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MEASURING CHINA'S GDP

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Introduction

As Chinese economy develops and integrates into the world economy there is a growing interest in a reliable, internationally comparable measure of China's real income or gross domestic product (GDP)[1] and growth performance. This is would provide a common basis for international trade, aid and security assessments of China and a better understanding of the Chinese economy, its place in the world economy and its growth potential in the future.

However, measuring China's GDP is no easy task. Since the early 1950s, China's national accounting, price statistics, and statistical practices in general have been strongly influenced by the Marxian material product system. Official statistical information for the pre-reform period is limited. Studies of China's national accounts based on necessary statistical information only became possible about a decade ago when economic reforms began to push China's statistical system to change.

This paper reviews recent major studies on China's national accounts and growth performance, evaluates attentive estimates of China's national income as well as growth rates, and discusses their implications. Its main aim is to improve the understanding of these attentive estimates based on different approaches.

To make a reasonable measure of a country's national income on an internationally comparable basis it is necessary to fulfil the following basic conditions: 1) a conceptual consensus on the scope, meaning and coverage of national accounts, which defines national income or GDP; 2) estimates of GDP and its components in real and monetary terms following these general principles; and 3) appropriate converters to convert the estimates in different national currencies into a common numeraire or an 'international currency' (Maddison and van Ark 1994).

The widely adopted national accounting system is the United Nations System of National Accounts which consists of standardised national accounting practices based on well developed national accounts theory. Estimating GDP according to the SNA principles is the first and fundamental step towards international comparison of national income.

There are two main methods of converting national income into an international currency: the market exchange-rate (MER) method[2] and purchasing power parity (PPP) method. The market exchange-rate method (typically the '*World Bank Atlas* method', see for example, World Bank 1996a: 236) is criticised because of problems when used in cross-country comparisons. In principle exchange rates are mainly a reflection of purchasing power over tradeable goods and services. For these items inter-country price differences tend to be reduced because of possibilities for trade and specialisation. In poor countries where wages are low, nontradeable items like haircuts, health care, building construction and government services are generally cheaper than in high income countries, so exchange rates tend to understate the domestic purchasing power of these countries' national currencies. Exchange rates are also often strongly influenced by capital movements and in recent decades have been too volatile to serve as reliable indicators of purchasing power (Maddison and van Ark 1985). Furthermore, changes in exchange rates can be caused by decisions of national monetary authorities, (on interest rates and capital flows) which may distort international comparisons as they are not related to relative real growth rates in the countries compared.[3]

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1 This study focuses on GDP rather than GNP (gross national product) which includes net property income from abroad.

2 In this study Chinese official exchange rate is often used as MER because we do not have better information than the official data. It is realised that the official rate is not always the same as MER though it may to some extent reflect MER.

3 Ren and Chen (1994) gave a good example to explain this. In 1970 India's and China's per capita GDP was $110 and $130, respectively. During the next 20 years, per capita GDP in local currency grew at an annual rate of 5.5 per cent in China and of 2.0 per cent in India (assuming the growth rates are correct), raising the level of per capita GDP in China relative to that of India by about 3.5 per cent per year.

By contrast, the PPP method takes account of individual national currencies' real purchasing power within their own country, a reflection of both command of consumers over tradeables and nontradeables. There have been two different PPP approaches, the expenditure PPP approach developed by Kravis, Heston and Summers in the United Nations International Comparison Project (ICP) (Kravis, Heston and Summers 1982), and the industry-of-origin (or production) PPP approach developed by a group of researchers led by Maddison in the International Comparison of Output and Productivity (ICOP) project at the University of Groningen, the Netherlands (see Maddison and van Ark 1988; van Ark 1993).

One additional conversion methodology should also be mentioned here. It is often referred to as the 'physical/social-indicator' method. It is based on a comparison with at least one other economy which appears to be at a similar level of development to the country concerned, according to selected benchmark physical/social attributes. For example, China's income would be compared to that of Taiwan at some point in the past, such as the early 1960s. The best benchmarks are consumption of products which are relatively homogeneous, such as grain or other foodstuffs (Garnaut and Ma 1993), coal and steel, and some social indicators, such as longevity, number of physicians, and school attendance. However, this method is criticised for having strong underlying assumptions that could produce distorted estimates for China. For example, it assumes similar output quality of benchmark goods and similar output and consumption ratios of other products to the benchmark goods (i.e. a similar economic structure) in China and the economy to which it is compared.[4] Such assumptions may not be tenable.

China is currently moving towards a new SNA type of national accounting system which covers the years since 1978. However, the official techniques for measuring GDP for this period are obscure and for years before 1978 the old MPS measure of NMP is still in use. Since the 1990s, there has been a considerable effort by scholars to assess and reconstruct China's GDP on an internationally comparable basis. Because estimates produced by these studies vary greatly, there is a growing controversy about the real level of China's per capita GDP.

Measuring China's GDP growth is also difficult. China uses some unusual methods of constructing price indices and deflating GDP, which are widely believed to exaggerate GDP growth. This not only invalidates estimates of China's total factor productivity (TFP) performance which partially relies on a reliable GDP growth estimates, but also misleads assessments on China's future growth prospects.

In the following sections, we will first have a close look at the problems of China's national accounting system and review the studies attempting to reconstruct China's GDP. We then review the analyses designed to convert China's GDP into an international currency and reassess China's GDP growth rates. This will be followed by a discussion of PPP-based GDP projections and deficiencies of the PPP approach for international comparisons and growth forecast. Finally, important implications will be drawn from the studies reviewed.

National accounts and growth measurement

Material Product System MPS, versus the System of National Accounts, SNA

In the early 1950s, China adopted MPS from the Soviet Union with the central planning system. The MPS artificially divided economic activities into 'material production' and 'nonmaterial production', and measured output in quasi-physical terms in line with the

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However, if official exchange rates are used, the real per capita GDP in China relative to India did not increase at all over this period ($360 for China and $350 for India in 1990 based on *World Tables*, World Bank 1991).

[4] See World Bank (1994b: 35-7) for detailed assessment of the method.

physical targets of national plans. Under MPS, those services that are considered not directly linked to material production (e.g. passenger transport, health services, education, etc.) are treated as consumption rather than production of national income. The distinction between MPS and SNA in national income can be simply expressed as follows.

Let us start with the MPS concept of gross value of output, GVO. Given a time period, for each sector *i*, let the value of material input be C_i^m, the value of depreciation of fixed capital input be C_i^d and value added by 'material production' be V_i^m, then

$$\text{GVO}_i = C_i^m + C_i^d + V_i^m . \quad (1)$$

In Eq. (1) only the component V_i^m is considered 'newly created value' in Marxian economics. In Chinese statistical terminology it is called net value of output or NVO, which is the NMP, commonly used for the national income measured in centrally-planned economies (CPEs). We can therefore define NMP as

$$\text{NMP} = V_i^m = \text{GVO}_i - (C_i^m + C_i^d) . \quad (2)$$

The SNA concept of GDP in the following Eq. (3) can be contrasted with Eq. (2):

$$\text{GDP}_i = V_i^m + V_i^n + C_i^d \quad (3)$$

where the term V_i^n indicates net value added by the so-called 'nonmaterial production' of sector *i* in Marxian economics. Clearly, GDP is quite incompatible with either GVO or NMP. In practice, GVO contains double counting and NMP seriously underestimates national income by ignoring the value of capital depreciation of all sectors ($\sum_i C_i^d$) and the value added from all 'nonmaterial' services that are considered 'nonproductive' ($\sum_i V_i^n$). However, at sectoral level, the impact is different. The service sector is most affected as most of the ignored output by 'nonproductive' services is the valued added of the service sector.[5]

The introduction of a 'hybrid' national accounting system

Obviously, MPS was not a suitable national accounting system for a reforming Chinese economy. In late 1980s, alongside market-oriented reforms and opening up to international trade and investment, China began to consider some adjustments to its national accounting system to assist economic policy making and mutual understanding between China and the outside world. Since then China has taken a number of important steps to reform its national accounting system. In 1987 China's State Statistical Bureau (SSB) started a project to establish China's first SNA-type input-output table. China's first-ever SNA GDP estimates were released in 1988 with retrospective estimates of GDP back to 1978 (Wu 1993: 63-4). From then onwards, aggregate GDP and gross value added by major sector have been measured and reported by SSB, although SSB has made successive modifications to the previously released GDP estimates without proper explanations.

China's first SNA-type input-output table, *Input-Output Table of China 1987* was released in 1991 (DBNE and ONIOS 1991). This was probably due to the resource constraints caused by processing of the second national industrial census in 1985. The SSB also may have cross checked with the census results after they became available. Two input-output tables were published thereafter, a reduced version input-output table for 1990 (DBNE and OIOS 1993) and a new input-output table for 1992 which took into account China's first national census on

[5] See Wu (1993) for more detailed discussion on the difference of the two systems.

the tertiary sector for the same year.[6] Successive modifications to GDP estimates might have been related to these processes of cross-checking (Wu 1993: 6-9).

Although it is reasonable to believe that these practices have gradually improved the quality of China's national accounts, there are still serious shortcomings in the system. It should be noted that China has not in theory or practice been fully committed to SNA. The current version of input-output table is in fact a 'hybrid' between MPS and SNA (World Bank 1994b; Ren 1997; Maddison 1998). Chinese Marxist statisticians and economists (DBNE and ONIOS 1991: 3-12) claim that the new system is innovative in that it has the practical merits of both, which tye claim is able to satisfy Western economists and investors and provides a link back to the prevailing MPS for Chinese accountants and economists.

Apart from theoretical or ideological reasons, adoption of a hybrid system rather than a complete SNA might be motivated by cost saving (Wu 1997: 9). Full adoption of SNA is very costly because it means a thorough change at every stage of data collection throughout the SSB's established network which operated under the MPS for more than four decades. Relevant university courses would have to be completely restructured and qualified teaching staff recruited, and accountants would have to be retrained. Senior officials who are not willing to learn the new system but still want to stay in charge have to be satisfied and all historical data would have to be linked with the new statistics.

Problems yet to be solved

As the old system is to a large extent still in operation and the new SNA has been introduced as a system of conversion, many problems are expected to remain and contribute to GDP underreporting. Many studies have identified the problems in China's current 'hybrid' national accounting system, including shortcomings in statistical coverage and data collection, and problems in output valuation (World Bank 1992b and 1994b; Wu 1997; Ren 1997).

