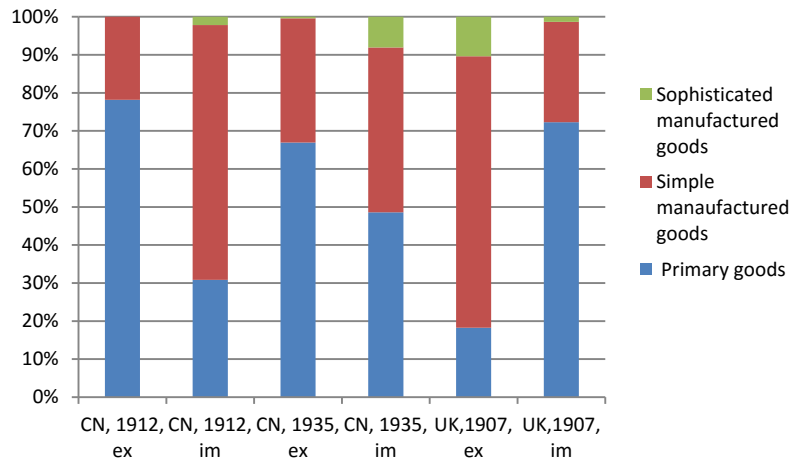
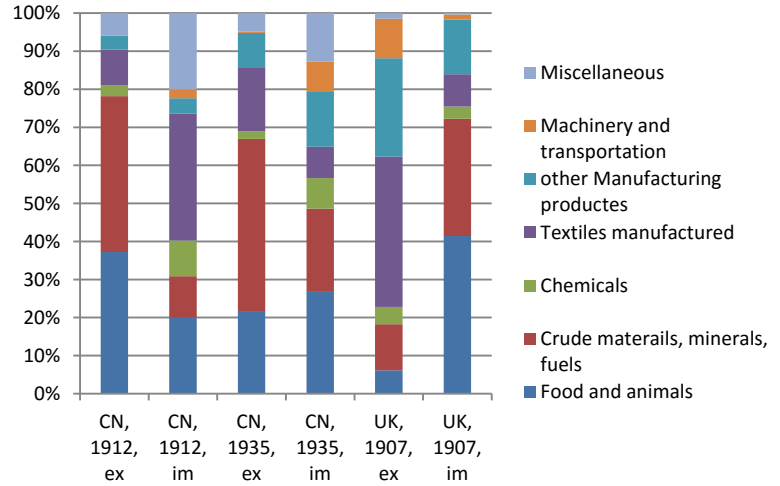
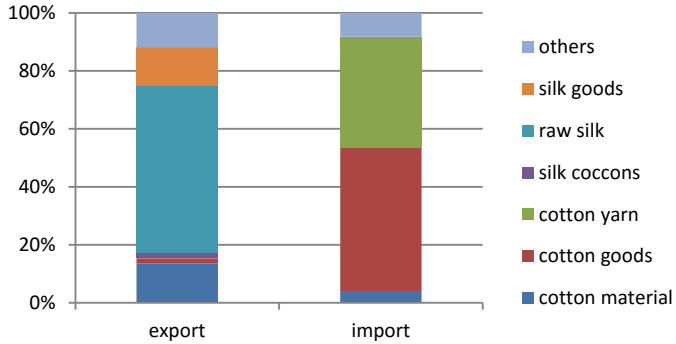


Figure 3.2 Shares of major industrial branches



Sources: Constructed by the authors, based on Table 3.

Figure 4 Export and import shares for textile products in China in 1912



Sources: Constructed by the authors, based on Table 3.

