Comparative labour productivity performance in Chinese manufacturing, 1952-1997: An ICOP PPP Approach

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ABSTRACT

This study joins the debate of whether Chinese manufacturing has experienced a significant catch-up with or a process of falling behind the world's advanced economies. It calculates a new set of industry-of-origin China-US PPPs for major manufacturing industries at 1987 prices. Then using a newly constructed data set, it derives China's comparative labour productivity level in manufacturing for 1952-97. The results show that China's comparative labour productivity increased from about 3.0 in 1952 to 7.6 in 1997 (USA=100), but with a long stagnation at around 4.5 between 1958 and 1990. A clear catch-up process has been observed since the 1990s when China's market-oriented reform deepened.

JEL classification: F31, L60, O47, P27

Keywords: Industry-of-origin purchasing power parity, Comparative labour productivity, Comparative advantage, Catch up

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1. Introduction

The post-reform Chinese economy has been one of the few most rapidly growing economies in the world. Even based on the most critical assessment so far of Chinese official output statistics, the economy grew at 7.5 percent per annum between 1978 and 1995 (Maddison, 1998), compared with the official figure of 10 percent. This growth rate is similar to that of Japan in 1952-78 and that of South Korea and Taiwan in 1952-95 (Maddison, 1998, Tables 3.4 and 3.10). As for the pre-reform period 1952-78, after Maddison's downward adjustment, the economy still managed to grow at 4.4 percent a year, compared with the official 6.1 percent a year (1998, p.160), which is still a respectable growth rate, especially given all the political and economic chaos that China suffered during that period.

The Catch-up theory argues that countries at low levels of income have a potentiality for a faster productivity advance than countries at high levels of income since the former can use the stock of technology already developed by the latter (Abramovitz, 1986). However, the realisation of catch-up is not guaranteed. It depends primarily on two factors, namely social capability and technological congruence. Social capability refers to the availability of an institutional framework, the capability of government of policy making and political backing, and the human capital (technological and skills) level of the population, whereas technological congruence refers to the capability of adopting Western technology (Abramovitz, 1989).

Based on studies focusing on detailed productivity comparisons at sector/industry level with the world's productivity leader USA using the ICOP (International Comparison of Output and Productivity) industry-of-origin purchasing power parity (PPP) approach,[1] it has been found that the post-war Japanese, South Korean and Taiwanese economies experienced significant catch-up (Pilat, 1994; Timmer and Szirmai, 1997; Timmer, 2000). Compared with these economies, it is unquestionable that the post-war Chinese economy differs distinctly in social and economic settings and has experienced radical, sometimes damaging, policy shifts. We may then ask: "Compared with the leading economies in the world, has the Chinese economy, whose leaders vowed in the 1950s to overtake the West in two decades, experienced any significant catch-up or a process of falling behind?" This is an important question for China at this time when facing a historical opening to international competition that will follow its WTO entry.

[1] The ICOP approach was developed by a group of researchers led by Angus Maddison at the University of Groningen. For a brief explanation see Section 2 and for details see Maddison and van Ark (1988) and van Ark (1993).

To answer this question this study first estimates a new set of China-US PPPs for manufacturing branches at 1987 prices using the ICOP industry-of-origin approach. It then applies the PPP estimates to a newly constructed data set for the gross value added and labour input in Chinese manufacturing in 1952-97 at industry level to derive China's labour productivity in manufacturing in comparison with that of the USA. We have found that in the entire post-war period, China's comparative labour productivity only increased by about 2.1 percent a year. However, the increase was faster (2.8 percent) during the economic reform period 1978-97 than during the central planning period 1952-78 (1.5 percent). As a result, China's comparative labour productivity level rose from 3.0 in 1952 to 7.6 in 1997 (USA=100). This was, however, accompanied by a long stagnation at around 4.5 between 1958 and 1990, but then followed by a clear catch-up process when the market-oriented reform deepened. More importantly, the results shed some lights on how individual industries performed in terms of the PPP-implied comparative advantage in Chinese manufacturing and hence provide an alternative assessment of China's development policies in both the central planning and reform periods.

This paper is organised as follows. The next section provides a brief review of the theories and previous studies of international comparisons, highlighting the problems to be tackled in this study. Section 3 presents the ICOP industry-of-origin PPP approach to the China-US bilateral comparison that is adopted in this study. Section 4 explains the data used and the problems encountered in this study. Section 5 presents and discusses the results. Finally, Section 6 gives some concluding remarks.

2. The Theories and Previous Studies

2.1 The Converter Problem in International Comparisons

International comparison naturally requires a conversion of the output in national currencies to a common *numeraire* or an "international currency". There are mainly two approaches available for the conversion, namely the market exchange-rate approach and the PPP approach. The exchange-rate approach (typically the "*World Bank Atlas* method", World Bank, 1999, p.247) is criticised for substantially underestimating the level of national income for developing countries (Kravis, Heston and Summers, 1982). This is because in principle exchange rates are mainly a reflection of purchasing power over tradable goods and services. For these items inter-country price differences tend to be reduced because of specialisation through trade. In poor countries where wages are low, nontradable items like health care, building construction and government services are generally cheaper than in high income countries. Therefore exchange rates tend to understate the domestic purchasing power of the poor countries' national currencies. Besides, exchange rates can often be strongly influenced by capital movements and speculations and in recent decades have been too volatile to serve as reliable indicators of purchasing power (Maddison and van Ark, 1988).

There are mainly two PPP techniques that have been developed for international comparison, namely the expenditure PPP approach and the industry-of-origin or production PPP approach. The PPP in an expenditure framework is most widely known through the International Comparison Project (ICP) of the United Nations.[2] It can be defined as the number of currency units required in the domestic market to buy goods and services that one unit of the base-country currency can buy in the base country (Kravis, Heston and Summers, 1982).[3]

Although the expenditure approach is useful for the analysis of expenditure patterns and income levels across countries, it provides no sectoral perspective. For that purpose the second method, the industry-of-origin or production approach, is more useful. Developed by the ICOP project at the University of Groningen (Maddison and van Ark 1988; van Ark 1993),[4] this approach takes an integrated view of input and output quantities, producer prices and the values derived from them. Unlike the expenditure approach in ICP which uses special surveys, it employs information from production censuses, input-output tables and national accounts. Its integrated statistics of quantity, unit value and values permit cross-checks not available to the expenditure approach in ICP. One of the most important benefits of this approach is that with appropriate conversion factors (PPPs) derived separately for individual sectors of the economy, it provides data which can be used for the analysis of industry-specific productivity performance, structural change and comparative advantage across countries.

The key concept of the industry-of-origin PPP approach is "unit value ratio" (UVR) which is derived from the unit values of the same product or product group between countries being compared. The unit values are obtained by dividing the ex-factory sales values by the corresponding quantities obtained from each country's

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[2] The expenditure PPP approach through ICP has become a regular exercise of several international organizations such as UN/Eurosat and OECD. The Penn World Tables (Summers and Heston, 1988, 1991), which supply comparative information on GDP and price levels for 130 countries, are also based on results from this approach.

[3] The prevailing international income comparison based on expenditure PPP converters was initiated by pioneering studies by Gilbert and Kravis (1954) and Gilbert and Associates (1958), and later developed in successive ICP (International Comparison Project) phases by Kravis (1976, 1984), Kravis, Heston and Summers (1978, 1982), Summers and Heston (1988, 1991). Also see Kravis (1984) for a complete review of the pre-World War II studies of PPPs.

[4] Based on previous work by Rostas (1948), Paige and Bombach (1959) and Maddison (1970).

production census or survey. These are in fact the prices used in the ICOP project. As van Ark (1993) points out, the main advantage of using unit values instead of specification prices is that the quantities and unit values are consistent with the total value of output.

2.2 PPP-based Studies on China in General

The first expenditure-PPP exercise for China in comparison with the United States was conducted by Kravis (1981) using price and expenditure information for 1975. It was however a "reduced information" exercise because the amount of details on prices and expenditure in China was significantly less than what is normally required by ICP standards, and the results were too high to be acceptable in terms of the value of renminbi yuan.[5] Following the procedure similar to that of Kravis, Ren and Chen (1994) conducted a China-US expenditure-PPP comparison for 1986 with much better Chinese price and expenditure information than Kravis. A recent revision of this exercise (Ren, 1997, p.47) has resulted in a yuan/US$ PPP of 0.94 for 1986 (compared to 0.34 by Kravis for the same year).[6]

Due to difficulties in obtaining the quantity and value data that are necessary for deriving unit values at commodity or commodity group level, compared with the ICP approach it is more difficult to apply the ICOP approach to the Chinese economy as a whole. An earlier effort by Taylor (1991) applies only a pseudo production approach.[7] Ren (1997) attempts to make an ICOP PPP comparison between China and the United States, but ends up with an ICOP-ICP hybrid approach due to insufficient information.[8]

Since more Chinese official data became available, there have been two important studies that follow the standard ICOP PPP approach. One is the China-US agricultural

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[5] The yuan/US$ PPP = 0.34 in 1986 as converted by Ren (1997, p.31). See also comment by Maddison (1995, pp.167-8).

[6] It should be noted that there were no new PPP estimates for China in the Penn World Tables of Summers and Heston (1993, PTW 5.5). Their estimates were in fact extrapolated from Kravis's results based on official consumption deflators, together with a geometric average of PPPs derived from Ren and Chen (1994).

[7] Taylor's study is also considered as a mixture of both expenditure and production approaches, or an unconventional ICP approach using value added weights (World Bank 1994).

[8] Ren's matching exercises fell into four categories in terms of the methods used: 1) applying a standard ICOP PPP method to agriculture, mining, manufacturing, utilities, transport and telecommunications; 2) applying expenditure PPPs (re-weighted) to wholesales and retails; 3) using a quantity-indicator approach to derive PPPs for the finance, insurance and real estate sectors; and 4) using expenditure PPPs as proxies for production PPPs for construction, education, health care, and government and other services (Ren, 1997, p.43).

comparison with 1987 as the benchmark by Maddison (1998)[9] and the other is the China-US manufacturing comparison with 1985 as the benchmark by Szirmai and Ren (2000). Next we concentrate on the latter study as it is more relevant to the present study.

2.3 Comments on the Work by Szirmai and Ren

As the first attempt that applies the ICOP industry-of-origin approach to Chinese manufacturing, the study by Szirmai and Ren (2000), despite various problems mainly due to data constraints, has laid an important foundation for any further work in this field.

Using data from the Chinese 1985 industrial census, Szirmai and Ren make 67 product matches in 23 sample industries, representing 13 of the 15 ICOP branches of manufacturing. The matched value of output represents 37.1 percent of the total gross value of output in China and 18.9 percent in the USA (2000, Appendix A). Their estimated yuan/USD PPP for the whole manufacturing sector for 1985 is 1.84 at the US quantity weights and 1.15 at the Chinese quantity weights, implying a Fisher average of 1.45 yuan per dollar, compared with the official exchange rate of 2.9 yuan per dollar (2000, Table 4).

The most striking result from the Szirmai-Ren exercise is that in production PPP terms and with the USA as the reference country, Chinese manufacturing experienced no catch-up at all in 1980-92, with an estimated comparative labour productivity value of 6.3 (USA=100) for 1980 and 6.2 for 1992 (2000, Table 8). However, if taking an arithmetic mean of the three years at each end of this period, one will get 6.4 for 1980-82 and 5.7 for 1990-92, indicating a clear decline over time. This result leads to the authors' conclusion that as other leading Asian economies exhibited catch-up during this period, China in fact experienced a process of falling behind in the Asian context.

To understand this conclusion of "no catch up" or "falling behind", one has to understand the nature of the Chinese and US data Szirmai and Ren used and the important adjustments they made to these data in order to estimate branch-level PPPs for 1985 and conduct the ICOP catch-up accounting for the period 1980-92. Obviously, the way of deriving PPPs, adjusting value added and employment data, and deflating nominal output figures can affect the result of the catch up accounting.