It is very likely that China's GDP has been underestimated because of inadequate GDP reporting coverage. As suggested by Keidel (1992) and two major World Bank studies (1992b and 1994b), output of grain, vegetable production and rural industrial and service enterprises (township and village enterprises, TVEs) are underreported, as are urban and rural housing expenditure. Other studies maintain that the output of defence industries are also probably underreported (Maddison 1998; Wu 1997).

China's largely unreformed statistical data collection system contributes to GDP underreporting. This system depends heavily on complete administrative reporting rather than a modern system of random sampling. Grassroots reporting still follows the artificial distinction between MPS 'material' and 'nonmaterial' output categories and generally measures output in quasi-physical terms rather than in current value terms. To satisfy the SNA concept of GDP, GDP's 'nonmaterial' components are separately treated through *ad hoc* surveys and estimates which probably causes more distortions (World Bank 1992b). One study lists all major areas that need adjustment when converting Chinese output data into GDP, including own grain consumption, commercial real estate earnings, inventory growth, in-kind services, depreciation charges and government subsidies for SOE losses (World Bank 1994b).

Problems with output valuation also contribute to an underestimation of China's GDP. The main reason for problems with output valuation is China's price system. Keidel in his World Bank study (World Bank 1994b) argues that in spite of significant price reform, China's price system to some extent still causes higher prices for industrial goods and lower prices for rural commodities, placing an implicit tax on rural incomes and subsidising urban profits, wages and urban necessities, such as housing.[7] Also, incomplete movement to a market based system

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6 The summary results of the first national census on the tertiary sector have recently been systematically reported by National Census Office for the Tertiary Sector (NCOTS 1996).

7 This is confirmed by macroeconomic statistics. In the 1987 Input-Output Table, the clearest statistical consequence of the price policy is very high industrial profits, very low or negative service profits and low rates of return relative to capital stock and land in rural areas (World Bank 1994b).

results in some government provided goods and services being undervalued (mainly housing and utilities).

Unusual practices in growth measurement

When measuring GDP China's statistical authority employs 'comparable price'-based output to calculate growth indices rather than deflating GDP in current prices by a price index, eg. CPI (consumer price index). The term of 'comparable prices' is taken from Soviet statistical practice based on MPS and does not have the same meaning as 'constant prices' in Western statistical usage.

The SSB claims that the 'comparable prices' are assembled by five SSB administrative 'constant prices',[8] which are average prices of 'representative items' belonging to the same product category for a particular period (Li ed. 1986: 837-8). However, this method is not transparent; there is no detailed information on how these representative products were chosen and how the average prices are computed over time.[9]

Many researchers believe that the use of 'comparable prices' to construct the GDP deflator has understated inflation and overstated growth because they do not adequately reflect price increases (Maddison 1998; Woo 1996, Keidel 1992; Perkins 1988). Generally, this approach suffers from irregularities introduced by weights which gives excessive weights to the price level of items covered by state listed prices and too little to the price level of valued at using negotiated or market prices. In addition, the practice of not writing off unsaleable inventories also tends to inflate China's real growth (Ren 1997; Borensztein and Ostry 1996).

Woo (1996) gave three reasons to show why the base-year price reporting system tends to overstate growth, particularly for nonstate enterprises. Firstly, unlike SOEs, most collectively-owned enterprises and rural TVEs are much less clear about how to do the base-year computation, especially because in base-year 1980 (the 1980 prices were used until 1990) most of them did not exist. Because these enterprises are not closely supervised by the central ministries, they tend to report identical figures for output in current and base-year prices, either out of ignorance or convenience. Secondly, since high growth performance can be interpreted as evidence of superior management ability from the upper management level, all enterprises including SOEs have an incentive to over-report growth. Thirdly, when a new product appears it involves an estimation of what its based-year price would have been given its 'quantity' attributes, e.g. how many 286 chips are equivalent to one pentium chip in operational capacity. As a result of these complexities many enterprises report the value of new products in current prices as the value in base-year prices.

Reconstructing China's GDP

To measure China's national income on an internationally comparable basis, the first and most fundamental task is to reconstruct China's GDP according to SNA principles. This is also the most difficult and tedious stage because researchers have to rely on insufficient information to improve coverage, match economic activities, remove price distortions and adjust factor costs. There have been only a few studies in this area even after the great increase in statistics available since the 1990s.

In the 1960s and 1970s scholarly activity by Western economists on China's national income was largely based on Chinese official statistics published in the 1950s.[10] They were motivated

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8 Since the start of the material product system the SSB has used 1952, 1957, 1970, 1980 and 1990 constant prices (SSB 1996: 59 - Explanatory notes).

9 See Wu for more detailed discussion (1993: 69-70, footnote 17 and Appendix Table 2).

10 See, for example, Hollister (1959), Li C. (1959), Eckstein (1961), Liu and Yeh (1965, 1973), Chao (1965, 1968, 1970, 1974), Field (1980) and Perkins (1975, 1980).

by then widely accepted assumption that China's official output index contained upward biases which made it unreliable for assessing China's performance under the communist government. The most important pioneer work in reconstructing China's national income and assessing China's economic performance was done by Liu and Yeh (1965 and 1973) and Chao (1965, 1968, 1970 and 1974). Liu and Yeh estimated China's national income by both industrial origin and end-use expenditure methods, while Chao based his estimation primarily on a physical output approach. Their results supported the hypothesis of an upward-bias in official statistics.[11]

Such quantitative research work gradually petered out in the 1970s and 1980s because the Chinese authorities released no systematic statistical data at all during the 1960s and 1970s.[12]

The beginning of the 1990s saw a resurgence of the studies on China's national accounts following the start of SSB's regular publication of GDP and other macroeconomic data for China. Two studies by Wu (1993 and 1997) attempted to construct GDP time series for China covering the entire central planning period. Two different approaches were adopted in the two studies. In his first attempt, Wu (1993) developed an econometric method based on the relationship between the SNA concept of GDP and the MPS concept of NMP to estimate GDP by sector for 1952-77 using official data for 1978-90. In his second attempt, Wu (1997) reconstructed a GDP series for China's industrial sector at branch level by estimating independent growth indices using official physical output data and the Chinese 1987 Input-Output Table (SNA type). However, both studies implicitly assumed that the SSB's basic collection techniques were acceptable, leaving the problems of undercoverage and price distortions unsolved.

An extensive national account adjustment aimed at removing all price 'distortions' was first attempted by Keidel (1992; World Bank 1994b[13]). His latest modified result raised Chinese GDP for 1987 (1,319 billion yuan) by 34 per cent (World Bank 1994b), down from his earlier 55-per cent upward adjustment (Keidel 1992) but still so high that the estimate was difficult to accept. The 34-per cent increase in yuan GDP adjusts for statistical shortcomings (scope adjustment plus a minor consistency adjustment, 13.6 per cent) and China's price system (valuation adjustment 18.3 per cent).[14] Keidel reestimated profit rates in all sectors to reflect a more uniform rate of return to productive assets and land. He also reallocated the impact of subsidies.

Keidel's justification for these adjustments is based on the identified statistical shortcomings in China reported by a World Bank statistical mission to China in 1990 (World Bank 1992b) and the common knowledge of price distortions in CPEs and transition economies. However, such extensive price imputations are likely to produce further distortions given inadequate knowledge of such variables as the size of the capital stock by sector. As argued by Maddison (1998), for a huge, very self-contained economy, which had only half emerged from central planning (especially in 1987), it is probably unrealistic to try to create a counterfactual estimate of what prices would be if it had been run in a market system. A full-fledged adoption of the Keidel level adjustments would make it difficult to use presently available PPP estimates which are based on converters relevant to the prevailing price system.

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11 For the industrial sector in 1952-57 for example, both studies showed significantly slower annual growth than official estimates, 13.7 and 13.9 per cent (Chao 1965 and Liu-Yeh 1965, respectively) compared with official 19.5 per cent (see details from Wu 1997: Table 1).

12 During the 1970s, the USA's CIA carried out some work attempting to reconstruct Chinese industrial growth independently. But the method was rather crude as data were very poor at that time and the work stopped after 1982. The CIA measures for China were published by the Joint Economic Committee (JEC) of the US Congress in 1972, 1975, 1978 and 1982.

13 World Bank China Report No. 13580-CHA was prepared by Keidel in 1994 and provided an extension of Keidel's initial work in 1992.

14 The compounded total adjustment is 34.3 per cent (1.343=1.136*1.183) (World Bank 1994b: Table 2.7).

Maddison (1998) also attempted to reconstruct China's GDP by adjusting sectoral coverage but used a more moderate approach than Keidel. Maddison's benchmark year is also 1987. He mainly adjusted output of the agricultural and service sectors using an industry of origin approach. His main efforts were made in coverage adjustment rather than valuation adjustment. The combined effect of Maddison's adjustments raised his estimate of China's 1987 GDP by 10.2 per cent above the official figure. Based on the growth trend of each sector,[15] Maddison reconstructed a complete time series of GDP sector by sector for the period 1952-94. The implied GDP growth by his estimates will be discussed later in this study.

The expenditure-PPP conversion of Chinese GDP

The prevailing international income comparisons based on expenditure purchasing power parity, PPP, 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).[16]

Purchasing power parity in an expenditure framework can be defined as the number of currency units required to buy goods and services in the domestic market equivalent to those that can be bought with one unit of the currency of a base country (Kravis, Heston and Summers 1982). Note PPP is the commonly used term to refer to the parity computed for the fixed basket of products and services, even though theoretically this parity would be more appropriately labelled the purchasing power of currencies (PPCs) (Gilbert and Kravis 1954).

Conceptually, PPP methods represent a significant improvement over exchange-rate estimates because they adjust each country's GDP to a standard set of relative prices in the process of conversion to a common currency. The actual work of bilateral comparisons from the expenditure side includes two main steps. First, for each category within the classification system of the ICP the analyst chooses a sample of items and matches their qualities and prices for the two countries being compared to calculate PPP for each item, and the aggregates the PPPs to category levels. Second, the analyst aggregates category-level PPPs to sector level using the respective expenditure weights of the two countries being compared.[17]

The following formulas give the aggregated PPPs for sector j for countries a and b using respective weights:

(4) $$PPP_j^a = \sum_{i=1}^{n} (P_{ij}^a / P_{ij}^b) \; w_{ij}^b ;$$

(5) $$PPP_j^b = \frac{1}{\sum_{i=1}^{n} (P_{ij}^b / P_{ij}^a) \; w_{ij}^a} ,$$

where P is the price for i category and w is the expenditure weight for i category of sector j.