Appendix A The construction of PPPs in manufacturing, China 1912 and UK1907

Table A.1 Gross output, China/UK, 1912/1907

			China			UK		
			unit	q	v	**unit**	q	v
					1000Chinese Yuan			1000pounds
Manufacturing								
Food, drink, and tobacco					**1044295**			**94615**
	flour: bean meal		**Tons**	46.8	13424	**Tons**	15	146
	fruit,canned or bottled		**Tons**	58.6	1954	**Tons**	156	3441
	sugar		**Tons**	138.8	43891	**Tons**	574	8995
	beverage:alcohol		**Tons**	10920.2	948407	**Tons**	4508	58581
	tabacco	snuff	**Tons**	0.0	17	**Tons**	1	307
		cigarettes	**Tons**	0.0	96	**Tons**	14	8195
		other	**Tons**	133.0	36507	**Tons**	35	14950
Textile					**134457**			**145381**
	cotton:piece-good		**yards**	1123442.4	82249	**yards**	7019729	81313
	woollen product	fabrics	**yards**	121.4	85	**yards**	412836	41168
		carpets	**yards**	2.2	7	**yards**	25702	3251
		rug	**number**	255.2	580	**number**	534	138
	Jute,hemp,linen:piece-good		**yards**	169364.7	10062	**yards**	622311	13520
	silk		**yards**	65464.9	40270	**yards**	18468	1589
	Hosiery:hose		**pairs**	3485.2	1205	**pairs**	172668	4402
Leather					**17593**			**996**
	skins:fellmongery		**number**	3381.1	4103	**number**	9831	996
	skins:tanned		number	3214.5	13489	number		
Clothing					**26281**			**23696**
	boots and shoes		**pairs**	15229.7	16086	**pairs**	97984	20066
	hats	hats:felt	**number**	2075.9	826	**number**	16428	2068
		hats:straw	**number**	2072.2	602	**number**	17208	1139
		hats:other(silk)	**number**	9568.9	8766	**number**	2460	423
Chemicals					**23435**			**10177**
	seed oil and cake		**Tons**	1973.6	447029	**Tons**	1396	13188

	Acid	nitric	**Tons**	0.2	36	**Tons**	6	91
		sulphuric	**Tons**	0.0	0	**Tons**	475	861
	soap	household laundry	**Tons**	3.7	461	**Tons**	287	6194
		toilet	**Tons**	0.3	81	**Tons**	13	946
		polishing and scouring	**Tons**	0.0	7	**Tons**	6	146
	candle		**Tons**	94.8	22124	**Tons**	48	1829
	paraffin wax		**Tons**	0.7	723	**Tons**	4	110
Clay,stone,glass					**24522**			**6329**
	bricks		**thou.number**	2378.3	24522	**thou.number**	4760	6329
paper					**1476**			**8953**
	paper:fine		**tons**	0.8	128	**tons**	120	3059
	paper:printing		**tons**	10.2	1349	**tons**	462	5894

Sources: Constructed by the authors from the Chinese census of 1912 and the UK census of 1907.

Table A.2 Gross output PPPs in manufacturing, China/UK, 1912/1907

		China/UK	China weights			UK weights			*Paasche*	*Laspeyres*	Fisher average
		UVR	I	II	III	I	II	III	CN weights	UK weights	
Manufacturing									**6.67**	**6.56**	**6.61**
Food, drink, and tobacco			**0.52**			**0.19**			**4.64**	**14.81**	**8.29**
flour		30.12		0.02			0.35		0.03	30.12	
fruit,canned or bottled		1.51		0.05			0.09		0.66	1.51	
sugar		20.19		0.04			0.07		0.05	20.19	
beverage:alcohol		6.68		0.85			0.36		0.15	6.68	
tabacco	snuff	2.70		0.04	0.00		0.13	0.01	**1.49**	**2.14**	
	cigarettes	4.84			0.05			0.35			
	other	0.64			0.95			0.64			
Textiles			**0.10**			**0.22**			**6.27**	**6.68**	**6.47**
cotton:piece-good		6.32		0.45			0.59		0.16	6.32	
woollen product	fabrics	6.98		0.01	0.12		0.26	0.92	**0.09**	**8.31**	
	carpets	25.09			0.34			0.07			
	rug	8.79			0.54			0.00			
Jute,hemp,linen:piece-good		2.73		0.07			0.11		0.37	2.73	
silk		7.15		0.40			0.02		0.14	7.15	
Hosiery:hose		13.56		0.06			0.03		0.07	13.56	
Leather			**0.01**			**0.02**			**11.98**	**11.98**	**11.98**
skins:fellmongery		11.98		1.00			1.00		0.08	11.98	
skins:tanned				0.00			0.00		0.00	0.00	
Clothing			**0.03**			**0.07**			**5.09**	**4.91**	**5.00**
boots and shoes		5.16		0.62			0.82		0.19	5.16	
hats	hats:felt	3.16		0.38	0.08		0.18	0.57	**0.20**	**3.80**	
	hats:straw	4.39			0.06			0.31			
	hats:other(silk)	5.33			0.86			0.12			
Chemicals			**0.23**			**0.05**			**20.79**	**12.49**	**16.12**
seed oil and cake		23.98		0.94			0.27		0.04	23.98	
Acid	nitric	11.42		0.01	1.00		0.50	0.10	**0.09**	**9.34**	
	sulphuric	9.12			0.00			0.90			
soap	household laundry	5.74		0.00	0.84		0.18	0.85	**0.19**	**5.42**	