[9] For reader's reference, Maddison's study made 60 farm product matches of 11 branches of agriculture, representing 89 percent of (FAO) gross value for China and 94 percent for the USA. The estimated yuan/USD PPP for the 1987 benchmark is 2.313 at Chinese quantity weights and 3.012 at US quantity weights, implying a Fisher average of 2.639, compared to the official exchange rate of 3.722 in 1987 (Maddison, 1998, Table A.11 and Table A.24).

Assuming that the US data are less problematic, our discussion below will focus on likely problems in their treatments of the Chinese data.

First, as the authors have indicated, their PPP (UVR) estimates could be biased since they were derived using the value and quantity figures of the census that do not match (2000, p.28). However, the census provides no useful information for one to gauge the degree of the possible biases. Another and perhaps more important problem is that output valuation in 1985 was still heavily affected by the price distortions developed under central planning. Basically, producer goods were underpriced to serve the government's heavy industrialisation strategy since the 1950s. Combined with various forms of subsidies, the effect of the price distortions across industries was very complex. But, one thing is clear, that is, most industries did not produce according to their underlying real factor costs. Therefore, it could be misleading if the estimates were used to conduct the usual ICOP analyses of industry-specific productivity, structural change and comparative advantage across countries.

Second, the Chinese and US output data they used are conceptually different. The former, which follows the material product system (MPS), refers to "net industrial output" (i.e. net material product or NMP), while the latter refers to the "US census concept of value added" that differs from the SNA concept of value added by including the "cost of intermediate service inputs from outside the manufacturing sector" (see Maddison and van Ark, 1988). To make the Chinese and US output data compatible, Szirmai and Ren first sum up the "net industrial output" and "depreciation" (approximately equal to the SNA concept of value added) in the census, and then add their estimates for "material service inputs" based on ratios for such inputs calculated from the Chinese 1987 Input-Output Table (2000, p.26). This treatment is also problematic. Since the MPS concept of "net industrial output" already includes "payments for material services",[10] their treatment has certainly exaggerated service inputs, and hence overestimated Chinese value added per labourer, other things being equal.

Third, it is sensible for the authors to consider seriously the upward bias contained in the SSB (State Statistical Bureau of China) "comparable price"-based output deflators (See Wu, 2000a). They argue that the SSB industry-specific producer price indices may serve as better output deflators. Indeed, their calculation shows that, for example, the real output of Chinese manufacturing grew at 7.6 percent a year in 1980-92, about one third lower than the official rate of 10.9 percent (2000, Table 6). However, the indices may also have problems, especially for the period under their

[10] See Wu (2000a, Appendix A) for a mathematical expression of this problem.

study. As indicated by the CIESY (China Industrial Economic Statistical Yearbook) compiler, the indices are constructed with “selected products” from “national key enterprises” (DITS, 1993, p.268). Although there is no information on how the product selection is conducted and how the national key enterprises are defined, to most people’s knowledge, the selected products would be the major ones routinely reported in CIESY and the “national key enterprises” in the Chinese tradition would be referring to those who are large in size, definitely state owned, heavy-industry firms. Here we should realise two things existing before the 1990s. Firstly, compared with other enterprises, these “key enterprises” were less reformed. Secondly, official statistical work adjusted gradually to cover more output sold at market prices. These may have some mixed effects on the SSB industry-specific producer price indices constructed. On one hand, the indices might tend to understate the actual price movements in industrial output in general. On the other hand, the likely increase in the statistical coverage of market prices might tend to overstate the actual price movements. The net effect is however an empirical question that is not tackled in Szirmai and Ren (2000).

Fourth, it is also sensible for the authors to remove those employees in the Chinese census who provide auxiliary services in manufacturing enterprises (e.g. working in factory-run child care, medical clinic, canteen, etc.), which makes the Chinese employment data match the US data. Using the information provided in China’s 1985 Industrial Census, they make a substantial down-scale adjustment of manufacturing employment by 9.8 percent for 1985 (2000, p.27), which is important for both their productivity level and catch up analyses. However, they provide no information on how the adjustment has been made to other years in 1980-92.

3. Methodology

This study attempts to derive the industry-of-origin (production) PPPs for 15 Chinese manufacturing branches using the US as the reference economy and 1987 as the benchmark year, the time when both the Chinese 1987 Input-Output Survey and the US 1987 Census of Manufactures were conducted.[11] The methodology used in this study is the same as the one adopted by Szirmai and Ren (2000), which follows van Ark (1993).

[11] We use industry-of-origin PPPs throughout this study which are the same as UVRs used in Szirmai and Ren (2000).

To derive China/US industry-of-origin PPPs, two major steps are followed.[12] First, the average PPP for an industry *j* is obtained by weighting the unit value (*P*) of all matched items (*i=1,2,...m*) belonging to *j* by the quantity weights of China (Q^C),

$$\text{PPP}_j^{CU(C)} = \frac{\sum_{i=1}^{m}(P_{ij}^C Q_{ij}^C)}{\sum_{i=1}^{m}(P_{ij}^U Q_{ij}^C)} \tag{1}$$

and by the quantity weights of the USA (Q^U),

$$\text{PPP}_j^{CU(U)} = \frac{\sum_{i=1}^{m}(P_{ij}^C Q_{ij}^U)}{\sum_{i=1}^{m}(P_{ij}^U Q_{ij}^U)}, \tag{2}$$

where

$\text{PPP}_j^{CU(C)}$ is the purchasing power parity of the yuan against the US dollar in sample industry *j* at Chinese quantity weights (i.e. the Paasche weights);

$\text{PPP}_j^{CU(U)}$ is the purchasing power parity of the yuan against the US dollar in industry *j* at US quantity weights (i.e. the Laspeyres weights).

Second, the aggregation of *j* industry-level (*j=1,2,...n*) PPP to *k* branch level is obtained by taking the weighted average of sample industry PPPs using the gross values of output (GVO) of the sample industries as weights. The following formulas are developed especially to take into account the size effect of industries and branches in aggregation (see van Ark, 1993). The exercise in this step results in two PPPs at branch level, one at quantity weights of China or the Paasche weights

$$\text{PPP}_k^{CU(C)} = \frac{\sum_{j=1}^{n}\text{GVO}_{jk}^C}{\sum_{j=1}^{n}[\text{GVO}_{jk}^C / \text{PPP}_{jk}^{CU(C)}]} \tag{3}$$

and the other at quantity weights of the USA or the Laspeyres weights

$$\text{PPP}_k^{CU(U)} = \frac{\sum_{j=1}^{n}[\text{GVO}_{jk}^U \cdot \text{PPP}_{jk}^{CU(U)}]}{\sum_{j=1}^{n}\text{GVO}_{jk}^U}. \tag{4}$$

[12] In the discussion of estimation procedures, we name the levels of aggregation from the bottom to the top as: product items/product groups (*i*), industries (*j*), branches (*k*) and the manufacturing sector as a whole (simply manufacturing). These notations are used throughout this study.

As discussed previously Fisher geometric average is often used to combine the two PPPs that is to neutralise the influence of both countries' weights:

$$\text{PPP}_k^{CU(\text{Fisher})} = \sqrt{\text{PPP}_k^{CU(C)} \cdot \text{PPP}_k^{CU(U)}}\ . \qquad (5)$$

The same procedures are used to complete the final aggregation to the manufacturing sector level.

4. Data Sources and Problems

4.1 Chinese Data

All the required data in this study are not directly available from Chinese official sources, but are based on the author's estimates in the present and previous studies. Although the unavoidable data problems have forced us to resort to some compromises between data availability and methodological ideal, we generally pursue the spirit of the ICOP approach throughout this study.

4.1.1 Gross Value Added in Manufacturing (GVA)

The branch-level GVA data for the benchmark year 1987 are obtained from the Chinese 1987 Input-Output Table - China's first SNA-type input-output table. The figures are reported in Table 1. This means that unlike the study by Szirmai and Ren (2000, p.26) that adopts the US census concept of value added, this study follows the SNA concept of value added that does not include the "cost of intermediate service inputs from outside the manufacturing sector" and hence does not exaggerate productivity level.[13] The branch-level gross value of output (GVO) data for 1987 are also extracted from the Chinese 1987 Input-Output Table (Table 1). Unlike Szirmai and Ren who focus on the independent accounting units at the township-and-above level, both the GVA and GVO data used in this study refer to the national total.

The 1952-97 time series GVA data for individual branches are adopted from Wu (2000b). His procedures are explained as follows. Firstly, about 200 major industrial products or product groups, published annually by DITS (Department of Industrial and Transportation Statistics, SSB), are aggregated to the branch level in the 1987 weights based on detailed ex-factory price data surveyed by SSB (see 2000b). Secondly, output indices for individual branches are constructed based on the so-aggregated output series. Thirdly, GVA series for individual branches are derived

[13] This makes a significant difference in that the SNA concept value added for US manufacturing in 1985 (US$804,377 million, BEA, 1998) is only 80.4 percent of that of the US census concept value added (US$1,000,142 million, Szirmai and Ren, 2000, Table 2).

using the SNA-concept value added figures for 1987 from the Chinese 1987 IO Table. Wu's estimates have supported the upward bias hypothesis about the SSB output indices. They show that China's industrial growth rate is overstated by at least 2 percentage points for the pre-reform period and 3.5 percentage points for the post-reform period. Wu's results may contain two major biases, the constant 1987 input-output ratio assumption and the underlying assumption of constant quality of products. However, since empirical evidences suggest that while product quality improves over time the input-output ratios actually declines (2000b, Table 6), the net effects of the assumptions may be insignificant and the estimates should be justified. The advantage of using Wu's indices is that they are to a large extent independent of official deflators. The estimates for selected years are given in Appendix Table A1.

4.1.2 Manufacturing employment

To match the above output data a compatible employment indicator is in order. However, Chinese official employment data have even more flaws than the output data in that there is not any employment indicator that could reflect important changes in China's employment system and at the same time maintain historical consistency.

China's statistical authorities have provided no working hour estimates that are based on regular sample surveys, and have not followed the internationally accepted unemployment measurement, which makes it very difficult for researchers to properly measure labour input for productivity analysis. Therefore, problems like ineffective working hours in many state-owned enterprises (SOEs), largely due to shirking, lack of job, and short of energy supply, and unemployed workers who remain on the payroll in all SOEs, largely due to political reason, are inherent in the official data.[14] In addition, widely observed data misreporting, tampering and fabricating by local officials with political incentives have further aggravated the problem. Data fabrication is a particular problem in small-scale rural enterprises because these enterprises are not capable of following standard accounting procedures and therefore the problem is almost impossible to detect.[15]

[14] It should also be noted that China's official working hours also declined from 48 hours per week prior to May 1, 1994, to 44 hours between May 1, 1994 and April 30, 1995, and further to 40 hours since May 1, 1995. In recent years, aiming to boost consumption, the authorities have at least doubled the number of national holidays from 8 to 16 days.

[15] The information here is based on the author's interviews with senior statisticians in SSB. Some of them believe that about 40-50% of the reported output and labor data for village level and below-village level enterprises are flawed. An investigation in 1997, jointly run by several ministries including SSB, found 75,000 cases violating the state Statistical Law, most of them related to misreporting, tampering and fabricating data, and most of the worst cases related to small rural industrial enterprises (*Outlook Weekly*, No.15/1998, pp.10-12).