The Fisher Index, i.e. the geometric mean of the a country-weighted and b country-weighted PPPs, is then calculated for each sector j.[18]

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15 Including indices estimated by Liu and Yeh (1965) and Wu (1997), and various official growth indices (Maddison 1998).

16 See Kravis (1984) for a complete review of pre-World War II studies of PPPs.

17 Technically, the methods chosen for the bilateral comparisons should satisfy three requirements: *characteristically* test, *country-reversal* test and *factor-reversal* test. See Ren and Chen (1994) for an explanation.

18 This is also called 'ideal index number' because it meets the criteria set by Fisher as necessary conditions for an ideal index (Fisher 1922). It should be noted that the Fisher index is attractive only because it is a compromise solution. As Kravis, et al (1978: 220) once commented, 'It has little to recommend it, even though it is often favoured for this pragmatic reason.'

Finally, the estimated national income in PPP terms, GDP_{ppp}, is derived by summing up all j sectors (j=1, 2, ..., m)

$$GDP_{ppp} = \sum_{j=1}^{m} PPP_j \; GDP_j \,, \tag{6}$$

In practice, the expenditure PPP-based ICP is basically a highly sophisticated quality-matching comparative pricing, weighting and aggregating exercise. It involves the collection of carefully specified price information for representative items of consumption, investment goods and government services.

The first expenditure-PPP exercise for China in comparison with the USA was conducted by Kravis (1981) using price and expenditure information for 1975 supplied by official sources in both countries according to the standard specifications of ICP. However it was a 'reduced information' exercise because the amount of details on prices and expenditure in China was significantly less than normally required by ICP standards. Although the study involved the highest levels of expertise available in this field, the results were unacceptably high compared with other estimates. It showed China's per capita GDP to be 10.4 per cent of that in the USA in 1975. As ICP comparisons are normally carried out at multilateral (Geary-Khamis) prices, Kravis made a rough estimate of what China's per capita product might have been on a Geary-Khamis (G-K) dollar basis.[19] The end result was a Chinese per capita GDP 12.3 per cent of that in the USA in 1975. If this result is updated to 1990 by official growth rate for 1975-90, it would give $4,264 in 1990 G-K dollars (Table 1) (Maddison 1995: 167-8).

China has not officially participated at any phase of ICP. However, a significantly modified version of the Kravis estimates was used in the Penn World Tables of Summers and Heston (1993, PTW 5.5). Their estimates were based on official consumption deflators, together with a geometric average of PPPs they derived from Ren and Chen (1993)[20]. Their estimated PPP GDP per capita was $2,700 in 1990 G-K dollars (Table 1). Maddison (1995) argues that the Summers-Heston estimate is therefore a hybrid, and is not significantly different from what one would obtain by taking a simple geometric average of the Kravis and Ren-Chen estimates. On the basis of improved prices indices and a revised estimation of growth, Summers and Heston recently (1996, PTW 5.6) substantially reduced their per capita GDP estimate for China to about $1,600 for 1990 (been converted to 1990 price, Table 1).

Table 1

Various estimates of China's per capita PPP-based GDP for 1990

Reference of research	Conversion Approach	Per capita GDP (US$ or Int.$) (Original result: year/price)	Per capita GDP (1990 or updated to 1990) (1990 prices)
Kravis (1981)	ICP	$769 (1975/1975)	$4,264
Summers & Heston (PWT 5.5) (1993)	ICP	$2,700 (1990/1990)	$2,700
Summers & Heston (PWT 5.6) (1995)	ICP	$1,324 (1990/1985)	$1,600
Ren-Chen (1994)	ICP	$1,044 (1986/1986)	$1,749
Ren (1997)	ICP	$1,014 (1986/1986)	$1,690
World Bank (1992)	ICP	$1,950 (1990/1990)	$1,950

[19] The 'Geary-Khamis dollar' is also known as 'international dollar'. The 'Geary-Khamis' method is the principal aggregation method of the ICP project. It was proposed by Geary (1958) and later pursued by Khamis (1970, 1972). It is based on the twin concept of 'purchasing power parities' of currencies and 'international (average) prices' of commodities.

[20] The study by Ren and Chen in 1993 was an unpublished draft of the World Bank. It was later published by *Review of Income and Wealth* in 1994. Note PWT 5.5- Penn World Tables 5.5.

World Bank (1996)	ICP	$1,800 (1992/1992)	$1,454
Maddison (1998)	ICOP	$1,855 (1990/1990)	$1,855
Ren (1997)	ICOP	$886 (1986/1986)	$1,484
Taylor (1991)	Mixed	$788 (1986/1986)	$1,135

Ren and Chen (1994) conducted an expenditure-PPP comparison between China and the USA for 1986, following the procedure similar to that of Kravis. They had much better Chinese price and expenditure information than Kravis, using over 200 items compared with 93 items. Their estimate of per capita PPP GDP for 1986 was $1,044, applying an estimated Fisher converter of 0.8079 (Ren and Chen 1994: Table 6) to the yuan figure of 909 yuan. The spread between the results at US weights ($1,818) and at Chinese weights ($571) was large (three-fold), but not as wide as Kravis found for 1975 (four-fold). Maddison updated the Ren-Chen estimate of per capita GDP from 1986 to 1990 using official growth rate figures, yielding $1,749 in 1990 G-K dollars (Table 1).

Ren's latest study (1997), which slightly revised the Ren-Chen results (1993) for 1986, implying a per capita GDP of $1,690 for 1990 in 1990 Fisher dollars (Table 1).[21] Ren's new study was based on more reliable information on difficult items like housing and government services (1997: 38). Maddison (1998) adjusted the latest Ren estimates to a Geary Khamis basis and also made a small upward adjustment to the official yuan figure for 1990.

Since the 1990s the World Bank has been moving away from its previous preference for adjusted market exchange rate (MER) converters towards use of ICP-type (expenditure PPP) estimates. For countries like China which have not participated any phase of ICP, it has adopted a regression method (regression approximation) to derive ICP-based GDP estimates, given as

$$\ln(GDP_{ppp}) = \ln(GDP_{Atlas}) + \ln(ENROL) + \qquad (7)$$

where GDP_{ppp} is ICP estimates of per capita GDP in international currency, GDP_{Atlas} is per capita GDP estimated by the *World Bank Atlas* method, *ENROL* is secondary school enrolment (see for example World Bank 1995: 244). GDP_{Atlas} and *ENROL* are used as rough proxies of intercountry wage differentials for unskilled and skilled human capital, respectively. Following Isenman (1980), the rationale adopted here is that ICP and conventional estimates of GDP differ mainly because wage differences persist among nations due to constraints on the international mobility of labour.[22]

The World Bank began to report ICP estimates for China from *World Development Report 1993* based on the regression method and other *ad hoc* estimates for China also following the ICP method. However, the World Bank estimates have been different from other ICP estimates (e.g. $1,950 for 1990, compared to $2,700 of Penn World Tables, PWT 5.5) and inconsistent with officialreal growth rates (Table 2).

Table 2

Inconsistencies in China's per capita GDP estimates by World Development Report 1990-1994

[21] 'Fisher dollars' hare refers to 'comparable dollars' derived from Fisher (geometric) average of China and USA weighted PPPs.

[22] By fitting the regression model to the 1987 data from 81 participant countries in ICP, the *World Development Report* obtained a result of adjusted R-squared 0.96 and RMSE (root mean squared error) 0.223 (World Bank 1995: 244)

Year	Per capita GDP (in current international dollars Int.$)	Base-country (USA) CPI	Per capita GDP (in 1990 Int.$)	Implied real growth index, WDR (previous year=100)	Compared with:*	
					Real growth index based on official CPI	Real growth index by SSB
1990	1,950	100.0	1,950	--	--	--
1991	2,040	103.8	1,965	101.0	111.7	107.9
1992	1,910	106.9	1,787	91.1	113.8	113.0
1993	2,330	109.7	2,124	108.5	112.7	112.4
1994	2,510	112.2	2,237	115.5	107.7	111.5
1995	2,920	115.0	2,539	113.0	105.1	109.4

Source: World Bank (1992a, 1993, 1994a, 1995, 1996a, 1997), OECD (1997), SSB (1996) and Table 3 of this study.

Note: *Converted to per capita GDP growth rates, using population growth rate of 1.3 per cent for 1991, 1.2 per cent for 1992, and 1.1 per cent for annual growth of 1993-95 (SSB 1996: 69)

The production-PPP conversion of Chinese GDP

The production approach to PPP GDP estimates has been developed by the ICOP project of the University of Groningen since 1983 (Maddison and van Ark 1988; van Ark 1993), based on work by Rostas (1948), Paige and Bombach (1959) and Maddison (1970). It involves a comparison of real output (value added) in major sectors (agriculture, industry and services) and of branches within these three broad sectors, as well as measures for GDP as a whole. It 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, national accounts and, more recently, from individual firms. Its integrated statistics of quantity, unit value and values permit cross-checks not available to ICP. It also identifies variations in the coverage of national accounts and gives high priority to the measurement of output and productivity in services, issues not explored by ICP.

To some extent the production-PPP approach is superior to the expenditure-PPP approach because it can reveal many 'disguised' economic, especially service activities which are not closely and explicitly examined by the expenditure-PPP approach. The latter, for example, values distribution services at the same margin in all countries.[23]

As pointed out by Maddison and van Ark (1994), the ICOP production approach is not a substitute for the ICP expenditure approach, but a supplement to it. The two approaches share the common features of PPPs and can be used to cross-check each other as they examine national income from different angles.

The key concept of the production-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 value by the corresponding quantities obtained from each country's production census or survey. These are the prices used in the ICOP project. 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 (van Ark 1993).

[23] Distribution is one of such "disguised" services, where ICP's "potato-is-a-potato" rule infers that the distributive service content of various types of expenditure is the same in all countries (Kravis, Heston and Summers, 1982, p.31).