	toilet	3.16		0.12		0.13			
	polishing and scouring	6.51		0.04		0.02			
candle		6.13	0.05		0.04		0.16	6.13	
paraffin wax		33.27	0.00		0.00		0.03	33.27	
Clay,stone,glass			**0.03**		**0.08**		**7.75**	**7.75**	**7.75**
bricks		7.75	1.00		1.00		0.13	7.75	
paper			**0.01**		**0.04**		**9.91**	**8.88**	**9.38**
paper:fine		5.97	0.06		0.34				
paper:printing		10.39	0.94		0.66				

Sources: Constructed by the authors, from the Chinese census of 1912 and the UK census of 1907.

Appendix B An new estimation of per capita GDP for China in 1912

Table B.1 A China/UK PPP for 1912 (Chinese Yuan/ $)

	Chinese Yuan Prices/Ton [a]	UK £ Prices/Ton [b]	PPP Yuan per £	Chinese weights [c]	British weights [d]
Agriculture			**9.10**[e]		
Rice	101.85	10.10	10.08	0.89	0
Wheat	71.40	8.14	8.77	0.10	0.80
Maize	46.49	6.88	6.76	0.01	0.20
Agriculture			9.10	0.78	0.118
Industry			6.61 [f]	0.08	0.441
Service			7.85 [g]	0.14	0.441
The economy as a whole					
	China/UK PPP		**8.09**		
	China/US PPP		**1.33**[h]		

Sources: Constructed by the authors.

[a] The Chinese prices for wheat and maize are the wholesale prices in Tianjing in 1913, from the statistical material recollected by Kong and Pend (1988). The Chinese price for rice is the market price in Yangzi Delta in 1912, from Wang (1992), Table 1.1.

[b] The UK prices are from Jacks, O'Rourke, and Williamson (2011).

[c] The Chinese weights within the agricultural sector are calculated by a combination of market prices in 1912-1913 and output quantities in 1915. The output data is from the Chinese census of 1915. The Chinese weights of the whole economy are from the estimation of Ma and De Jong (2016).

[d] The UK weights within the agricultural sector are assumed to an opposite of the Chinese weights in general. We also assume that in 1912 the UK output of rice was negligible. The UK weights of the whole economy are from Feinstein (1976), which are actually employment shares of the three sectors.

[e] Fisher PPP is calculated here.

[f] The industry PPP for 1912 is assumed to equal the manufacturing PPP from Table 5.

[g] The service PPP for 1912 is assumed to be the average of the agriculture and manufacturing PPP.

[h] Using US/UK PPP ($/£), 6.1, from Woltjer (2013), we calculate China/US PPP from China/UK PPP. 8.09/6.1=1.33.

Table B.2 A benchmark estimate of GDP per capita in 1912 in 1990 international dollars

China	
GDP per capita (Yuan) [a]	51.75
US	
GDP per capita ($)	359.6
Exchange rates in 1912	
exchange rate (Yuan per $)	2.06
PPP (Yuan per $) [b]	1.33
Comparative China/UKGDP per capita (%)	
At the exchange rate	0.068
At PPP	0.109
GDP in 1990 international dollars	
US [c]	5017
China	545
Maddison's estimation for 1913 [c]	552

Sources: Constructed by the authors.

[a] The per capita GDP in Chinese Yuan is calculated from the level in taels.

In 1912, officially 1 tael=1.5 Chinese Yuan. 34.5 taels×1.5 Chinese Yuan/tael=51.75 Chinese Yuan.

[b] PPP is from Table B.1 in this Appendix.

[c] The estimate of per capita GDP for 1909 US is from Maddison data 2014 version from Bolt and van Zanden (2014).