Our problem is how to clean the mess in official employment statistics. In this study, we attempt to follow the BEA (Bureau of Economic Analysis, US Department of Commerce) concept of full-time equivalent employment used in US manufacturing statistics. Firstly, we base our estimates on an employment indicator "staff and workers" constructed by DITS that only covers employment in independent accounting industrial enterprises at or above the rural-township level. We argue that the overstatement of effective labour input and the inappropriate inclusion of service labour in the DITS employment could be offset by the inappropriate exclusion of effective labour input at or below the rural-village level. We feel this argument could be justified by the following empirical evidences.

Compared with manufacturing employment data reported in the Chinese 1990 Population Census, the DITS indicator for manufacturing "staff and workers" accounts for about 86 percent of the total found in the census. This suggests that the DITS indicator has perhaps excluded about 14 percent of the labourers engaged in manufacturing who worked at or below the village level. Now assume that 50 percent of the labourers could be discounted in order to get effective labour input (or full-time equivalent employment) at or below the village level, that is, about 7 percent of the total. Could this 7 percent be accommodated by the DITS indicator? Szirmai and Ren have found that 9.8 percent of the DITS employment figures are auxiliary service labourers for 1985 (2000, p.27). Taking into account also the previously discussed problems of ineffective working hours and inappropriate inclusion of unemployed state workers, we assume at least 12 percent of the DITS employment figures should be discounted for these reasons, that is, about 10 percent of the total. This is more than sufficient to accommodate the 7-percent improper exclusion of the effective labour input at or below the village level.

The DITS series is only available for the period 1985-97. Following the DITS concept of "staff and workers", Wu (2000b) has estimated a series for the manufacturing sector as a whole for 1952-84. Further data work has been undertaken to obtain the branch-level employment data for the pre-1985 period. Firstly, with the help of DITS statisticians using mainly unpublished information kept by DITS, the branch level manufacturing employment figures for SOEs are reconstructed and adjusted to the current Chinese industrial classification for the whole period in the study. Based on this work and Wu (2000b), total non-state manufacturing employment figures are derived. Secondly, with recently disclosed materials in the State Archives of the 1956 survey on traditional manufacturing and handicrafts, the branch shares of the non-state employment for 1956 are estimated. Assuming that the branch shares could be used as a proxy for the 1950s and that there were linear changes in these shares between 1960 and 1985, we interpolate the shares for this period. Finally, the *total* non-state employment for each year is allocated to *individual* branches according to the so-estimated branch shares. The so-reconstructed "full-time equivalent" employment series for Chinese manufacturing are reported for selected years in Appendix Table A1.

4.1.3 Data on Prices and Quantity of Products

In this study ex-factory price data instead of unit value data are used to estimate industry-of-origin PPPs. The data are obtained from an unpublished source containing ex-factory prices of about 2000 industrial products surveyed by SSB covering the period 1985-97 (Wu, 2000b). We choose not to use the unit values estimated by Szirmai and Ren (2000) based on the 1985 industrial census because we believe their estimates could not capture the significant effects of the price adjustments or the newly introduced market-planning dual track price system during 1986-87 which substantially removed the existing price distortions developed in the central planning period. Besides, there is no time-matching problem using the 1987 ex-factory price data because the US manufacturing census was conducted in the same year, whereas in Szirmai-Ren the 1987 US census data have to be roughly adjusted to match the 1985 Chinese industrial census data.

There are no quantity data that could exactly match the ex-factory price data. To obtain proper quantity data for weighting, two data sources are used. One is the physical output of 200 major industrial products/product groups published by DITS (SSB), which Wu (2000b) uses for constructing the real output indices, and the other is the relatively more detailed physical output data reported by various industrial ministries. The quantity data are used to work out the weights for average ex-factory prices.

TABLE 1

Gross Value of Output, Gross Value Added and Labour Productivity in Current National Currencies by Manufacturing Branch, China versus USA, 1987

	China				USA			
	Gross Value of Output (GVO) (ml. yuan)	Gross Value Added (GVA) (ml. yuan)	Number of Employed (‘000s)	GVA per Employed Person (yuan)	Gross Value of Output (GVO) (ml. US$)	Gross Value Added (GVA) (ml. US$)	Number of Employed (‘000s)	GVA per Employed Person (US$)
Food and Beverages	155,779	29,174	4,807	6,069	317,171	79,098	1,594	49,622
	(12.5)	(7.5)	(7.8)	(96)	(13.0)	(8.9)	(8.4)	(106)
Tobacco Products	28,918	19,405	267	72,650	24,869	10,353	54	191,722
	(2.3)	(5.0)	(0.4)	(1,150)	(1.0)	(1.2)	(0.3)	(409)
Textile Mill Products	166,207	42,592	8,529	4,994	62,406	20,137	718	28,046
	(13.4)	(10.9)	(13.8)	(79)	(2.6)	(2.3)	(3.8)	(60)
Wearing Apparel	31,037	9,124	2,176	4,193	63,290	23,031	1,086	21,207
	(2.5)	(2.3)	(3.5)	(66)	(2.6)	(2.6)	(5.7)	(45)
Leather Products & Footwear	15,539	4,523	976	4,635	8,812	3,939	147	26,796
	(1.2)	(1.2)	(1.6)	(73)	(0.4)	(0.4)	(0.8)	(57)
Wood Products, Furniture & Fixtures	21,557	6,864	1,545	4,443	108,857	46,685	1,325	35,234
	(1.7)	(1.8)	(2.5)	(70)	(4.5)	(5.3)	(7.0)	(75)
Paper Products, Printing & Publishing	44,329	14,271	2,499	5,710	246,455	99,830	2,132	46,825
	(3.6)	(3.7)	(4.0)	(90)	(10.1)	(11.2)	(11.2)	(100)
Petroleum Refineries	36,436	15,930	449	35,448	138,141	22,051	160	137,819
	(2.9)	(4.1)	(0.7)	(561)	(5.6)	(2.5)	(0.8)	(294)
Chemical Products	140,857	46,296	4,836	9,574	216,173	83,802	1,013	82,727
	(11.3)	(11.9)	(7.8)	(152)	(8.8)	(9.4)	(5.3)	(176)
Rubber & Plastic Products	46,805	13,735	2,156	6,369	86,110	29,580	848	34,882
	(3.8)	(3.5)	(3.5)	(101)	(3.5)	(3.3)	(4.5)	(74)
Building Materials	80,025	32,796	7,391	4,437	60,125	23,313	561	41,556
	(6.4)	(8.4)	(12.0)	(70)	(2.5)	(2.6)	(3.0)	(89)
Basic & Fabricated Metal Products	157,056	50,825	6,621	7,677	265,543	97,135	2,127	45,668
	(12.6)	(13.0)	(10.7)	(122)	(10.9)	(10.9)	(11.2)	(97)
Machinery & Transport Equipment	179,976	61,183	12,502	4,894	541,850	208,890	4,063	51,413
	(14.5)	(15.7)	(20.3)	(77)	(22.2)	(23.5)	(21.4)	(110)
Electrical-Electronic Equipment	106,371	28,587	4,802	5,953	207,254	87,640	1,763	49,711
	(8.6)	(7.3)	(7.8)	(94)	(8.5)	(9.9)	(9.3)	(106)
Other Manufacturing	32,557	14,769	2,185	6,760	98,291	53,108	1,367	38,850
	(2.6)	(3.8)	(3.5)	(107)	(4.0)	(6.0)	(7.2)	(83)
Total Manufacturing	1,243,451	390,072	61,740	6,318	2,445,349	888,592	18,958	46,872
	(100.0)	(100.0)	(100.0)	(100)	(100.0)	(100.0)	(100.0)	(100)

Source: Data for China are calculated based on Wu (2000b, 2001) and the discussion in the text. Data for US are calculated based on BEA (1998). See the discussion in the text.
Note: Figures given in parentheses are branch shares in total manufacturing, except for GVA per employed which are given as branch ratio to total manufacturing (=100).

4.2 US Data

4.2.1 Gross Value Added in Manufacturing (GVA)

The basic data on manufacturing GVA for 1952-97 are the BEA annual chained estimates of Gross Product Originating by industry, which is a new method to replace the fixed weights to calculate constant price GDP (GVA) indices. An important property of chain-type quantity indices is that the implied growth rates are not affected by a shift in the benchmark year and that chain-type indices incorporate the changes in the industry-composition.[16] In this regard, our fixed-weight (1987) Chinese GVA data are not exactly compatible with the US GVA data. We do not attempt to correct for this incompatibility because a) it is not important for our purpose in this study and b) there are no data that allow such correction.

The new BEA GVA data are not available for the period 1952-97. The Groningen Growth and Development Centre (GGDC) has produced a 1987-based series that satisfies our needs. The work by GGDC also takes into account the differences between the 1972 SIC (Standard of Industrial Classification) and the 1987 SIC, and adjusted the series under the former (1952-86) to the latter (Inklarr and Timmer, 2001). In this study we adopt the GGDC-adjusted series of GVA. The 1987 benchmark figures are given in Table 1. The GGDC-adjusted figures for selected years are given in Appendix Table A2. The 1987 benchmark branch-level GVO data are also obtained from BEA (1998) (Table 1).

4.2.2 Manufacturing Employment

The full-time equivalent employment data by branch are originally constructed by BEA (1998). The only adjustment that needs to be made to this series is the conversion of the 1972 SIC-based series (1952-86) to the 1987 SIC. We also adopt the conversion made by GGDC (Inklaar and Timmer, 2001). The GGDC-adjusted figures for selected years are reported in Appendix Table A2. The 1987 benchmark figures are reported in Table 1.

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[16] The downside of chain type indices is that they are not additive, that is, the sum of the parts of the aggregate is not equal to the aggregate itself. Normally, the further they are away from the benchmark year, the bigger is the discrepancy, and typically, the higher is the sum of the components relative to the total the further back in time (Inklaar and Timmer, 2001). However, this problem is not a significant source of bias in this study.

4.2.3 Unit Value of Matched Products

Calculation of the unit values of matched products is based on product-specific gross value of output and quantity of output. They are obtained from the US 1987 Census of Manufactures (US Department of Commerce, 1990).

5. Results and Discussion

5.1 Estimated 1987 China/US Production PPPs

Following the ICOP PPP estimation steps explained in Section 3, we have calculated China/US production PPPs for each branch in manufacturing for the benchmark year 1987 (Table 2). In this exercise 66 product or product-group matches of 39 sample industries are made. These sample-industry PPPs are then aggregated into 14 manufacturing branches that have been used in ICOP studies. The PPPs for Chinese manufacturing as a whole at both Chinese and US weights are the weighted average of branch PPPs with gross value of output as weights. They are also used as proxies for the "other manufacturing" branch. The results reported in Table 2 also include the calculation of Fisher (geometric mean) PPPs.

The matched value of output in this comparison represents 35.7 percent of the gross value of output in China and 17.2 percent in the USA (see Appendix Table A3), which is similar to the coverage in Szirmai and Ren (2000) of 37.1 and 18.9 percent, respectively. This coverage is fairly reasonable given the usual data problems in this kind of exercise and is in line with similar exercises for the former centrally planned economies.[17]

[17] For example, the corresponding figures are 18.5 percent and 16.3 percent for a USSR/US comparison, 32.0 and 23.2 for a Czechoslovakia/West Germany comparison, 33.1 and 19.3 for a Hungary/West Germany comparison, and 33.6 and 19.4 for a Poland/West Germany comparison (Kouwenhoven, 1996, Table 5). Even for industrialized market economies, the coverage is not high. For example, a West Germany/US comparison by van Ark and Pilat (1993) manages to cover only 24.4 percent of West Germany's manufacturing output and 24.8 percent of US manufacturing output.