Although the terms UVR and PPP are interchangeable, for output comparisons the former is preferable to the latter because it identifies more clearly the nature of prices used in ICOP.[24]

There are two major steps in deriving production PPPs, as explained by van Ark (1993). First, the average PPP (i.e. UVR) for the industry *j* is obtained by weighting the unit value (*P*) of all matched items (*i=1,2,...m*) belonging to *j* by the corresponding quantity weights of one of the two countries compared, *a* and *b*:

$$(8) \qquad PPP_j^{ab(a)} = \frac{\sum_{i=1}^{m}(P_{ij}^a Q_{ij}^a)}{\sum_{i=1}^{m}(P_{ij}^b Q_{ij}^a)} \text{ and } PPP_j^{ab(b)} = \frac{\sum_{i=1}^{m}(P_{ij}^a Q_{ij}^b)}{\sum_{i=1}^{m}(P_{ij}^b Q_{ij}^b)}.$$

Second, the aggregation of industry-level (*j=1,2,...n*) PPP to branch level (*k*) is made by taking the weighted average of sample industry PPPs using sample industry gross value added (GVA) as weights:

$$(9) \qquad PPP_k^{ab(a)} = \frac{\sum_{j=1}^{n} GVA_{jk}^a}{\sum_{j=1}^{n}[GVA_{jk}^a \; / \; PPP_{jk}^{ab(a)}]} \text{ and}$$

$$PPP_k^{ab(b)} = \frac{\sum_{j=1}^{n}[GVA_{jk}^b \quad PPP_{jk}^{ab(b)}]}{\sum_{j=1}^{n} GVA_{jk}^b}.$$

In bilateral comparisons two PPPs are derived at every level of aggregation, one at quantity weights of country *a* and the other at quantity weights of country *b*.[25] As discussed previously Fisher geometric average is then used to average the two PPPs.

Due to difficulties in obtaining necessary data especially on the unit value of inputs and outputs, fewer studies have attempted to convert China's GDP with the production-PPP approach than an expenditure-PPP approach. The earlier attempt by Taylor (1991) applied only a pseudo production approach.[26] Taylor's estimates are based on gross-value-output and intermediate-input weights to derive overall PPPs. The obvious difference in Taylor's study is that only China's gross output value was used as weight to derive sectoral PPP rather than the weights of both China and the USA being compared, as suggested by the ICOP approach. As pointed out by Ren (1997), another important source of error in Taylor's study is the use of average PPPs of the industrial and agricultural sectors which include most tradeable products to generate PPPs for services which consist of mainly nontradable products. Taylor's estimate of per capita GDP is therefore very low, $788 for 1986, updated by Maddison to $1,135 for 1990 in 1990 G-K dollars (Maddison 1995: 168) (Table 1).

Ren (1997) made a rough ICOP comparison between China and the USA based on Szirmai and Ren (1995) and Ren and Chen (1994). He could not apply a complete ICOP method due to inadequate information.[27] Ren's comparisons fell into four categories in terms of methods used: 1) a standard ICOP method was applied to agriculture, mining, manufacturing, utilities,

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[24] To be consistent throughout this study, PPP is still used here but it refers to UVR in production-PPP comparisons.

[25] If the production structures are very different, as is often the case in a comparison of a low-income country with a high-income country, the PPPs may differ quite significantly, making the Fisher index unrealistic (see later discussion on this issue).

[26] 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 1994b).

[27] Ren's data are mainly from official sources including industrial census data (ONIC 1987-88), industrial statistics (DITS 1993), input-output tables (DBNE and ONIOS 1991), price data USEST (various years) and other macroeconomic data SSB (various years).

transport and telecommunications; 2) reweighted expenditure PPPs were used for the distribution sector (wholesales and retails); 3) quantity-indicator approach was used to derive PPPs for the finance, insurance and real estate sectors; 4) expenditure PPPs were used as proxy for production PPPs for construction, education, health care and government and other services.

Ren estimated that China's per capita GDP based on production PPPs was $886 for 1986 (implying a total GDP of $945 billion). If updated to 1990 following Maddison (1995), per capita GDP would have been $1,484 for 1990 in 1990 G-K dollars, compared with Ren's revised expenditure PPP of $1,699 in the same study (Table 1).

Ren (1997) argued that although the ICP and ICOP approaches have different strengths and weaknesses, in the Chinese case preference might be given to the ICOP estimate over the ICP estimate for the following two reasons. Firstly, Chinese data for manufactured goods from the industrial census used in his ICOP approach estimation are much better than the expenditure data for the final product used in his ICP approach estimation. To maximise reliability, the choice of method for any pair of countries must depend largely on relative quality of industry and final product data for manufacturing goods (Gilbert and Beckerman 1961). Secondly, the breakdown of GDP by industry of origin was based on China's 1987 input-output table and more reliable than the breakdown of GDP from expenditure side based on his own estimates with insufficient information.

Further research with the production PPP approach will be necessary when more detailed census and input-output-table data become available. As Maddison (1995) once pointed out, although China has moved towards a market system it still uses a mixture of controlled and market prices which makes international comparisons of growth and level very difficult. There is therefore a strong case for augmenting the ICP type comparisons by the ICOP method.

Reassessing China's GDP growth rate

Reassessing China's GDP growth rate relies on reliable GDP deflator data. Although China has adopted the SNA guidelines in national accounts, China's State Statistical Bureau has continued to use a non-standard and largely MPS-based approach to measure real GDP growth. In fact, some Chinese official statisticians began to question the reliability of official growth indices early in the late 1980s. The expectation is that the official growth indices have overestimated growth.

In 1989 a study carried out by Industrial Division of SSB Hunan Branch (1989) established an independent industrial index for Hunan Province for 1983-87 showing that the annual real growth rate based on this industrial index (9.2 per cent)[28] was systematically lower than that based on the 'comparable-prices' approach (13.5 per cent). Unfortunately, this study has not had any impact on SSB's practice in computing growth rates.

It is obviously very difficult to construct an independent GDP deflator for China with limited alternative price information. Most ICP and ICOP studies with time series extensions have first focused on benchmark-year estimation and extrapolated the benchmark-year estimates to obtain time series estimates. Such extrapolation is often based on China's official GDP growth indices and inflation rates of the base country. Ren's extrapolation for his ICOP benchmark results produced a GDP growth rate of 7.3 per cent, compared with the official growth rate of 9.8 per cent for the period 1985-94 (see Ren (I) in Table 3).[29]

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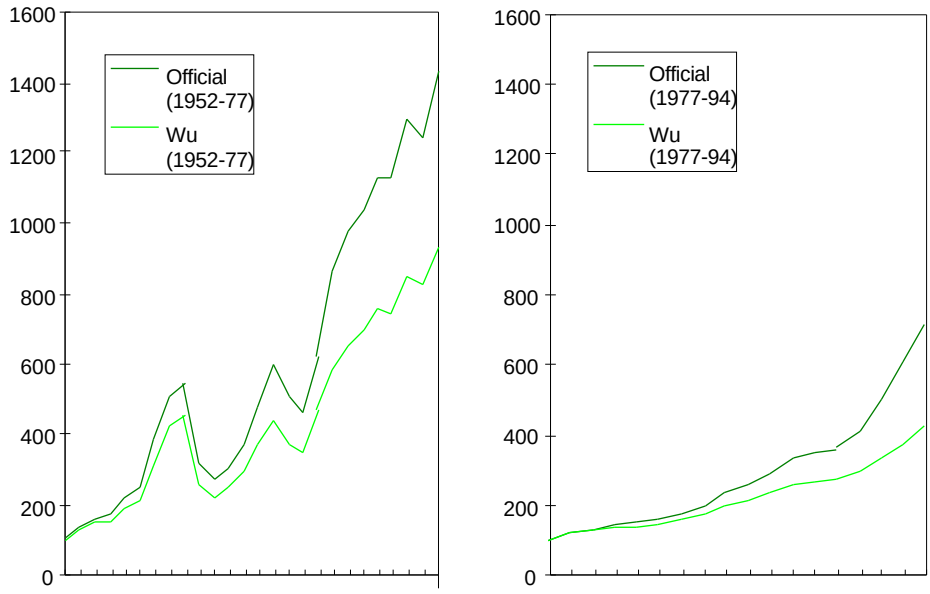
[28] This result is very close to Wu's 9.7 per cent for the nation's industrial sector for the same period (Wu 1997). See discussion below.

[29] By contrast, Ren's extrapolation results for his ICP benchmark estimates imply a growth rate of 8.4 per cent (Ren 1997: Table 5.3). This is not included in our Table 3 because Ren argued that the ICOP estimates were preferable. However, Ren's results look rough as he did not have consistent growth estimates throughout his study with the same extrapolation approach. It seemed that Ren also provided

Figure 1

China's pre- and post-reform industrial growth trends: Wu versus official estimates

(Pre-reform 1952=100; Post-reform 1977=100)



Source: Wu (1997).

Constructing a physical output-based index, as attempted by Wu (1997), might be the only way to obtain an independent deflator, but is only possible for sectors with available time series data on physical output. Based on the physical output of China's industry and the Chinese 1987 Input-Output Table, Wu constructed an independent industrial output index which implies that China's industrial sector[30] grew by 9.1 per cent per annum in 1952-94, compared to SSB's estimate of 11.6 per cent (Figure 1).

Other studies focusing on China's industrial sector have supported the hypothesis that SSB's figures have overstated China's industrial growth. For example, using factory-gate price indices and rebasing official output data on 1990 prices, Woo (1996) obtained an industrial growth rate of 8.7 per cent for the period 1978-93. Based on their ICOP-approach benchmark GDP level estimates and using similar industrial price indices, Szirmai and Ren arrived at an annual rate of industrial growth of 7.4 per cent for the period 1980-92, a revision of their earlier results (Szirmai and Ren 1995). This is closer to Wu's estimate of 7.9 per cent for the same period (Wu 1997),[31] but about one-percentage point lower than Woo's estimate of 8.3

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constant-price growth rate estimates in his Table 5.1 but they were different from those in Table 5.3. If the estimates in Table 5.1 were in current prices, their differences from the constant-price estimates in Table 5.3 suggested very unrealistic underlying inflation rates. Ren gave no explanation to the inconsistencies.