TABLE 2
Industry-of-Origin PPPs and Price Levels by Major Manufacturing Branch, China/USA, 1987

	PPP (Yuan/US$)			Relative Price Level	
	At Chinese Quantity weight	At US Quantity weight	Geometric mean	PPP over Official Exchange Rate	PPP over Market Exchange Rate
Food Products	1.92	2.43	2.16	0.58	0.38
Beverages	2.63	1.99	2.29	0.62	0.40
(Food and Beverages)	(2.02)	(2.35)	(2.18)	(0.59)	(0.38)
Tobacco Products	0.77	0.77	0.77	0.21	0.14
Textile Mill Products	0.57	1.02	0.76	0.21	0.14
Wearing Apparel	1.12	1.12	1.12	0.30	0.20
Leather Products & Footwear	1.95	2.63	2.26	0.61	0.40
Wood Products, Furniture & Fixtures	7.96	7.90	7.93	2.13	1.39
Paper Products, Printing & Publishing	3.59	3.73	3.66	0.98	0.64
Petroleum Refineries	3.27	4.69	3.92	1.05	0.69
Chemical Products	4.78	4.56	4.67	1.26	0.82
Rubber & Plastic Products	0.65	2.28	1.21	0.33	0.21
Building Materials	2.35	1.93	2.13	0.57	0.37
Basic & Fabricated Metal Products	2.89	5.17	3.87	1.04	0.68
Machinery & Transport Equipment	1.95	6.57	3.58	0.96	0.63
Electrical-Electronic Equipment	5.42	5.49	5.45	1.47	0.96
Total Manufacturing	1.97	4.92	3.11	0.84	0.55
Official Exchange Rate	3.72	3.72	3.72	n.a.	n.a.
Market Exchange Rate*	5.70	5.70	5.70	n.a.	n.a.

Source: Author's estimation. See Section 3 for methodology and Section 4 for the data used.
Note: *Referring to China's foreign exchange "swap market" rate for 1987 (Wu, 1998b). n.a. = Not applicable.

As shown in Table 2, the average PPP for total manufacturing is 3.11 yuan per US dollar for 1987 which is lower than but not significantly different from the then prevailing official (planning-controlled) exchange rate of 3.72 yuan. By contrast, Szirmai and Ren (2000) estimate a PPP as 1.45 for 1985, which is only 50 percent of the official exchange rate of 2.90. It may be argued that for a centrally planned economy the spread between average PPP and official exchange rate should not be so large as estimated in Szirmai and Ren. This is because exchange rate control has to be, by its nature, associated with price control, or the level of controlled exchange rate has to be close to the average production costs that can be reflected by PPP estimates.[18] If

[18] A study on the Soviet manufacturing by Kouwenhoven (1996, Table 4) also finds that at the 1987 benchmark the PPP of ruble (0.455 ruble = US$1) is not significantly different from the official (planning-controlled) exchange rate of ruble (0.523 ruble = US$1).

this is true, then Szirmai and Ren may have underestimated the yuan/USD PPP or overestimated the value of yuan.

Studies on export costs in China may also shed some light on this discussion, even though the estimation of Chinese export costs does not follow production approach and hence provides no sector/industry perspective. Lardy (1992) estimates the average costs of Chinese exports to be 3.67 yuan per US dollar for 1985 and 4.20 for 1987, whereas using a CPI (consumer price index) method Wu (1998) arrives at 4.50 and 5.37, respectively. These estimates could be compared with China's effective exchange rates of 3.49 and 4.17, respectively, which are adjusted by the planning and market shares in foreign exchange transactions. These studies show that official exchange rate was often forced to adjust to changes in export costs. The depreciation of yuan in 1985-87, from 2.90 down to 3.72 yuan per US dollar, was an attempt to make such an adjustment (Wu, 1998, Table 2).

It is not surprising that the average PPP for manufacturing is only 55 percent of the yuan's market exchange rate (yuan/USD PPP of 3.11 versus yuan/USD exchange rate of 5.70), or the yuan's domestic purchasing power is about 1.8 times its international purchasing power, because the latter largely reflects the prices of the tradables, which are mainly on the "market track" under the prevailing dual-track price system.

5.2 Relative Price/Cost Level and Comparative Advantage

PPP estimates can reflect the relative costs of, and hence comparative advantage in, manufacturing of the countries being compared. As shown in Table 2, the lowest PPP is found in Chinese textiles (0.76), followed by tobacco products (0.77) and wearing apparel (1.12), largely reflecting low costs and comparative advantage of these products produced in China. For most of the branches with high PPPs (higher than official exchange rate as given in Table 2) China has obviously no comparative advantage. They include wood products, for which the highest PPP was found (7.93), followed by electrical-electronic machinery (5.45), chemical products (4.67), petroleum refineries (3.92) and basic and fabricated metal products (3.87).

Using US prices as references, China's relative price levels across manufacturing branches can be derived by comparing the PPP estimates with Chinese official and market exchange rates. Reported in the last columns of Table 2, these price levels can also serve as indicators of China's relative costs of, and hence comparative advantage in, individual manufacturing branches.

Another point to address is that the PPPs with US quantity weights are found higher than the PPPs with Chinese quantity weights. This is similar to the pattern found by Szirmai and Ren (2000), which is expected in bilateral comparisons between rich and poor countries. Due to differences in both production structure and consumer preferences, products which are relatively cheap and common in the USA will tend to be expensive and rare in countries like China and vice versa. Therefore, at least theoretically, industries with high PPPs (low-value yuan) should receive high quantity weights in the USA and low weights in China, whereas industries with low PPPs (high-value yuan) should receive low weights in the US and high weights in China.

There are some good examples to support this theory in our findings. Referring to Tables 1 and 2, branches with high PPPs or factor costs in China, such as manufacture of wood and paper, account for larger shares in total manufacturing output in the USA than in China, whereas branches with low PPPs or factor costs in China, such as textiles and building materials, account for smaller shares in the USA than in China. There are, however, some interesting exceptions in our findings. The output share of wearing apparel and rubber-plastics products seems too low in China if judged by the *low* PPPs of these branches and the output share of metal products and machinery seems too high if assessed by the *high* PPPs of these branches. This clearly reflects the structural distortions resulting from the government's costly industrial strategy under central planning that focused on heavy industries at the expense of light industries.

5.3 Comparative Productivity Performance at the 1987 Benchmark

Applying the estimated PPPs in Table 2 to Chinese and US gross value added (GVA) in Table 1, we can examine Chinese and US output level on a comparative basis, because this approach measures Chinese and US manufacturing outputs using the same set of prices. Such a PPP-based comparison can to a large extent correct for the underestimation of Chinese GDP due to price distortions. The derived comparative GVAs can show the position (scale) of Chinese manufacturing industries relative to that of the USA.

As reported in Table 3, at the 1987 benchmark, total Chinese manufacturing output was about 15.9 percent of the US level in GVA.[19] The estimates suggest that the largest manufacturing branch in China in 1987 was textiles which was about 2.8 times the US textiles industry, followed by tobacco (2.4 times), building materials (66 percent), leather-footwear (51 percent), rubber-plastics (38 percent) and wearing apparel (36 percent), whereas the smallest branch in China was wood products which was only less than 2 percent of the US level, followed by paper-printing industry (3.9 percent), electrical-electronic equipment (6.0 percent) and machinery (8.2 percent).

[19] If measured in gross value of output (GVO), which can be done following the same approach with the GVO data in Table 1, China's relative position would be 18.9 percent of the US level, or roughly one fifth of the size of US manufacturing in 1987 (PPP) dollars.

Because of the importance of manufacturing for any economy in general and for these two countries in particular, these findings suggest the strength of the Chinese economy relative to that of the USA. Undoubtedly, there is still an enormous gap for the Chinese to fill.

TABLE 3

Gross Value Added (GVA) by Major Manufacturing Branch at 1987 Chinese and US Producer Prices, and China/USA Comparative Output Level (USA=100)

	At Chinese Producer Prices			At US Producer Prices			Geometric
	China (million 87yuan)	USA (million 87yuan)	China/ USA (%)	China (million 87US$)	USA (million 87US$)	China/ USA (%)	mean China/ USA(%)
Food Products & Beverages	29,174	185,608	15.72	14,436	79,098	18.25	16.94
Tobacco Products	19,405	7,972	243.42	25,201	10,353	243.42	243.42
Textile Mill Products	42,592	20,584	206.91	74,685	20,137	370.89	277.02
Wearing Apparel	9,124	25,683	35.53	8,182	23,031	35.53	35.53
Leather Products & Footwear	4,523	10,360	43.66	2,320	3,939	58.89	50.71
Wood Products, Furniture & Fixtures	6,864	369,013	1.86	863	46,685	1.85	1.85
Paper Products, Printing & Publishing	14,271	372,666	3.83	3,974	99,830	3.98	3.90
Petroleum Refineries	15,930	103,473	15.40	4,875	22,051	22.11	18.45
Chemical Products	46,296	382,011	12.12	9,681	83,802	11.55	11.83
Rubber & Plastic Products	13,735	67,426	20.37	21,281	29,580	71.94	38.28
Building Materials	32,796	45,098	72.72	13,972	23,313	59.93	66.02
Basic & Fabricated Metal Products	50,825	502,267	10.12	17,588	97,135	18.11	13.54
Machinery & Transport Equipment	61,183	1,372,060	4.46	31,301	208,890	14.98	8.17
Electrical-Electronic Equipment	28,587	481,057	5.94	5,274	87,640	6.02	5.98
Other Manufacturing	14,769	261,291	5.65	7,497	53,108	14.12	8.93
Total Manufacturing	390,072	4,206,569	9.27	241,129	888,592	27.14	15.86

Source: Derived based on data in Table 1 and the PPP estimates in Table 2.

The same approach can be used to derive comparative labour productivity for individual manufacturing branches in China. The results are reported in Table 4. At the 1987 benchmark, Chinese comparative labour productivity in manufacturing was 4.3 percent of the US level (USA=100), which is a Fisher average of 2.7 at Chinese producer prices and 6.8 at US producer prices. This is lower than the 5.7 percent estimated by Szirmai and Ren (2000), which could be due to any of the factors or the combined effect of them discussed in the data section.[20]

[20] This is also lower than 7.9 percent estimated for India (1986) by van Ark (1991), 10 percent for Indonesia (1987) by Szirmai (1994) and 26.4 percent for South Korea (1987) by Pilat (1994). However, since the sector, ownership, size of establishment coverage of these studies vary, these comparisons are only indicative.

TABLE 4
Labour Productivity (GVA per Employed Person) by Major Manufacturing Branch at 1987 Chinese and US Producer Prices, and China/USA Comparative Labour Productivity Level (USA=100)

	At Chinese Producer Prices			At US Producer Prices			Geometric
	China (87 yuan)	USA (87 yuan)	China/ USA (%)	China (87US$)	USA (87US$)	China/ USA (%)	Mean China/ USA(%)
Food Products & Beverages	6,069	116,442	5.21	3,003	49,622	6.05	5.62
Tobacco Products	72,650	147,626	49.21	94,350	191,722	49.21	49.21
Textile Mill Products	4,994	28,669	17.42	8,757	28,046	31.22	23.32
Wearing Apparel	4,193	23,649	17.73	3,760	21,207	17.73	17.73
Leather Products & Footwear	4,635	70,473	6.58	2,377	26,796	8.87	7.64
Wood Products, Furniture & Fixtures	4,443	278,500	1.60	558	35,234	1.58	1.59
Paper Products, Printing & Publishing	5,710	174,796	3.27	1,590	46,825	3.40	3.33
Petroleum Refineries	35,448	646,708	5.48	10,848	137,819	7.87	6.57
Chemical Products	9,574	377,108	2.54	2,002	82,727	2.42	2.48
Rubber & Plastic Products	6,369	79,511	8.01	9,869	34,882	28.29	15.05
Building Materials	4,437	80,389	5.52	1,890	41,556	4.55	5.01
Basic & Fabricated Metal Products	7,677	236,139	3.25	2,656	45,668	5.82	4.35
Machinery & Transport Equipment	4,894	337,696	1.45	2,504	51,413	4.87	2.66
Electrical-Electronic Equipment	5,953	272,863	2.18	1,098	49,711	2.21	2.20
Other Manufacturing	6,760	191,142	3.54	3,432	38,850	8.83	5.59
Total Manufacturing	6,318	230,608	2.74	3,207	46,872	6.84	4.33

Source: Derived based on data in Table 1 and the PPP estimates in Table 2.

In 1987, the manufacturing branches with low comparative labour productivity, and hence no comparative advantage, were, not so surprisingly, wood products (only 1.6 percent of the US level), machinery-transportation equipment (2.7 percent), chemical products (2.5) and electrical-electronic equipment (2.2), whereas the branches with high comparative labour productivity, and hence strong comparative advantage, were tobacco (49.2), textiles (23.3), wearing apparel (17.7) and rubber-plastics (15.1). Compared with the findings in Tables 2 and 3, these suggest that in most cases, the manufacturing branches (such as tobacco, textiles, wearing apparel, rubber-plastics) that have lower PPPs tend to enjoy higher comparative labour productivity and larger share in output, which is in line with the theory. We shall further examine this in a dynamic perspective.

5.4 Comparative Productivity Performance in the Long Run

Following exactly the techniques used in deriving the 1987-benchmark output and labour productivity, estimates for 1952-97 are obtained using the time series of output and labour input introduced in Section 4. The estimates for the comparative output (GVA) level of Chinese manufacturing are reported in Table 5 and the estimates for the comparative labour productivity level of Chinese manufacturing are reported in Table 6. Readers are reminded to closely follow the concept of “China-US comparative level" in the discussion below to avoid being overwhelmed by the common sense of "growth" in a dynamic perspective. For example, a decline in Chinese comparative output or labour productivity over a certain period is a decline in *relative* rather than *absolute* terms. It declines because it grows not as fast as that of the USA or it declines more rapidly than that of the USA. The same should be applied to an increase in comparative output and productivity. Chinese electronic industry (grouped with electrical equipment in this study) is a good example. Its labour productivity in *absolute* terms grew at 16.6 percent a year in 1987-97, one of the fast growing industries, but in *relative* terms it only grew at 2.8 percent a year, which means that its growth was only 2.8 percentage points faster than that of the US counterpart (see Appendix Table A4).

Over the entire period 1952-97, as shown in Table 5, the comparative output level of Chinese manufacturing (the USA=100) increased from 2.9 to 27.8, up by 5.1 percent per annum, with an increase by 4.7 percent per annum for the pre-reform period 1952-78 and an increase by 5.7 percent per annum for the post-reform period 1978-97. During the central planning period the branches that grew fastest were metals, machinery and electrical-electronic equipment, while during the reform period wearing apparel, leather and footwear, tobacco, building materials and food grew fastest. These findings generally reflect the policy orientation of the two periods, that is, heavy industry-oriented industrialisation under central planning and light industry-oriented development during economic reform.

In terms of the relative size (with the USA=100) of branches, in 1977 (the time representing the pre-reform level) there was only one branch that was larger than the US counterpart, that is, textiles with a size of 1.7 times the US size. By 1997, there were 6 branches that were either greater or similar to the US level. They are, by the relative size, textiles (450), tobacco (445), leather-footwear (319), wearing apparel (214), building materials (128) and rubber-plastics (93) which are all labour-intensive indeed. On the other hand, branches at about or below 20 percent of the US level are wood (5), paper-printing (10), electrical-electronic (10), machinery (14) and metals (22) which rely more on either natural resources or capital and technology.

By far, the findings seem to well conform to the theory of comparative advantage. However, we are not so sure until we know whether the performance of comparative labour productivity in Chinese manufacturing can show a clear sign of catch up (falling behind) of the branches that grew faster (slower) during the economic reform.

TABLE 5

Comparative Performance of Chinese and US Manufacturing: Gross Value Added in 1987 PPPs by Major Manufacturing Branch, China versus USA, 1952-1997

(Fisher Average, USA=100)

	Total Manufac-turing	Food and Beverages	Tobacco Products	Textile Mill Products	Wearing Apparel	Leather, Footwear	Wood Products	Paper, Printing	Petroleum Refineries	Chemicals	Rubber, Plastics	Building Materials	Metal Products	Machinery -Transport Equipment	Electrical-Electronic Equipment	Others
1952	2.93	2.34	15.23	155.74	8.56	2.23	1.58	0.36	4.54	1.58	3.13	4.55	0.41	0.30	0.27	3.16
1953	3.53	2.71	22.13	198.20	10.37	2.63	2.32	0.40	4.82	1.82	3.89	5.46	0.49	0.48	0.44	4.97
1954	4.22	2.93	24.79	229.47	12.32	3.85	2.76	0.47	5.35	2.47	5.44	6.94	0.74	0.61	0.49	4.27
1955	3.73	3.17	22.31	194.13	9.57	3.51	2.13	0.48	5.36	2.40	4.99	7.40	0.79	0.65	0.44	2.84
1956	4.70	3.28	23.03	233.63	12.39	4.29	2.79	0.59	5.77	2.90	5.84	8.76	1.15	1.22	0.67	4.15
1957	4.97	3.53	25.25	227.45	11.00	5.51	2.72	0.75	6.58	3.28	7.19	11.30	1.49	1.42	1.22	5.02
1958	7.97	4.84	25.21	298.11	14.37	6.46	4.29	1.01	7.15	4.42	12.11	10.28	2.94	5.24	4.02	6.73
1959	9.07	5.78	27.50	322.53	15.80	6.52	4.49	1.29	7.03	5.31	9.94	10.97	4.19	5.85	5.88	9.68
1960	8.94	4.25	21.75	245.04	11.01	7.92	5.23	1.35	7.57	6.02	10.56	13.32	5.50	7.22	6.66	11.58
1961	4.52	2.61	11.83	134.56	6.43	4.87	2.62	0.81	8.10	3.08	7.17	8.95	3.03	2.23	2.13	5.84
1962	3.54	2.67	10.96	102.78	7.16	3.42	2.20	0.79	8.33	2.97	7.91	8.97	2.27	0.98	1.18	4.74
1963	3.90	2.78	14.40	104.41	7.48	3.64	2.32	0.85	8.95	3.53	8.69	9.38	2.38	0.98	0.97	5.16
1964	4.62	3.77	19.15	136.07	8.68	3.33	2.55	0.88	9.67	4.17	9.70	10.29	2.54	1.27	0.98	5.89
1965	5.30	4.21	22.38	163.49	9.91	3.20	2.48	1.02	10.19	5.04	10.48	11.04	2.91	1.55	1.01	7.03
1966	5.83	4.35	24.89	173.61	10.50	4.33	2.39	1.16	11.08	6.01	10.96	11.93	3.31	1.87	1.47	8.25
1967	4.91	4.11	21.83	158.03	9.93	5.32	2.46	1.09	12.31	4.61	9.79	9.54	2.24	1.15	1.12	7.59
1968	4.39	3.94	22.90	147.20	7.54	5.23	1.84	0.93	13.26	3.45	8.43	8.29	1.95	1.10	0.83	6.29
1969	5.66	3.67	29.21	187.05	8.21	6.24	2.03	1.08	15.35	4.77	10.66	10.45	2.84	1.79	1.55	7.18
1970	7.52	4.15	31.85	198.95	9.10	9.17	2.31	1.27	14.77	5.71	15.63	13.92	4.26	3.66	3.00	8.10
1971	7.92	4.37	27.85	183.67	10.17	9.67	2.24	1.35	15.49	6.22	15.07	16.18	5.30	4.64	3.46	7.63
1972	7.61	4.66	28.83	166.22	10.20	10.19	2.02	1.35	17.69	6.28	14.66	15.97	5.21	4.53	3.27	7.40
1973	7.51	4.83	31.37	177.89	10.64	10.57	1.67	1.37	18.64	6.13	14.78	15.10	4.85	4.63	3.16	8.25
1974	7.73	6.00	31.98	189.64	11.70	10.67	1.75	1.37	21.75	6.30	15.66	15.96	4.33	4.81	3.70	8.37
1975	9.69	6.13	35.12	231.11	13.99	12.79	2.03	1.66	24.26	7.26	20.50	21.30	6.08	6.51	4.32	9.60
1976	8.50	5.67	34.86	181.42	13.87	11.84	1.69	1.53	24.97	5.98	19.80	19.32	4.95	5.55	3.72	8.66
1977	8.93	6.51	44.72	170.77	13.38	14.11	1.82	1.59	25.01	6.47	19.53	22.13	5.40	5.53	3.24	8.45
1978	9.72	6.67	41.39	184.71	11.61	15.21	1.74	1.78	37.65	7.75	21.75	24.50	6.83	6.07	3.81	8.56
1979	10.21	7.12	45.96	190.45	12.66	19.36	2.04	1.91	28.42	8.57	22.81	26.62	7.37	6.10	3.83	8.50

TABLE 5 (Continued)

	Total Manufac-turing	Food & Beverages	Tobacco Products	Textile Mill Products	Wearing Apparel	Leather, Footwear	Wood Products	Paper, Printing	Petroleum Refineries	Chemicals	Rubber, Plastics	Building Materials	Metal Products	Machinery -Transport Equipment	Electrical-Electronic Equipment	Others
1980	11.31	7.38	56.44	213.03	16.39	24.45	2.24	2.19	35.54	10.41	25.73	32.57	7.70	6.05	3.44	9.06
1981	11.15	9.25	58.99	229.08	17.74	29.24	2.25	2.20	20.00	9.98	22.53	36.78	7.04	5.32	3.00	8.88
1982	12.74	9.50	79.72	252.65	18.67	27.43	2.48	2.39	24.17	10.54	27.55	50.38	9.61	6.44	3.15	9.00
1983	12.93	10.15	105.24	220.85	17.20	27.76	2.23	2.55	19.28	9.96	30.78	47.67	11.25	7.18	3.63	8.71
1984	12.78	12.22	124.50	218.24	18.05	30.97	2.12	2.79	18.41	10.76	31.88	47.83	10.66	7.32	3.99	7.83
1985	14.16	13.75	146.45	248.14	20.66	37.47	2.08	3.26	16.78	12.26	34.79	53.54	11.57	8.17	5.57	7.97
1986	15.60	16.18	191.22	265.42	42.80	50.01	1.92	3.54	27.07	12.07	37.62	58.02	12.81	7.78	5.28	8.97
1987	15.86	16.94	243.42	277.02	35.53	50.71	1.85	3.90	18.45	11.83	38.28	66.02	13.54	8.17	5.98	8.93
1988	16.64	18.28	280.20	303.45	42.86	51.86	1.89	4.20	18.59	12.92	41.86	73.34	13.43	8.97	6.69	8.12
1989	16.92	19.43	350.39	313.85	43.61	51.39	1.83	4.44	15.63	13.39	40.40	71.56	14.37	8.39	6.27	8.66
1990	16.84	17.53	433.79	280.99	47.32	60.36	1.81	4.68	27.61	13.32	42.40	70.72	15.64	7.52	5.90	8.57
1991	19.35	19.98	534.39	301.83	54.72	71.48	1.88	5.15	34.81	14.70	49.17	89.83	17.94	9.52	6.61	9.48
1992	21.86	22.87	653.85	290.26	62.54	94.84	2.04	5.99	37.02	15.90	55.72	94.61	19.85	11.93	7.91	11.18
1993	24.24	24.77	693.64	306.60	93.93	144.37	2.65	6.62	41.04	17.58	63.63	113.22	21.01	12.92	9.14	14.97
1994	26.25	25.37	473.18	311.75	113.54	182.19	2.60	7.26	37.72	17.33	75.45	117.39	20.77	15.19	13.65	14.91
1995	31.80	26.44	423.69	433.84	261.21	336.43	7.70	10.46	33.89	22.06	82.61	134.07	20.98	20.29	11.92	20.59
1996	28.71	28.45	437.23	393.76	191.05	328.99	4.78	9.59	33.01	21.12	100.84	136.93	21.20	18.00	9.44	18.11
1997	27.80	29.43	444.67	450.39	213.99	319.26	5.02	9.91	42.03	22.84	93.02	128.28	21.71	14.20	10.01	19.76
1952-57	11.15	8.56	10.65	7.87	5.14	19.82	11.48	15.47	7.71	15.74	18.11	19.96	29.46	36.88	35.03	9.68
1958-62	-6.53	-5.44	-15.37	-14.69	-8.24	-9.09	-4.19	1.12	4.82	-1.96	1.91	-4.51	8.83	-7.16	-0.63	-1.15
1963-65	14.34	16.42	26.86	16.74	11.47	-2.19	4.12	8.83	6.97	19.34	9.84	7.14	8.62	16.33	-4.87	14.02
1966-70	7.26	-0.27	7.31	4.00	-1.70	23.41	-1.42	4.53	7.71	2.51	8.32	4.76	7.92	18.79	24.25	2.87
1971-78	3.27	6.12	3.33	-0.92	3.09	6.54	-3.48	4.29	12.40	3.89	4.21	7.32	6.08	6.55	3.03	0.70
1979-87	5.59	10.90	21.76	4.61	13.23	14.31	0.70	9.15	-7.62	4.81	6.49	11.64	7.89	3.35	5.13	0.47
1988-97	5.77	5.68	6.21	4.98	19.67	20.20	10.48	9.77	8.58	6.80	9.28	6.87	4.84	5.68	5.28	8.26
1952-78	4.72	4.12	3.92	0.66	1.18	7.66	0.37	6.30	8.48	6.31	7.74	6.69	11.44	12.32	10.71	3.90
1979-97	5.68	8.12	13.31	4.80	16.57	17.37	5.73	9.47	0.58	5.85	7.95	9.10	6.27	4.57	5.21	4.50
1952-97	5.13	5.79	7.79	2.39	7.41	11.66	2.60	7.63	5.07	6.12	7.83	7.70	9.23	8.98	8.35	4.15