30 The Western concept of 'the industrial sector' which includes mining, utilities and manufacturing, is used here. Unlike the Chinese classification, it excludes logging.

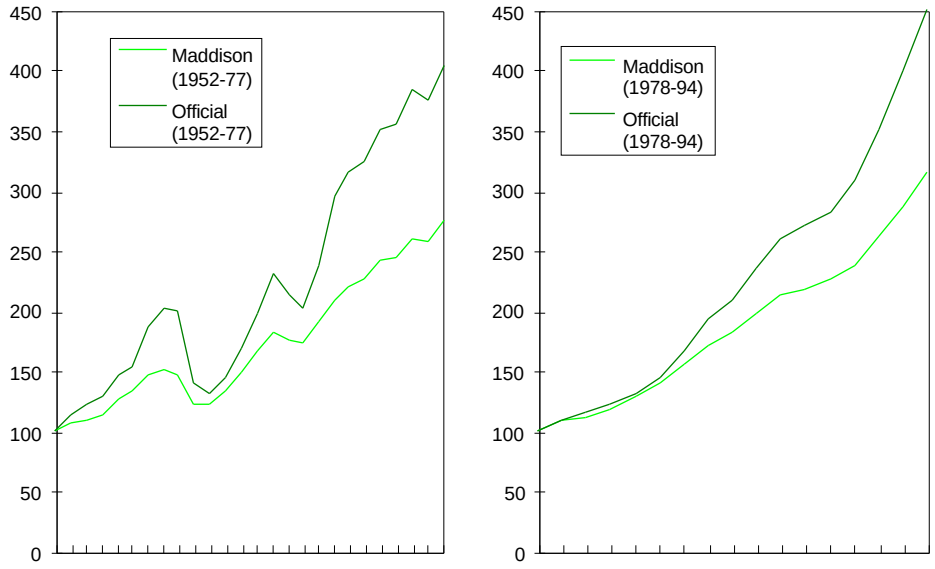
31 Different estimates by Wu and Szirmai-Ren are not surprising because they used different methods and data. However, there is a much larger gap in the estimates of manufacturing growth rates between Wu and Szirmai-Ren (1997), 8.5 against 7.6 per cent per annum than for industry growth rates. The industry sector includes manufacturing plus mining and utilities, which are among the few industries still subject to some price control because they are considered essential for industrial production and urban living. Since there are no particular price indices for the two industries, if overdeflated by an inappropriate deflator (as a proxy), their growth will be underestimated and as will be growth for the industrial sector as a whole.

per cent over this time period. These estimates are all significantly lower than the SSB's growth estimate of 10.9 per cent for these years (SSB 1996: 42).

Figure 2

China's pre- and post-reform growth GDP trends: Maddison versus official estimates

(Pre-reform 1952=100; Post-reform 1978=100)



Source: Maddison (1998: Table C-4) and SSB (1993: 31, 34; 1996: 42)

Maddison forthcoming is the first researcher to reconstruct a GDP time series sector by sector for the period 1952-1994.[32] Wherever possible Maddison used a 'volume movement'-based extrapolation from his benchmark estimates.[33] His final result is obtained by incorporating his own estimates particularly for agriculture and services using the latest available statistical information, with Liu-Yeh's (1965) and Wu's (1997) results based a method compatible to his approach. Maddison's estimated annual growth rate for the pre-reform period 1952-78 is 4.4 per cent against the official 6 per cent, and for the post-reform period 1978-94 is 7.4 per cent against the official 9.8 per cent (Figure 2). Maddison's estimates are based on a defensible methodology and appear reasonably robust. They should be considered more reliable than official and other estimates and the best derived to date. Table 3 gives the comparisons between Maddison's estimates and others' for the period 1985-94.

An alternative approach of reassessing official growth rate is the use of more reliable, preferably independent, deflators to get rid of the 'comparable price' effect. Ren applied three different official price indices, namely, farm and sideline products purchasing price index (FPPPI), industrial products producer price index (IPPPI) and consumer price index (CPI), to the primary, secondary and tertiary sectors, respectively, to derive sectoral GDP growth and hence total GDP growth at constant prices. He arrives at an annual GDP growth rate of only 6 per cent for the period 1985-94 (Ren II, Table 3), lower than his ICOP estimate (7.3 per cent, Ren I, Table 3).

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[32] His other benchmark year estimates for China include 1820, 1890, 1913 and 1933 in 1990 G-K dollars (Maddison 1995).

[33] The 'volume movement' approach is used to remove the influence of real price movement that are not fully reflected by official deflators. For example, Maddison adopted Wu's estimate of industrial output time series this was based on physical output and he also used employment trends for some services.

Although it has been generally accepted that the Chinese official growth deflators have overstated China's real growth, there has been no agreement about the degree of the overstatement. It is therefore difficult to compare different growth rates. However, Ren's alternative estimate might have contained more problems than other estimates. Firstly, two of his sectoral deflators, the FPPPI for the primary sector and the IPPPI for the secondary sector, are in fact state procurement price indices largely for intermediate products which were (and very likely still are) based on 'comparable prices'. This means his approach may still have been influenced by SSB's problematic 'comparable prices'. Secondly, his low growth estimate for the total economy is mainly attributed to his significantly lower growth estimate for the service sector (Table 3), which contradicts evidence of the rapid post-reform growth of China's previously suppressed services in China.

Apart from Ren's alternative estimate (Ren II), all non-official estimates, including Ren's ICOP estimate (Ren I), of China's GDP growth also appear more in line with growth of other countries in the region than do official growth rates (Table 4).

Table 3

Various estimates of China's GDP growth by sector and total economy, and the implied per capita G

(Growth index with previous year=100 and per-annum compound growth rate in per cent)

	Total GDP					Primary		Seconda
	CPI	Maddison	Ren (I)	Ren (II)	SSB	Ren (II)	SSB	Ren (II)
1986	107	107	110	108	109	102	103	112
1987	109	108	108	108	112	103	105	108
1988	105	108	108	106	111	97	102	109
1989	96	102	95	95	104	96	103	93
1990	106	103	106	102	104	122	107	102
1991	113	106	110	111	109	108	102	111
1992	116	109	115	114	114	106	105	120
1993	113	110	104	106	113	105	105	113
1994	108	110	109	104	113	98	104	108
1995	107	--	--	--	111	--	105	--
GDP growth rate (% p.a.):								
1985-1994/95	7.9	7.0	7.3	6.0	9.9	3.9	4.1	8.3
Implied per capita GDP growth (% p.a.):*								
1985-1994/95	6.5	5.6	5.9	4.6	8.4	--	--	--

Source: Derived from Maddison (1998: Table C-4), Ren (Ren (I), 1997: Table 5.3; Ren (II), 1997: Table 4.4), SSB (199

Note: See text for the method used by each study. *The implied the per capita GDP growth is derived from 1.4-pe during the period.

Table 4

Total and per capita GDP growth in 1978-95: China compared with selected East and Southeast Asian countries/economies

(in per cent)

Country/Economy	GDP growth p.a.	Per capita GDP growth p.a.
China (official)	9.9	8.5
China (Ren II, Table 3)	6.0	4.6
China (Maddison 1998)*	7.4	6.0
China (CPI, this study)	7.9	6.5
Hong Kong (China)	6.7	5.0
Taiwan (China)	7.5	6.2
Singapore	7.9	6.5
Republic of Korea	7.7	6.6
Malaysia	7.0	5.5
Thailand	8.1	6.5

Source: Asian Development Bank (1996).

Note: *1978-1994.

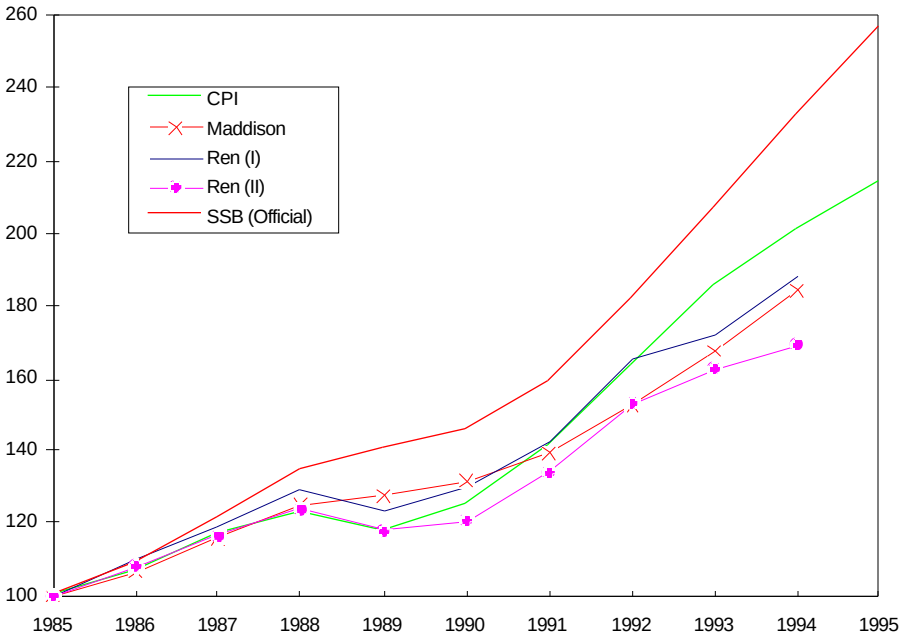
A simple and possibly relatively acceptable approach to deriving China's 'real' GDP growth rate is to use China's official CPI as a single deflator. This is a standard approach that is widely used when there is no appropriate GDP deflator available. This approach gives an annual GDP growth rate of 7.9 per cent (1985-95), standing in the middle range of all estimates in Table 3 between Ren's 6 per cent and SSB's 9.9 per cent. These different growth trends including the CPI approach-based estimate by this study are shown in Figure 3.

It is observed from Figure 3 that Maddison's estimate shows the least fluctuations among all estimates. Ren's two estimates and this study's estimate using CPI follow similar fluctuations though at different levels, suggesting the influence of similar underlying price indices.

Figure 3

China's GDP growth trend by various estimates, 1985-1995

(1985=100)



Source: Table 3.

PPP-based GDP projection

PPP-based GDP estimates for China have made possible internationally comparable projections of China's GDP growth and China's likely relative position in the future world economy. This research area has attracted much attention from politicians and strategists around the world and generated considerable controversy.

GDP growth projections obviously depend on the starting level of PPP-based per capita GDP selected and an annual average expected growth rate of the countries being compared over the projected period. In the past, many such projections mistakenly simply have applied non-PPP growth rates to per capita PPP-estimates. In the case of China, researchers often use China's recent average growth trends, derived from official GDP growth indices which, as discussed above, appear to have exaggerated growth. Generally, the non-PPP growth rate is higher than would be if calculated with PPP-adjusted sector shares because such adjustments reduce the weighting for high-growth-rate industrial sectors (World Bank 1994b). Consequently, the resulting projections exaggerate the future size of the Chinese economy and overstate how soon China will 'catch up' to more developed economies.

Another complex and much debated issue is the possible change in PPP ratios against the base country over time as a country's economy reaches higher levels of economic development. This is because the likely increase in the ratio of tradeables to nontradables as a result of structural change as incomes grow and the growth of productivity adjusted incomes as overall productivity increases. Changes in PPPs may be measured and predicted by the relationship between the PPP-based GDP level to the market exchange rate (MER)-converted GDP level (the PPP-MER ratio) over the income rante that GDP per capita is expected to reach. The difficulty here is that for developing economies it is hard to know what the real MER would be if all restrictions on the exchange rate were removed. This has to be born in mind when interpreting any PPP projection.

Using 1996 WB Development Report data on ER and PPP GDPs (Table 1) it is possible to compare the ratios of PPP to MER GDP per capita of several East Asian countries. For a country like Thailand that has a similar GDP now to that projected for China by 2020 ($2400) this ratio is only slightly lower than China's current ratio (about 3.3) at 2.9. That is, the convergence anticipated theoretically may not in fact occur to any great extent over the relatively low income gap we are talking about ($600 to $2400 MER income pc, $2000 to $9000 PPP income pc). As income levels converge to the US's, this ratio tends to fall to 1. However, Malaysia (with MER GDP of $3480 in 1994) still has a ratio of PPP to MER income of 2.4, and Mauritius at $3150 pc MER income has a ratio of 4.0. Other factors apart from GDP per capita drive convergence, including the openness of the trade regime.

For economies at earlier development stages, real MER will often appreciate as income grows. This has been evident in several Asian developed economies over the last 20-30 years and could be more than compensate for any reduction in PPP measures of GDP.[34] For example, if China's MER is appreciated to 6.6 yuan by 2020 from 8.3 yuan per dollar in 1994, up by 0.86 per cent a year, it would compensate for a 20-per cent-drop in PPP-MER ratio from 3.75 to 3 over the projection period, similar to Thailand's current PPP-MER ratio 2.9.[35] Consequently, while convergence is a reasonable theoretical point, it appears unlikely to be significant empirically over the income levels projected for China in the next 25 years.

Forecasting China's future PPP-based GDP growth is difficult not only because there has been no agreement on the starting level of per capita GDP (Table 1), but also because there has been no agreed PPP-based estimates of China's recent growth trend. As previously demonstrated, PPP estimates for China are all level-estimates focusing on benchmark periods and most PPP growth estimates are extrapolated based on Chinese official growth rates and price indices, and the base country (the US) inflation rates. Compared with Ren (1997) who only has one benchmark (1985/86) level-estimates, Maddison (1998) has more benchmark estimates for all major sectors of a much longer period of Chinese history (1890-1994); with benchmark year 1952, 1957, 1978, 1987 and 1994 for the post-1949 period. As a result Maddison's GDP growth estimates are probably more realistic than other estimates.

The recent EAAU PPP-based GDP projection for China (EAAU 1997), three alternative starting estimates of per capita GDP in 1994 international dollars, an upper bound $2,500, middle range $2,000 and lower bound $1,500 based on the range of recent estimates (Table 1).[36] It applied three alternative growth rate scenarios, 6, 7 and 8 per cent per annum to each of these starting levels. The US starting level of per capita GDP is $25,880 for 1994 also in 1994 prices (World Bank 1996: 189) and the US growth rate is 2.7 per cent per annum as experienced between 1973 and 1994 (Maddison 1995: Table B10-a).

This analysis makes several simplifying assumptions including that: over the projection period the gap between the exchange rate and PPP exchange rate will remain constant as income rises; the real exchange rate will not appreciate; and the economic and political environment in both countries will remain unchanged.

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34 For example, from 1969 to 1989, the Japanese yen appreciated by 161 per cent from ¥360 per US dollar to ¥138 per US dollar, and the Singapore dollar appreciated by 157 per cent from S$3.06 to S$1.95 per US dollar (World Bank 1991).

35 In 1994 yuan, China's per capita GDP was 4,399 yuan, or 5,237 billion yuan for 1994. If growing by 7 per cent per annum China's total GDP will be 30,415 billion yuan by 2020, or 19,879 yuan per capita, equal to MER-based PPP of $3,012 at $1=6.6 yuan, compared to $2,395 at $1=8.3 yuan. Multiplied by a PPP-MER ratio of 3, the MER-based PPP $3,012 will be converted to a PPP-based GDP $9,036, the same as the result derived from the previous MER ($1=8.3) and PPP-MER ratio (3.75).

36 Estimates in Table 1 are in 1990 prices. To change them to 1994 prices, one has to apply a US GDP deflator for 1990-4, 1.122 (OECD 1997), which means that the $2,000 middle-range GDP level in 1994 prices represents almost $1,800 in 1990 prices.

Table 5

EAAU's projection for China and US GDP levels in 1994-2020, alternative starting level of per capita GDP and growth rate scenarios

(Total GDP in trillion 1994 international dollars)

	US GDP	Chinese PPP-based GDP starting at								
	$25,880 per capita	$2,500 per capita			$2,000 per capita			$1,500 per capita		
	2.7%	8%	7%	6%	8%	7%	6%	8%	7%	6%
1994	6.7	3.0	3.0	3.0	2.4	2.4	2.4	1.8	1.8	1.8
2000	7.9	4.7	4.5	4.2	3.8	3.6	3.4	2.8	2.7	2.5
2005	9.0	6.9	6.3	5.7	5.6	5.0	4.5	4.2	3.8	3.4
2010	10.3	10.2	8.8	7.6	8.2	7.0	6.1	6.1	5.3	4.5
2015	11.8	15.0	12.3	10.1	12.0	9.9	8.1	9.0	7.4	6.1
2020	13.5	22.0	17.3	13.5	17.6	13.8	10.8	13.2	10.4	8.1

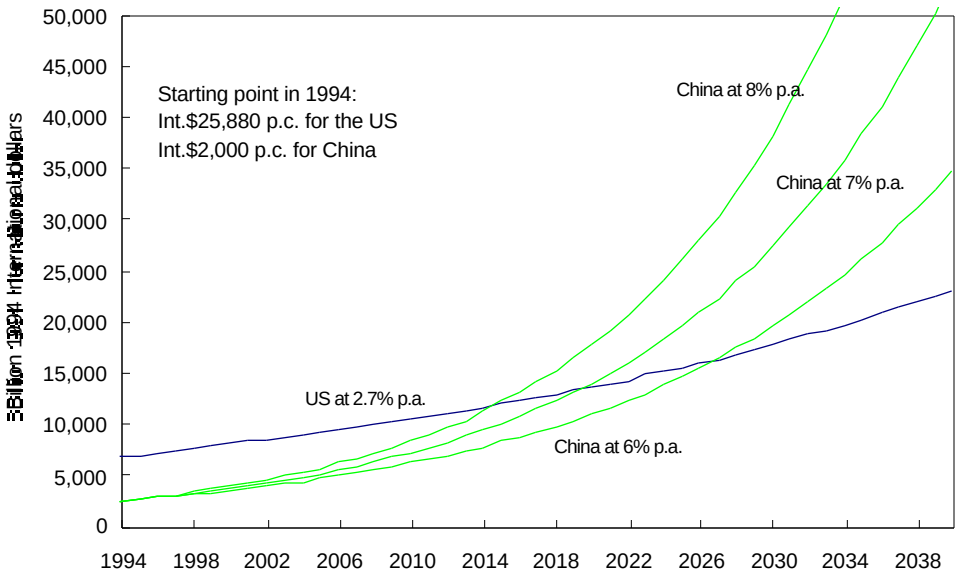
Source: EAAU (1997).

The results are reported in Table 5 and the estimates for the middle-range starting level are graphed in Figure 4. The prediction results of the 7-per cent growth scenario show that by 2020 the GDP of the Chinese economy ($13,833 billion, in 1994 dollars) will overtake the GDP of the US economy ($13,482 billion). This also means that by 2020 China's per capita PPP GDP will be around $9,000 (with a predicted population of 1.53 billion by 2020) and the US's per capita GDP will be about $43,000 (with a predicted population of 312 million by 2020), compared with $2,000 (the middle range) and $25,880 in 1994 (World Bank 1996a). Over the projected period 1994-2020, Chinese per capita GDP would rise by 5.9 per cent annually, from 8 to 21 per cent of the US level. Such annual per capita GDP growth is compatible with the experiences of other East Asian countries (Table 4).

Figure 4

Projected Chinese and US PPP-based total GDP growth, 1994-2040

(Billion 1994 International dollars)



Source: EAAU (1997: Figure 1.24)

Assuming the official exchange rate (MER) $1=8.3 yuan will remain unchanged and all other assumptions hold, a calculation using the $530 exchange rate-based per capita GDP in 1994 and the 7-per cent growth scenario arrives at a total GDP of $3,666 billion by 2020, implying a per capita GDP of about $2,400, the same as Thailand's current level of exchange rate-based per capita GDP (World Bank 1996a).

Given China's low per capita income and the fact this will be only about Thailand's current level in exchange rate terms by 2020, continuing reform commitment and other underlying characteristics of the economy - high savings, abundant labour, outward oriented economy, high FDI inflows, etc., 6-8 per cent growth is a reasonable forecast. Slower growth (e.g. Japan) often comes at a much higher income level than this. In fact, prior to the 1997 currency realignment most East Asian economies were still achieving 6-8 per cent annual growth (Table 4), even though some of the economies (e.g. Hong Kong and Singapore) have reached the income level of current developed economies.