Source: Derived based on PPP estimates in Table 2 and the basic time series data for China and the USA as explained in Section 4.

TABLE 6

Comparative Performance of Chinese Manufacturing: Gross Value Added per Employed Person in 1987 PPPs by Major Manufacturing Branch, China versus USA, 1952-1997, (Fisher Average, USA=100)

	Total Manufac-turing	Food and Beverages	Tobacco Products	Textile Mill Products	Wearing Apparel	Leather, Footwear	Wood Products	Paper, Printing	Petroleum Refineries	Chemicals	Rubber, Plastics	Building Materials	Metal Products	Machinery -Transport Equipment	Electrical-Electronic Equipment	Others
1952	3.04	6.54	31.23	93.22	7.96	4.93	0.90	1.25	56.07	6.40	35.35	4.43	0.78	1.45	2.53	1.65
1953	3.56	6.63	36.54	110.45	9.20	5.35	1.22	1.30	43.39	6.39	37.91	4.69	0.92	2.18	3.95	2.52
1954	3.60	6.17	37.31	106.29	9.05	6.70	1.15	1.34	40.19	8.32	48.06	5.43	1.11	2.34	3.76	1.94
1955	3.59	4.18	31.29	107.55	10.43	7.91	0.95	1.41	39.53	8.32	47.72	4.83	1.59	2.61	3.54	1.56
1956	4.81	4.66	30.06	123.30	16.28	10.18	1.51	1.78	34.94	7.37	39.31	5.07	2.39	3.66	4.18	2.73
1957	5.18	4.93	29.30	115.03	14.35	12.80	1.38	2.16	47.72	7.96	45.45	7.03	2.93	4.03	7.16	3.37
1958	3.44	3.19	22.22	96.55	16.32	9.60	3.40	1.44	19.64	1.74	21.41	1.51	0.89	4.15	7.93	3.19
1959	5.09	4.24	20.25	113.19	23.82	11.90	4.36	2.07	14.50	2.45	20.04	2.14	1.98	5.22	13.24	5.63
1960	5.31	3.35	26.00	90.26	17.57	13.51	4.89	2.61	15.45	2.99	22.96	2.90	2.40	5.62	13.68	5.61
1961	3.45	2.57	14.75	57.15	9.55	8.30	1.74	1.88	19.63	2.56	16.48	2.83	2.23	2.15	5.47	4.38
1962	3.72	3.08	15.98	54.89	13.99	7.78	1.83	2.34	20.05	3.17	22.22	4.41	2.78	1.32	4.26	4.56
1963	4.15	3.69	23.07	53.53	12.28	7.23	1.37	2.45	23.65	5.31	24.91	5.75	3.62	1.47	3.58	4.15
1964	4.66	4.80	30.10	62.51	14.24	6.85	1.49	2.53	23.88	5.98	28.37	5.94	3.96	1.88	3.42	4.19
1965	5.21	5.03	34.07	74.58	17.53	7.13	1.65	3.01	22.68	6.11	32.28	5.37	4.25	2.23	3.43	4.75
1966	5.70	4.99	35.93	78.99	17.69	9.53	1.51	3.41	24.09	6.92	35.96	5.39	4.74	2.76	5.34	5.29
1967	4.68	4.88	31.45	72.74	18.27	11.45	1.70	3.28	25.02	5.15	29.21	3.67	3.20	1.53	3.86	4.84
1968	4.08	4.77	31.67	69.53	15.03	11.80	1.40	2.84	26.12	3.64	26.50	3.11	2.71	1.39	2.59	3.85
1969	4.74	4.18	38.15	81.97	15.17	12.03	1.49	2.98	29.56	4.53	31.25	3.24	3.65	1.98	4.26	3.77
1970	5.32	4.32	36.57	77.77	16.31	14.15	1.68	3.13	23.81	4.09	38.98	3.88	4.36	2.98	5.35	3.55
1971	4.81	3.93	26.22	64.18	16.26	12.36	1.53	2.78	20.14	3.52	30.75	3.71	4.33	2.79	4.43	3.50
1972	4.48	3.95	26.18	58.26	16.77	11.92	1.52	2.64	18.44	3.21	27.49	3.26	4.14	2.52	3.85	3.41
1973	4.40	3.89	28.21	61.85	17.06	11.42	1.29	2.62	19.04	2.99	26.43	2.87	4.05	2.63	3.89	3.85
1974	4.31	4.52	27.06	61.42	17.82	10.13	1.35	2.47	21.36	2.85	24.76	2.69	3.54	2.63	4.41	3.88
1975	4.52	4.28	25.31	60.76	21.21	9.94	1.60	2.66	21.79	2.91	23.03	2.81	4.23	2.86	3.99	4.10
1976	3.77	3.80	23.09	49.48	23.16	9.16	1.62	2.35	20.30	2.25	21.58	2.34	3.39	2.31	3.37	2.74
1977	4.05	4.26	27.20	44.67	24.00	10.41	2.20	2.45	19.95	2.32	21.39	2.56	3.77	2.27	2.95	3.69
1978	4.51	4.51	24.74	47.93	25.71	10.86	3.98	2.78	29.29	2.73	22.45	2.64	5.03	2.46	3.59	3.74
1979	4.68	4.12	26.41	43.47	20.35	11.47	2.90	2.81	22.89	3.11	21.29	2.90	5.37	2.80	3.76	3.41

Table 6 (Continued)

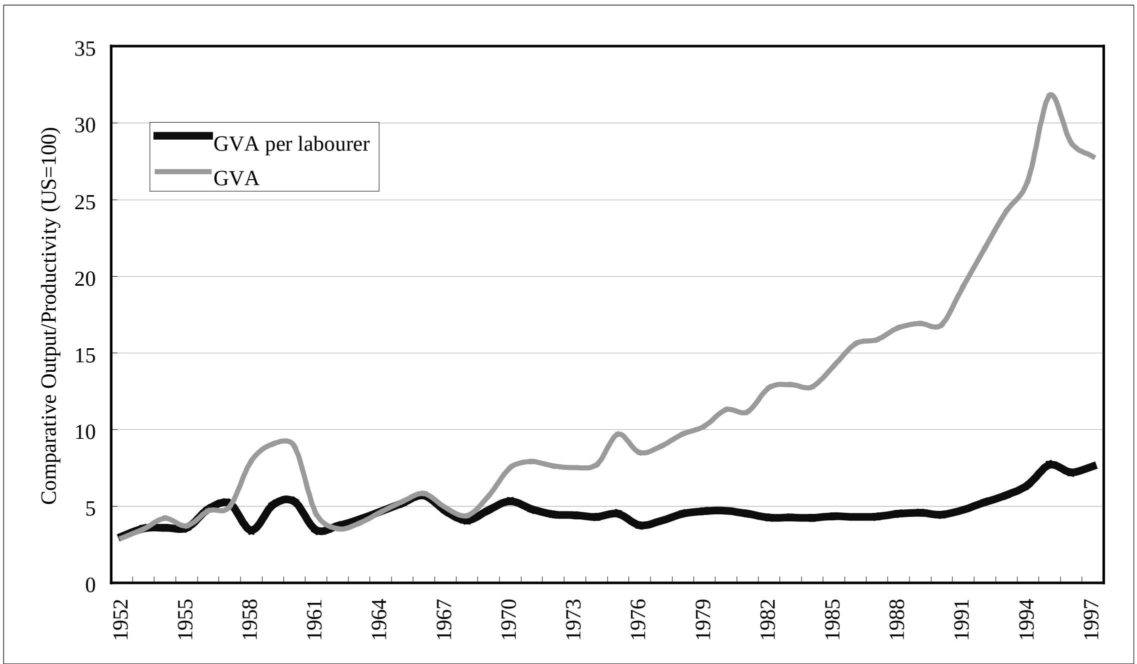
	Total Manufac-turing	Food & Beverages	Tobacco Products	Textile Mill Products	Wearing Apparel	Leather, Footwear	Wood Products	Paper, Printing	Petroleum Refineries	Chemicals	Rubber, Plastics	Building Materials	Metal Products	Machinery -Transport Equipment	Electrical-Electronic Equipment	Others
1980	4.70	4.52	28.07	37.05	14.92	9.53	2.48	2.49	23.97	3.37	14.19	4.53	4.23	2.59	2.19	7.02
1981	4.51	5.54	29.35	38.12	15.70	11.57	2.38	2.50	13.76	3.19	12.55	4.87	3.75	2.25	1.89	6.93
1982	4.27	4.34	26.14	30.20	12.06	8.53	2.04	2.42	14.77	3.01	11.93	4.97	4.25	2.46	1.75	6.04
1983	4.26	4.46	32.87	26.14	11.03	7.90	1.94	2.60	11.22	2.70	13.46	4.63	4.61	2.55	1.99	5.61
1984	4.24	5.00	35.25	24.37	11.19	7.52	1.85	2.76	9.64	2.73	14.41	4.59	4.33	2.65	2.24	4.85
1985	4.34	4.93	37.55	23.70	10.83	7.25	1.72	3.06	7.95	2.96	14.47	4.54	4.35	2.88	2.85	4.51
1986	4.30	5.59	43.30	22.81	21.90	7.86	1.62	3.06	10.34	2.60	14.60	4.33	4.28	2.59	2.43	4.20
1987	4.33	5.62	49.21	23.32	17.73	7.64	1.59	3.33	6.57	2.48	15.05	5.01	4.35	2.66	2.62	4.13
1988	4.52	5.89	53.22	24.38	21.22	7.74	1.67	3.60	5.83	2.63	15.85	5.64	4.28	2.90	2.84	3.86
1989	4.58	6.35	60.80	24.46	21.51	7.65	1.63	3.86	4.54	2.68	15.62	5.70	4.56	2.77	2.63	4.11
1990	4.46	5.71	73.25	20.91	21.42	8.04	1.56	4.01	7.82	2.57	15.91	5.72	4.83	2.42	2.30	3.82
1991	4.77	6.37	82.64	20.79	22.48	7.97	1.50	4.15	8.51	2.69	17.06	6.62	5.18	2.83	2.30	3.94
1992	5.27	7.18	96.03	20.59	25.08	10.10	1.69	4.63	8.55	2.81	19.32	6.81	5.43	3.47	2.59	4.13
1993	5.73	7.21	92.96	22.77	35.94	13.54	2.25	5.09	11.44	2.83	23.30	7.82	5.31	3.65	2.82	5.58
1994	6.40	7.47	65.68	23.57	42.00	14.66	2.26	5.61	9.85	2.71	29.09	7.95	5.50	4.48	4.06	5.50
1995	7.70	7.75	52.85	32.67	90.83	24.03	6.73	7.99	6.06	3.44	30.73	9.14	5.66	6.20	3.19	8.53
1996	7.20	8.88	56.65	30.71	64.42	23.95	4.44	7.18	5.95	3.30	38.62	9.89	6.00	5.52	3.12	6.27
1997	7.59	9.27	57.41	38.24	72.84	20.71	4.99	8.27	7.31	3.64	37.08	9.75	6.61	4.70	3.44	9.63
1952-57	11.20	-5.50	-1.27	4.29	12.50	21.04	8.93	11.61	-3.18	4.48	5.15	9.69	30.40	22.72	23.11	15.34
1958-62	-6.38	-9.00	-11.42	-13.76	-0.50	-9.47	5.77	1.64	-15.92	-16.83	-13.33	-8.93	-1.04	-19.97	-9.84	6.22
1963-65	11.86	17.76	28.71	10.76	7.81	-2.90	-3.35	8.74	4.19	24.43	13.26	6.83	15.21	19.03	-7.00	1.36
1966-70	0.41	-2.98	1.43	0.84	-1.43	14.71	0.34	0.79	0.98	-7.69	3.84	-6.30	0.48	5.95	9.30	-5.64
1971-78	-2.05	0.53	-4.77	-5.87	5.85	-3.26	11.38	-1.49	2.62	-4.95	-6.66	-4.68	1.80	-2.39	-4.87	0.65
1979-87	-0.45	2.47	7.94	-7.69	-4.04	-3.83	-9.69	2.04	-15.30	-1.05	-4.34	7.36	-1.60	0.87	-3.44	1.10
1988-97	5.77	5.14	1.55	5.07	15.18	10.49	12.11	9.53	1.08	3.91	9.43	6.88	4.28	5.88	2.77	8.84
1952-78	1.52	-1.42	-0.89	-2.53	4.61	3.09	5.88	3.13	-2.47	-3.23	-1.73	-1.96	7.44	2.05	1.35	3.19
1979-97	2.78	3.87	4.53	-1.18	5.63	3.46	1.20	5.91	-7.04	1.53	2.68	7.11	1.45	3.48	-0.22	5.10
1952-97	2.05	0.78	1.36	-1.96	5.04	3.24	3.87	4.29	-4.43	-1.25	0.11	1.77	4.87	2.65	0.69	4.00

Source: Derived based on PPP estimates in Table 2 and the basic time series data for China and the USA as explained in Section 4.

It may be argued that in a more market-oriented and less distorted economy, more capital will go to the industries that have some comparative advantage, which will lead to more rapid increase in marginal productivity of labour of these industries. If this is the case for the post-reform China, in terms of China-US comparison the industries in which China has comparative advantage should have enjoyed some degree of catch up, *ceteris paribus*.

For the manufacturing as a whole in 1952-97 China's comparative labour productivity level rose from about 3.0 to 7.6 (USA=100), up by about 2.1 percent a year. Dividing the time into two periods, the increase was estimated at 1.5 percent per annum during the central planning period and 2.8 percent per annum during the reform period (Table 6). While our findings have shown a clear productivity catch-up in Chinese manufacturing in 1952-97, they have also suggested a long stagnation at around 4.5 between 1958 and 1990. The results cannot rule out the possibility suggested by the Szirmai-Ren study (2000) that there was no catch up in Chinese manufacturing between the early 1980s and the early 1990s.

FIGURE 1
Comparative Performance of Chinese Manufacturing: GVA and GVA per Labourer in 1987 PPPs, 1952-1997
(USA=100)



Source: Based on Tables 5 and 6.

As depicted in Figure 1, from the early 1950s to the mid 1960s the growth of the comparative output level was accompanied by the growth of the comparative labour productivity level in Chinese manufacturing, except for the Great Leap Forward campaign around 1958-59. But after the mid 1960s, the latter slowed down and was eventually left far behind by the former. This suggests that the output growth in Chinese manufacturing in the 1970s and the 1980s was fuelled mainly by the increase in labour and physical capital inputs rather than technological progress and efficiency improvement.

A closer examination of the comparative productivity level of Chinese manufacturing may raise questions about the radical fluctuations of many branches over the entire period under study. Such fluctuations could be most explained by abrupt changes in institutions and development policies in the Chinese economy. To help understand how these changes might have affected China's position relative to that of the USA in manufacturing, in both Tables 5 and 6 we provide the growth rates of both China's comparative output and labour productivity in different periods,[21] even though most of our discussions will focus on a broader division of pre- and post-reform periods.

When examining the fluctuations of China's comparative productivity estimates in Table 6 it is also important to bear in mind the nature of China's socialist labour employment system that prevailed under central planning and still to a large extent remain in the state sector after the reform. Under this employment system, jobs were allocated through planning authorities rather than the market. Once a job was assigned to a person it meant a (working) life-time employment thought it was generally not changeable. Therefore, if no proper capacity adjustment for labour (or for capital as it could provide some implication for labour capacity in use), the estimated (*absolute*[22]) labour productivity could be upward biased if production operation moved from low to high capacity,[23] and downward biased if the opposite happened, other things being equal.

Comparing the pre- and post-reform periods, the best performer in catch up was building materials, whose annual growth of comparative productivity rose from -2.0 to 7.1 percent over the two periods. This was followed by wearing apparel (4.6 to 5.6),

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[21] They are, namely, 1) the first five-year plan period (1952-57) when central planning system and heavy industrialisation strategy were adopted, 2) the Great Leap Forward campaign and its aftermath (1958-62) when the Maoists attempted to boost both agricultural and industrial output by mass campaigns but failed, 3) the post-GLF recovery and adjustment period (1963-65) when light industries were paid some attention, 4) the chaotic period of the Cultural Revolution (1966-70), 5) the period of "grasping revolution, promoting production" (1971-78) when both heavy industrialisation and rural industrial development were promoted, 6) the early reform period (1979-87) when an export-oriented development policy was adopted and 7) the period of deepening reform and matketisation (1988-97).

[22] The *comparative* labour productivity is calculated based on the *absolute* labour productivity of the countries being compared and their respective PPPs.

[23] It should be noted that in some special cases such as during the Korean War (1951-53) and the Great Leap Forward (1958-59), workers had to work over their full capacity, that is, 8 hours a day or 48 hours a week.

tobacco (-0.9 to 4.5) and food (-1.4 to 3.9). Over the two periods, the worst performer was metals (down from 7.4 to 1.5), followed by wood (down from 5.8 to 1.2), petroleum (-2.5 to -7.0) and electrical-electronic (1.4 to -0.2) (Table 6). There are, however, some interesting cases. For example, textiles experienced a process of falling behind (-2.5 to -1.2), while leather-footwear maintained steady catch up over the two periods (3.1 to 3.5) (Table 6).

As a result, by 1997 wearing had apparel enjoyed the highest level of comparative labour productivity (73 percent of the US level), followed by tobacco (57), textiles (38) and rubber-plastics (37). The electrical-electronic equipment branch had the lowest level of comparative labour productivity (only 3.4), followed by chemicals (3.6), machinery (4.7), wood (5.0) and metals (6.6) (Table 6).

The case of textiles may deserve some special attention. Tables 5 and 6 show that in the 1950s textiles was the largest branch in Chinese manufacturing with a size that was about 1.6 times that of the USA and a labour productivity that was between a level similar to and 1.1-1.2 times that of the USA. Is this labour productivity level plausible for Chinese textiles? Apart from the possible upward bias in the estimates that are perhaps caused by the lack of labour capacity adjustment as discussed above, one has to admit that Chinese textile industry should be quite close to its western counterparts prior to China's implementation of central planning in the 1950s. Firstly, China traditionally had strong comparative advantage in textiles which explained why this industry became the first and, at that time, perhaps the most modernised industry through foreign trade and investment.[24] Secondly, the nature of textile production did not require heavy investment in technology and human knowledge in which the USA enjoyed some comparative advantage over China. We could argue that as Table 6 shows, it was the ill-suited central planning system and heavy industry-oriented government policy that made China fall behind in the industries that China used to enjoy comparative advantage.

While China's relatively large size in textiles has maintained for long and even expanded since the 1980s, its labour productivity has been declining over time. One possible reason is that prior to the reform textiles in China did not face any competition while after the reform it only carried on producing low quality products using the abundant supply of cheap labour. This has made this industry incapable of adjusting to rapidly changing technologies in textile production that has been driven by increasingly fierce competition in the world textiles and fashion markets.

[24] In fact, it mainly concentrated in China's coastal cities especially the old treaty ports such Shanghai, Tianjin and Qingdao.

Our findings, except for textiles, are quite compatible with the factor cost level across branches that are suggested by the PPP estimates (Table 2). As we argued above, China's market-oriented reform has driven those branches with comparative advantage to grow faster than those without comparative advantage.

The branch level examination further confirms that China's catch up since the 1990s is a healthy sign as it happened at the time when the industries in which China has comparative advantage began to enjoy faster growth, the non-state sector started to play more important roles in industrial production, and market competition further intensified.

6. Concluding Remarks

This study joins the debate of whether Chinese manufacturing has experienced a significant catch-up with or a process of falling behind the world's advanced economies. It has estimated a new set of industry-of-origin China-US PPPs for major manufacturing industries at 1987 prices. Then using a newly constructed data set, we have derived China's comparative labour productivity level in manufacturing for 1952-97.

Firstly, our findings show a clear productivity catch-up in Chinese manufacturing in 1952-97, but they have also suggested a long stagnation at around 4.5 between 1958 and 1990. Therefore the results cannot rule out the possibility suggested by the Szirmai-Ren study (2000) that there was no catch up in Chinese manufacturing especially during the first decade of the reform.

Secondly, since a clear catch up appeared at the time when the market-oriented reform deepened and market competition intensified, our findings strongly supports the conditional catch up hypothesis that the changes made China more capable of improving economic efficiency as well as adopting new technology (Abramovitz, 1989).

Thirdly, the approach used in this study also helps reassess China's development policies during the central planning and reform periods because the production PPPs could serve as an indicator of factor costs in the countries being compared and hence the degree of distortion in production structure (resource allocation). Our findings suggest a clear resource misallocation effect under central planning and a somewhat healthy shift towards Chinese comparative advantage since the market-oriented reform.

Lastly, our findings show that industries with comparative advantage have been the engine of the post-reform growth and catch up. This looks encouraging for China at this time when it is facing a historical opening to international competition that will follow its WTO entry. It is reasonable to expect that if this catch up continues, more capital with embodied new technologies would be invested to these industries, which will lead to further catch-up.