Deficiencies of the PPP approaches in measuring China's GDP

Despite their obvious advantage over the MER-based income comparison technique, both expenditure-PPP and production-PPP methods have several practical and theoretical shortcomings and problems. Unlike the straightforward MER approach, the PPP methods rely heavily on individual item-level output, value and price data which are not always available in developing countries.

Compared with the expenditure-PPP approach, the production-PPP approach relies on even more detailed statistics on products and services. For this reason there are no complete PPP estimates for China using the standard ICOP approach.

Another common problem of the two PPP approaches is the conventional method of obtaining PPP converters. Each country in a PPP comparison has a different pattern of expenditure weights (ICP) or production weights (ICOP). Using PPP ratios to compare two economies such as China and the US thus requires deciding which country's weights should be used to average individual sector PPP ratios. Conceptually, one should use yuan-based Chinese weights for calculating the cost of Chinese expenditures or products in dollars, and dollar-based US weights for calculating the cost of US expenditure or products in yuan. However, the convention is that two sets of PPPs are calculated for China, one using Chinese weights (Paasche PPPs) and one using US weights (Laspeyres PPPs), respectively, and then a geometric mean (Fisher index) is used to average the two sets of PPPs. Therefore, US weights become part of the conversion of Chinese GDP to dollars.

The purpose of a geometric mean of the two differently weighted PPPs is to come up with a neutral statistic to compare each currency's purchasing power. It is not surprising that the difference between the Paasche and Laspeyres PPPs varies between countries across branches of the economy under investigation. However, 'the gap between the two measures is generally widest for comparisons between countries with very different income or productivity levels' (Maddison and van Ark 1994). In such cases, a geometric-mean of the two PPPs is likely to produce unrealistic averages. The World Bank study (1994b) also argued that while the geometric mean averaging may have a moderating effect on all developing countries' PPP estimates in dollars, it may do this to an unusual degree for China, either because of the large dispersion of the sample-item price ratios, or because Chinese and US final expenditure weights and production structures are so different.

Obviously, compared with countries like the US, China has a very different economic structure, productivity and income level. The differences are not only due to the different stages of economic development but also price distortions inherited from the central planning period, even though most products have been freed from price controls since the reform. The World Bank study (1994b) believes that by including US weights through the geometric mean technique, China's PPP dollar estimates have been biased significantly[37].

Another major challenge facing all PPP comparisons which is crucial to PPP estimates for China is how to overcome quality-matching difficulties between countries like China and the US. Quality-matching problems exist in both the production-PPP and expenditure-PPP approaches. Usually, the quality of products of a heterogeneous nature (such as machinery and vehicles) are more difficult to match than products of a homogenous nature (such as power cables, vitamin tablets and non-ferrous ingots). Exported products are understandably less problematic in quality-matching than products not for export, as their quality is already 'measured' by the world market.

The World Bank study (1994b) pointed out that in previous ICP (e.g. Ren and Chen 1994) and non-ICP (e.g. Taylor 1991) studies, most price data were from official price lists in China and the US, although products on the US list were virtually certain to be of higher quality than products with the same name on the Chinese list. Calculating a PPP ratio from such prices without necessary adjustment for quality inevitably would lead to an upward-biased dollar PPP GDP estimate for China.

Studies like Chen-Ren's often followed an 'equivalence in use' rule in quality-matching exercise, which means that items were matched if they served the same basic function, even if they were are not of the same quality (Chen and Ren 1994: 382). In the case of food this practice ignores the better quality of many foods products in the USA and the much greater degree of packaging and processing, and for furniture it ignores enormous price variation with quality and style between the two countries and the fact that furniture in the US is generally

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[37] If we believe remaining price controls in China tend to lower prices below their market level, PPP estimates for China using the Fisher geometric mean technique will be upwards biased. However, the final PPP converter is a result of several stages of aggregation in which upward-bias and downward bias could offset each other.

much higher quality than in China. These factors result in a higher dollar price than would otherwise be the case for an identical Chinese equivalent, thereby resulting in PPP ratios which exaggerate China's PPP-based GDP estimates.

Most existing problems are practical rather than theoretical. Solving these problems requires on more reliable data from the expected ICP-type expenditure survey in China which is believed to be under preparation by the SSB. Meanwhile it would be useful if China could establish standard GDP national accounts by expenditure type.[38] As for the ICOP type of research, the newly completed first national census on the tertiary sector conducted in 1992 and the third national census on the industrial sector conducted in 1995 could upgrade the current estimates significantly once their electronic database become available. Another issue which is methodologically important is how to assure comparability of these surveys with those for other countries. It could be useful if Western researchers become involved in China's statistical surveys at an early stage through design and training. This could be facilitated by the national accounts and statistical sections of UN, the World Bank and OECD allocating more resources for this purpose.

Conclusions and implications

This study has reviewed recent research designed to improve the measurement of the level and growth of China's national income on an internationally comparable basis. Drawing policy implications from the analysis, a major concern is whether PPP-based GDP estimates change conventional views and judgements about China and its role in the world economy.

Living standard

The primary purpose of the PPP-based income comparison is to evaluate a nation's real standard of living by measuring the local purchasing power of the national currency on an internationally comparable basis. For low-income countries like China, the PPP-based per capita GDP is generally higher than the exchange rate-based per capita GDP measurement mainly because labour (adjusted for productivity) is cheaper in these countries than in high-income countries. Although new and different PPP-based GDP estimates may add confusion to already controversial estimates, continuously improved data and estimation techniques are moving estimates closer to the reality. The result is that the Chinese per capita GDP level is probably no more than $2,000 (in 1990 international dollars), much lower than was previously believed.

The lower PPP-based GDP estimates for China imply lower living standards. For example, following recently accepted per capita ICP-PPP $1,800 for 1992 (World Bank - East Asia & Pacific Region 1996), or about $1,500 for 1990 in 1990 prices,[39] which is only about half of the estimate by Summers and Heston in the early 1990s (PWT 5.5), the World Bank has substantially altered its poverty assessment for China. The lower estimate of per capita income resulted in a near tripling of the World Bank's estimate of the percentage of China's population living under the international poverty line US$1 per day (in 1985 prices).[40] By this international yardstick, China's poverty incidence is now estimated to be 27 per cent in 1994

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38 SSB began to calculate SNA expenditures and report highly aggregated data on GDP by expenditures in 1995 (see SSB 1995: 36-8; 1996: 46-8), shifting away from MPS expenditure statistics. There has been, however, no regular and detailed report on SNA standard national accounts by expenditures.

39 If extrapolated back to 1990 using Maddison's growth rate (Table 3) and converted to 1990 dollars, the level would be close to $1,500.

40 US$1 a day (1985 prices) is an international poverty threshold set by the World Bank using PPP conversion rates (World Bank - East Asia & Pacific Region 1996: Box 3).

(compared to 7 per cent if old measurement is used), down only marginally from 32 per cent in 1987 (World Bank 1996b: Box 1.1).[41]

Obviously, more reliable forecasts of future living standards depend on more reliable measurement of China's current national income and past growth. The new, lower estimates of China's income level and growth more accurately reflect the reality and have prolonged the interval necessary for China to catch up with advanced countries.

Total factor productivity (TFP) performance

Total factor productivity (TFP) growth measures the growth in output unrelated to the growth in inputs and hence is one measure of efficiency performance of an economy. As TFP growth is measured as a residual after subtracting the contribution of input growth to GDP growth, to the extent that China's GDP growth is overstated on account of insufficient deflation of output, China's TFP would be similarly overestimated, assuming that capital and labour are accurately measured. Remeasured growth would therefore alter the estimates for TFP performance - a lower GDP growth could mean a poorer TFP growth.

Woo (1996) decomposed China's TFP growth into labour reallocation effect and net TFP effect, after correcting for the overstatement of industrial output and inconsistent use of base years in calculating growth deflators. He calculated the labour reallocation effect to be about 1.1 percentage point and net TFP growth to be between 1.1 and 1.3 percentage points for the post-reform period (1979-93). Assuming his calculations for capital and labour inputs are accurate, even one percentage-point adjustment to GDP growth measurement would significantly alter China's TFP estimate as shown in Table 6.

Using Maddison's estimates to further correct GDP growth and allowing the residual to mainly explain resource reallocation effect, there may be little room left for net TFP growth in the post-reform Chinese economy.[42] This could possibly be close to the reality because the labour reallocation effect in China reflects the existence of large amount of labour employed in low-productivity agriculture and the success of the post-1978 reforms in creating higher-productivity jobs in the industry and service sectors (Woo 1996). If this is in fact the case, it implies that China's economic growth has been largely extensive in nature with little true technological progress[43]. This result should alarm any optimistic prediction for China's future growth as any sustainable growth will only be dependent on efficiency improvement rather than input growth, which requires a switch from extensive to intensive growth path.

Table 6

Woo's decomposed China's TFP performance after corrected for overstated growth, further adjusted by Maddison's growth rates

(Percentage point per annum)

Decomposition of GDP growth	1978-93	1984-93
Official GDP growth rate	9.3	9.7

41 Poverty incidence refers to the percentage of the population living below the poverty line. Note the altered estimate of poverty incidence for China is also a result of abandoning the official line of 60 cents a day and shifting from 'income' to 'consumption' criterion as consumption is considered a better and more reliable indicator of welfare than income because it measures more accurately and reflects households' ability to buffer their standard of living through saving and borrowing, despite income fluctuations (World Bank - East Asia $ Pacific Region 1996).

42 See Woo (1996) for more detailed discussion of decomposition of TFP growth into labour reallocation effect and net TFP growth that contains technological improvements.

43 This fits with micro level analysis of TFP growth in China. Perkins et al (1994) which shows that China's state sector experienced little or no TFP growth over the reform period and only the non-state sector, particularly foreign funded enterprises experienced significant TFP growth.

- Corrected for inconsistent use of base years	*0.2*	*0.3*
- Corrected for overstatement of industrial output	*0.5 ~ 0.7*	*0.9 ~ 1.2*
'Corrected' GDP growth rate	8.4 ~ 8.6	8.2 ~ 8.5
GDP explained by Input growth	6.2	6.6
Contribution from:		
- Capital accumulation	*4.9*	*5.5*
- Labour force growth	*1.3*	*1.1*
Overall TFP growth rate	2.2 ~ 2.4	1.6 ~ 1.9
- Labour reallocation effect	*1.1*	*1.3*
- Net TFP growth	*1.1 ~ 1.3*	*0.3 ~ 0.6*
GDP growth remeasured by Maddison (1998)	7.3	7.1
Derived overall TFP growth using Maddison (1998)	1.1	0.5

Source: Woo (1996) and Maddison (1998).