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APPENDIX: TABLE A1

Basic Data: Chinese Gross Value Added (GVA) and Full-Time Equivalent Employment by Major Manufacturing Branch, Selected Years, 1952-97

	1952	1957	1960	1965	1970	1978	1982	1987	1992	1997
GVA (million 1987 yuan):										
Food Products & Beverages	1,435	2,506	3,156	3,708	4,098	8,363	14,797	29,174	42,137	55,704
Tobacco Products	1,785	3,004	3,024	3,220	5,274	7,961	12,696	19,405	22,126	22,746
Textile Mill Products	6,939	10,413	11,650	12,465	18,149	23,475	31,310	42,592	51,709	78,760
Wearing Apparel	964	1,274	1,379	1,527	1,452	2,670	3,908	9,124	16,923	54,245
Leather Products & Footwear	211	528	791	387	954	1,734	2,844	4,523	8,614	24,875
Wood Products, Furniture & Fixtures	1,938	3,422	6,751	4,864	4,657	4,775	5,986	6,864	6,341	16,911
Paper Products, Printing & Publishing	463	1,138	2,251	2,164	3,014	5,491	7,367	14,271	21,575	34,183
Petroleum Refineries	723	1,211	1,649	2,760	4,619	10,772	11,272	15,930	23,176	32,256
Chemical Products	987	2,903	6,120	7,624	11,353	23,333	30,036	46,296	67,960	116,566
Rubber & Plastic Products	211	469	835	1,285	2,315	4,946	6,826	13,735	25,582	60,511
Building Materials	1,244	3,505	4,457	4,693	6,091	13,149	18,582	32,796	52,255	89,425
Basic & Fabricated Metal Products	1,111	4,487	14,846	10,532	15,725	28,525	32,298	50,825	72,105	101,851
Machinery & Transport Equipment	762	4,076	19,596	6,224	14,817	35,667	33,912	61,183	91,116	159,885
Electrical-Electronic Equipment	170	864	5,619	1,402	5,145	10,322	10,082	28,587	51,434	161,688
Other Manufacturing	1,235	2,227	5,743	4,470	6,354	10,388	11,551	14,769	19,454	31,322
Total Manufacturing	20,178	42,025	87,866	67,323	104,018	191,571	233,467	390,072	572,506	1,040,926
Full-Time equivalent employment (x1000):										
Food Products & Beverages	648	1,243	2,168	1,418	1,668	2,496	3,487	4,807	5,142	5,321
Tobacco Products	51	79	75	57	69	112	201	267	320	310
Textile Mill Products	1,911	1,896	2,432	1,988	2,435	3,445	6,040	8,529	9,348	7,302
Wearing Apparel	1,311	896	738	731	728	585	1,722	2,176	2,468	2,439
Leather Products & Footwear	172	156	204	155	201	366	704	976	1,126	1,372
Wood Products, Furniture & Fixtures	2,266	2,234	1,177	1,719	1,613	580	1,318	1,545	1,495	1,402
Paper Products, Printing & Publishing	381	487	757	533	711	1,172	1,874	2,499	2,806	2,683
Petroleum Refineries	19	32	99	80	117	257	312	449	667	776
Chemical Products	176	328	1,605	723	1,416	3,099	3,764	4,836	6,042	6,423
Rubber & Plastic Products	32	63	185	164	249	749	1,633	2,156	2,509	2,479
Building Materials	571	911	2,639	1,235	2,191	6,182	5,486	7,391	7,192	7,411
Basic & Fabricated Metal Products	1,297	1,326	5,465	1,799	2,734	3,894	5,221	6,621	7,336	7,177
Machinery & Transport Equipment	690	1,227	4,013	2,492	4,693	10,734	10,432	12,502	12,966	12,091
Electrical-Electronic Equipment	108	192	596	405	892	1,822	3,079	4,027	4,652	4,890
Other Manufacturing	1,753	1,456	2,000	1,554	2,686	3,204	2,112	2,960	3,579	2,679
Total Manufacturing	11,383	12,526	24,153	15,052	22,403	38,698	47,384	61,740	67,649	64,753

Source: See Section 4.1 for sources of the data reported here.

APPENDIX: TABLE A2

Basic Data: US Gross Value Added (GVA) and Full-Time Equivalent Employment by Major Manufacturing Branch, Selected Years, 1952-97

	1952	1957	1960	1965	1970	1978	1982	1987	1992	1997
GVA (million 1987 dollars):										
Food Products & Beverages	28,170	32,625	34,071	40,459	45,339	57,539	71,507	79,098	84,595	86,907
Tobacco Products	15,224	15,449	18,055	18,680	21,506	24,982	20,683	10,353	4,395	6,643
Textile Mill Products	5,835	5,996	6,227	9,985	11,948	16,646	16,231	20,137	23,332	22,903
Wearing Apparel	10,092	10,381	11,229	13,815	14,309	20,618	18,764	23,031	24,267	22,732
Leather Products & Footwear	4,171	4,228	4,407	5,333	4,594	5,031	4,579	3,939	4,011	3,441
Wood Products, Furniture & Fixtures	15,443	15,840	16,261	24,701	25,407	34,570	30,387	46,685	39,113	42,447
Paper Products, Printing & Publishing	34,803	41,689	45,381	58,141	64,892	84,437	84,351	99,830	98,421	94,166
Petroleum Refineries	4,070	4,698	5,562	6,916	7,984	7,306	11,910	22,051	15,986	19,597
Chemical Products	13,397	18,978	21,764	32,370	42,577	64,483	61,036	83,802	91,549	109,309
Rubber & Plastic Products	5,554	5,375	6,519	10,105	12,208	18,751	20,428	29,580	37,851	53,630
Building Materials	12,826	14,553	15,703	19,953	20,530	25,190	17,308	23,313	25,921	32,714
Basic & Fabricated Metal Products	70,245	77,991	69,823	93,586	95,469	107,982	86,982	97,135	93,973	121,384
Machinery & Transport Equipment	71,807	79,880	75,706	112,355	113,090	163,872	146,939	208,890	213,221	314,229
Electrical-Electronic Equipment	11,541	13,033	15,458	25,347	31,416	49,624	58,750	87,640	119,140	296,237
Other Manufacturing	12,537	14,239	15,935	20,429	25,207	38,977	41,207	53,108	55,890	50,912
Total Manufacturing	315,717	354,954	362,102	492,174	536,475	720,009	691,063	888,592	931,664	1,277,251
Full-Time equivalent employment (x1000):										
Food Products & Beverages	1,813	1,738	1,705	1,694	1,736	1,686	1,592	1,594	1,614	1,676
Tobacco Products	104	92	90	86	79	67	66	54	47	40
Textile Mill Products	1,144	959	896	907	952	894	722	718	663	620
Wearing Apparel	1,219	1,168	1,177	1,292	1,306	1,295	1,112	1,086	990	830
Leather Products & Footwear	379	362	348	344	310	261	219	147	120	89
Wood Products, Furniture & Fixtures	1,291	1,134	1,100	1,144	1,173	1,325	1,083	1,325	1,236	1,392
Paper Products, Printing & Publishing	1,307	1,412	1,458	1,579	1,755	1,834	1,900	2,132	2,168	2,239
Petroleum Refineries	231	232	202	178	188	200	191	160	154	135
Chemical Products	712	797	797	875	1,015	1,090	1,075	1,013	1,067	1,023
Rubber & Plastic Products	361	395	402	505	621	773	707	848	870	988
Building Materials	555	567	574	601	610	667	541	561	518	563
Basic & Fabricated Metal Products	2,463	2,612	2,387	2,629	2,796	2,865	2,311	2,127	2,006	2,187
Machinery & Transport Equipment	3,374	3,474	3,124	3,598	3,825	4,341	3,991	4,063	3,770	4,005
Electrical-Electronic Equipment	1,006	1,127	1,223	1,369	1,588	1,714	1,716	1,763	1,525	1,682
Other Manufacturing	914	977	970	1,049	1,178	1,400	1,416	1,367	1,321	1,305
Total Manufacturing	16,876	17,046	16,453	17,851	19,132	20,413	18,642	18,958	18,069	18,774

Source: See Section 4.2 for sources of the data reported here.

APPENDIX: TABLE A3

Matched Output as % of Gross Value of Output (GVO) in the ICOP Comparison in China-US Manufacturing, 1987

Manufacturing Branch	China (million 1987 yuan)			US (million 1987 dollars)		
	GVO Total	GVO Matched	Matched as % of Total	GVO Total	GVO Matched	Matched as % of Total
Food Products	124,116	73,653	59.3	271,657	40,152	14.8
Beverages	31,664	16,865	53.3	45,514	9,922	21.8
Food Products & Beverages	155,779	90,518	58.1	317,171	50,074	15.8
Tobacco Products	28,918	28,878	99.9	24,869	16,746	67.3
Textile Mill Products	166,207	6,900	4.2	62,406	6,121	9.8
Wearing Apparel	31,037	31,037	100.0	63,290	3,307	5.2
Leather Products & Footwear	15,539	15,506	99.8	8,812	4,309	48.9
Wood Products, Furniture	21,557	1,482	6.9	108,857	6,325	5.8
Paper, Printing & Publishing	44,329	18,157	41.0	246,455	8,876	3.6
Petroleum Refineries	36,436	26,627	73.1	138,141	84,434	61.1
Chemical Products	140,857	43,431	30.8	216,173	15,308	7.1
Rubber & Plastic Products	46,805	6,273	13.4	86,110	5,106	5.9
Building Materials	80,025	25,943	32.4	60,125	3,469	5.8
Basic & Fabricated Metals	157,056	90,756	57.8	265,543	21,307	8.0
Machinery & Transport Equipment	179,976	30,856	17.1	541,850	168,709	31.1
Electrical-Electronic Equipment	106,371	26,899	25.3	207,254	5,860	2.8
Other Manufacturing	32,557	324	1.0	98,291	8,804	9.0
Total Manufacturing	1,243,451	443,588	35.7	2,445,349*	408,753	16.7

Source: See Section 4.

Note: *BEA data, slightly different from the result of the 1987 US Census of Manufacturing figures US$2,475,901 million.

APPENDIX: TABLE A4

Annual Average Growth of Labour Productivity in Chinese Manufacturing, China Absolute versus China/US Comparative, Selected Periods (in percentage)

	1952-78		1978-87		1987-97	
	China 87yuan	China/US 87PPPs	China 87yuan	China/US 87PPPs	China 87yuan	China/US 87PPPs
Food Products & Beverages	1.61	-1.42	6.82	2.47	5.60	5.14
Tobacco Products	2.74	-0.89	0.25	7.94	0.11	1.55
Textile Mill Products	2.45	-2.53	-3.39	-7.69	8.00	5.07
Wearing Apparel	7.27	4.61	-0.94	-4.04	18.16	15.18
Leather Products & Footwear	5.33	3.09	-0.25	-3.83	14.61	10.49
Wood Products, Furniture & Fixtures	9.10	5.88	-6.62	-9.69	10.50	12.11
Paper Products, Printing & Publishing	5.32	3.13	2.23	2.04	8.36	9.53
Petroleum Refineries	0.31	-2.47	-1.84	-15.3	1.61	1.08
Chemical Products	1.13	-3.23	2.71	-1.05	6.60	3.91
Rubber & Plastic Products	0.01	-1.73	-0.40	-4.34	14.38	9.43
Building Materials	-0.09	-1.96	8.51	7.36	10.52	6.88
Basic & Fabricated Metal Products	8.60	7.44	0.52	-1.6	6.34	4.28
Machinery & Transport Equipment	4.33	2.05	4.40	0.87	10.45	5.88
Electrical-Electronic Equipment	5.03	1.35	2.54	-3.44	16.63	2.77
Other Manufacturing	6.04	3.19	4.91	1.1	8.89	8.84
Total Manufacturing	4.03	1.52	2.75	-0.45	9.79	5.77

Source: China absolute productivity growth is derived from Appendix Table A1. China/US comparative productivity growth is from Table 6.

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