Comparative productivity

The PPP-based measures of GDP have also enabled international comparison of productivity and increased the accuracy of such estimates. Labour productivity is one important indicator for an economy's growth potential. Table 7 compares Maddison's estimates (1995) of China's labour productivity performance based on ICP-PPPs with some of its Asian neighbours and selected advanced countries for the period 1973-92. Even though China's labour productivity per hour grew at an above-average rate of 3.7 per cent per year from 1973 to 1992, in 1992 it was still the second lowest of the economies compared. While its labour productivity was higher than India's, it was only 33 per cent that of the Republic of Korea, 25 per cent of Taiwan's, 50 per cent of Russia's, 64 per cent of Thailand's, 83 per cent of Indonesia's and about 10 to 15 per cent of the labour productivity of the advanced economies of the USA, the United Kingdom, Japan and Australia. This labour productivity gap between China and developed countries implies that China has huge growth potential if it continues to pursue appropriate economic policies.

Table 7

Labour productivity in China and selected countries/economies, ICP-PPP based estimation

Country/Economy	ICP-PPP GDP per hour worked (1990 international dollars)				Labour productivity growth (per cent per year)		
	1950	1973	1992	Rank by 1992	1950–73	1973–92	Rank by 1973–92
United States	12.66	23.45	29.10	1	2.72	1.03	10
United Kingdom	7.86	15.92	23.98	2	3.12	1.97	8
Australia	8.68	16.87	22.56	3	2.93	1.39	9
Japan	2.03	11.15	20.02	4	7.69	2.83	6
Taiwan (China)	1.17	4.13	11.06	5	5.64	4.80	2
Republic of Korea	1.28	3.22	8.48	6	4.09	4.72	3
USSR/Russia	3.07	6.59	5.66	7	3.38	-0.72	11
Thailand	0.74	1.68	4.34	8	3.63	5.12	1
Indonesia	1.02	1.86	3.35	9	2.65	3.15	5
China	0.82	1.31	2.79	10	2.06	3.67	4
India	0.60	0.94	1.58	11	1.97	2.50	7

Source: Estimates made with data derived from Maddison (1995, Table J-5).

Compared with other economic sectors manufacturing often plays a more important role in the process of a country's development and therefore productivity performance in manufacturing is crucial to a country's income growth. Although in *absolute terms*, China's manufacturing labour productivity, measured by value added per employer, grew by 5.5 per cent per annum between 1978 and 1994 (Wu 1997), Szirmai-Ren (1997) international comparisons based on ICOP-PPP estimates found that in *relative terms*, China's manufacturing labour productivity stagnated during the reform period. They found that only 4 of 14 manufacturing branches (food and beverages, tobacco, wearing apparel, non-metallic mineral products) experienced positive labour productivity growth relative to the US, 6 of them declined and 3 virtually stagnated (Table 8).

Table 8

Production PPP-based comparative labour productivity by manufacturing branch, China against the USA, 1980-1992

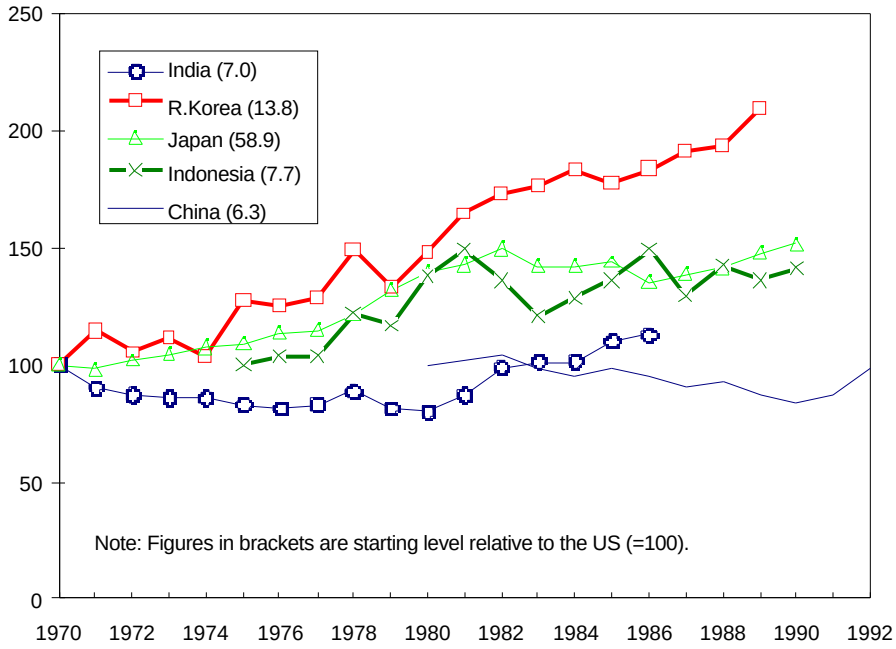
Manufacturing Branch	Comparative labour productivity China/USA, USA=100		
	1980	1992	Annual growth 1980-92 (%)
Food products and beverages	6.2	8.2	+2.36
Tobacco products	8.2	26.3	+10.20
Textile mill products	12.4	7.0	-4.65
Wearing apparel	7.1	8.9	+1.90
Leather products and footwear	15.9	12.2	-2.18
Wood products, furniture and fixtures	4.9	4.3	-1.08
Paper products, printing and publishing	3.9	4.1	+0.42
Chemicals, petroleum & coal products	7.9	6.3	-1.87
Rubber and plastic products	7.6	5.7	-2.37
Building & non-metallic mineral products	7.4	8.7	+1.36
Basic and fabricated metal products	11.7	11.9	+0.14
Machinery & transport equipment	3.3	3.7	+0.96
Electrical machinery & equipment	9.6	10.4	+0.67
Other manufacturing	4.8	3.7	-2.15
Total manufacturing	6.3	6.2	-0.13

Source: Derived from Szirmai and Ren (1997: Table 7).

Based on these findings, they argued strongly that the post-reform China's manufacturing has featured 'rapid growth without catch-up' (Figure 5). Although this conclusion needs further justification through refined measurement using more accurate information, it may explain the rapid post-reform growth of small rural-based, labour-intensive manufacturing enterprises (TVEs) and the poor performance of SOEs.

Figure 5

Growth index of manufacturing labour productivity on PPP basis, relative position to the US



Source: Derived from Szirmai and Ren (1997: Table 8).

Degree of openness

The trade dependency ratio - trade divided by total GDP, is often used to reflect the openness of an economy. The measurement of the GDP denominator is important. Obviously, the ratio will be substantially lowered by shifting from a MER-based to a PPP-based mreasurs of GDP. Researchers such as Lardy (1994) have pointed out that China's trade dependence ratio is too high because GDP is not properly measured of a MER is used to convert it to US dollars.[44]

If measured on MER basis, China's exports-to-GDP ratio is 21 per cent for 1995 (SSB 1996: 579). By contrast, the same ratio for the US is only 8 per cent (OECD 1997: 62-6).

Based on PPP estimates of China's GDP, Ren (1997: 13) estimated the trade dependency ratio was about 6 per cent in 1994, (using a numerator of half of the sum of exports and imports) Ren argued that the conventional exchange rate-based trade dependency ratio was 23 per cent gave a unrealistic picture of a very open Chinese economy.

However, this approach does not completely solve the problem. Conceptually, the value of trade can only be measured at the market exchange rate, which reflects the yuan's international purchasing power, but this is inconsistent with the PPP-measured GDP in the denominator. On the other hand, if the value of trade is measured by PPPs (i.e. increasing the value of the yuan relative to the dollar), it will unrealistically inflate the value of the yuan in the international

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44 There is also no agreement among economists on what should be used as 'trade': exports, imports, sum of the total (exports and imports) or half of the total. The ratio of exports to total GDP is preferable as it reflects an economy's ability to pay for imports through exports to the world market.

market and also make this ratio unmeaningful. Obviously, more work is needed in this area before any consensus can be reached among researchers.

International versus domestic purchasing power

Our review shows that even with the lowest PPP-conversion China's GDP (in international dollars) is 300 per cent higher than the MER-converted GDP level. However, this cannot be, interpreted as an increase in China's economic power in the world market, or its power to purchase technology, machinery and weaponry from foreign countries. The PPP-based GDP only indicates that the Chinese people's standard of living, measured by the renminbi's domestic market purchasing power, is higher than indicated by its exchange rate in the world market, and gives a better indication of the renminbi's purchasing power in internationally comparable terms.

The more realistic PPP measurement of China's standard of living will also have some commercial significance for foreign investors aiming at China's domestic market and employing domestic resources, especially human resources.

Future increases in the international purchasing power of the renminbi will depend on increases in China's productivity and hence competitiveness in international trade. As productivity rises, incomes will rise and the gap between PPP and MER measures of income will decline, eventually resulting in a convergence of the renminbi's domestic and international purchasing power.

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Abbreviations

CPEs	Centrally Planned Economies
CPI	Consumer Price Index
FPPPI	Farm Products Purchasing Price Index
GDP	Gross Domestic Product
GNP	Gross National Product
GVA	Gross Value Added
GVO	Gross Value of Output (MPS concept)
ICOP	International Comparison of Output and Productivity project at University of Groningen, The Netherlands
ICP	United Nations International Comparison Project
IPPPI	Industrial Products Producer Price Index
MER	Market Exchange Rate
MPS	Material Product System
NMP	Net Material Product (MPS concept)
NVA	Net Value Added
NVO	Net Value of Output (MPS concept)
PPCs	Purchasing Power of Currencies
PPPs	Purchasing Power Parities
PWT	Penn World Tables (reporting main results of ICP)
SNA	United Nations System of National Accounts
SOEs	State Owned Enterprises
SSB	China's State Statistical Bureau
TFP	Total Factor Productivity
TVEs	Township-Village Enterprises, also refers to all rural enterprises
UVRs	Unit Value Ratios
WDR	The World Bank *World Development Report*