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CHINA'S GDP LEVEL AND GROWTH PERFORMANCE: ALTERNATIVE ESTIMATES AND THE IMPLICATIONS

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This study critically evaluates alternative estimates of China's GDP level and growth, as well as its PPP GDP conversions, and, based on this evaluation, it draws important implications for the understanding of China's economic performance in both historical and international perspectives. It finds that although almost all empirical results have supported the downward-bias hypothesis for China's GDP level and the upward-bias hypothesis for China's GDP growth, they vary greatly, and that PPP estimates for China are also diversified. These estimates, if accepted, may substantially alter the existing views on the Chinese economy, particularly, its size, TFP level and catch-up performance. The discussion focuses on the theories, methodologies and data used in these studies, and particularly, the possible biases in their results thereby. It argues, however, that despite differences in estimates, they could still provide sensible boundaries for researchers to gauge the "real" values and hence assess China's "real" living standard and growth performance.

INTRODUCTION

As the Chinese economy rapidly develops and integrates into the world economy, the importance of correctly measuring China's economic performance is difficult to exaggerate. A reliable output measurement is also vital for the correct assessment of China's sources of growth, a foundation for understanding the Chinese model of economic transition from a centrally-planned to a market-oriented system. Although China in principle fully switched to the internationally adopted system of national accounts (SNA) in 1992, its statistical practice is still seriously influenced by the old material product system (MPS), which has affected output measurement. Institutional factors, such as heavy government involvement in business and administratively managed data reporting system, are still producing distorted incentives for economic agents as well as local officials to exaggerate output performance and hide problems when reporting data to the authorities.

With a growing interest in a reliable and internationally comparable measure of China's real GDP level and its growth, new estimates have appeared in attempt to challenge official estimates. Although studies have generally accepted that China's GDP level has been understated and China's GDP growth rate has been overstated, there has been no agreement as to what extent and by what approach official estimates should be adjusted.

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This paper attempts to critically evaluate alternative estimates of China's GDP level and growth rate that are made by different approaches, and discusses important implications of these estimates for the understanding of China's economic performance in both historical and international perspectives. It is organised in 6 sections. Section II discusses the downward-bias hypotheses for China's official GDP level estimates and reviews the studies attempting to reconstruct China's GDP. Section III discusses the upward-bias hypotheses for China's official growth rate and evaluates alternative estimates. Section IV reviews the studies attempting to measure China's per capita GDP by purchasing power parities (PPPs) and discusses the properties and deficiencies of the PPP approach for China. Based on the above discussions Section V draws implications for the understanding of China's economic performance. Finally, Section VI gives concluding observations.

II. Reconstructing China's GDP

The Downward-Bias Hypotheses for China's Official GDP

Two major hypotheses have been put forward to explain why China's official GDP estimates are likely to contain downward biases. The first one is based on the observation of the scope deficiencies of China's statistical system that tends to underreport output, or the *undercoverage effect*. In general, due to the long influence of MPS China's statistical system naturally undercounts the contribution of services, especially those that are considered "nonmaterial" and hence "nonproductive" (Appendix A). This system also tends to underreport income or expenditure items that are in kind or whose transactions are not usually made through the market. As suggested by many studies (e.g. Maddison, 1998; World Bank, 1994b and 1992b; Keidel, 1992) both rural and urban housing, personal services, self consumption of output (e.g. grains), welfare benefits in kind, as well as the production of the defence industry are likely underreported. It is reasonable to believe that despite the adoption of SNA in 1992 this system is not yet ready to cope with the shift and still affected by the old MPS in various aspects.

The economic reform began in 1978 have not only worsened but also complicated the underreporting problem. On one hand, the largely unreformed, administratively managed data collection system is incapable to sufficiently cover production activities in the emerging non-state sector, especially those by farm households and rural enterprises. This is because these activities are outside the state planning and administrative controls and these enterprises have incentives to underreport their output to avoid high tax obligations. On the other hand, local officials have strong political incentives to exaggerate the output of local non-state sectors in order to please their supervisory authorities and therefore to enhance their career prospects. The direction of the net effect is an empirical question. While some studies (World Bank, 1994b) argue that it is reasonable to believe that the net effect is underreporting, Xu maintains that as revealed by China's third industrial census, the overreporting problem should be more severe for small-sized rural enterprises (1999, p. 245).

The second hypothesis is based on the *price distortion effect*. Like most centrally-planned economies, China used to overprice industrial products and underprice agricultural products and services in order to shift resources to heavy industries. Despite significant price reforms China's price system to some extent continues to result in higher prices for some manufactured goods and lower prices for rural commodities, placing an implicit tax on rural incomes and subsidising urban profits, wages and urban necessities, such as urban housing (Maddison, 1998). This is supported by macroeconomic statistics. A World Bank study has found that the statistical consequence of the price policy is very high industrial profits, very low or negative service profits and low rate of return to capital stock and land in rural areas (World Bank, 1994b). It is argued that the net effect of such price distortions has substantially undervalued China's GDP.

Nevertheless, it should be clear that there can be no "correct" estimate of to what extent China's official GDP figures are downward biased, and that it is impossible for one to separate the undercoverage effect and the price distortion effect upon China's GDP.

Studies Attempting to Reconstruct China's GDP

Since the first estimate of the Chinese national accounts for the period 1931–36 led by Ou after the defeat of Japanese in 1945 (Ou, 1947), officially there was not any GDP estimate for the Chinese mainland for about four decades. Estimates by the Western economists appeared mainly in the end of 1950s through the early 1970s, largely based on Ou's work plus very limited, irregular official statistics. Liu and Yeh (1965) and Chao (1965), among others,[1] did the most important pioneer work for the 1950s. Quantitative research work gradually petered out in the 1970s because the Chinese authorities stopped publishing systematic statistical data during the 1960s and 1970s.[2] Following the economic reform that began in 1978, China's State Statistical Bureau (SSB) published its first GDP estimates in 1988, largely based on its first SNA-type input-output table for 1987, with retrospective estimates back to 1978. Based on the official GDP estimates for 1978–90, Wu (1993) made the first attempt to reconstruct China's GDP for 1952–77. Later in 1997 SSB and Institute of Economic Research at Hitotsubashi University jointly issued a new set of GDP estimates that covered the entire period 1952–95 (SSB and Hitotsubashi, 1997).

Although all these studies follow the basic concepts of SNA, they have different objectives. For example, the effort made by Liu and Yeh (1965) is mainly to fill the gaps in official output data using indirect information, Wu (1993) bases his retrospective estimates on the relationship between GDP and NMP (net material product of MPS) at sectoral level by an econometric model, while the SSB-Hitotsubashi study (1997) mainly rearranges the existing MPS-style national

[1]For example, Hollister (1959), Chon-ming Li (1959), Eckstein (1961 and 1973), Field (1980), Perkins (1975 and 1980), and Ashbrook (1972).

[2]During the 1970s, the U.S. Central Intelligence Agency (CIA) carried out some work attempting to reconstruct Chinese industrial growth independently. However, 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 U.S. Congress in 1972, 1975, 1978 and 1982.

accounts items into the SNA framework according to the "concrete differences" between the two systems. Despite the obvious advantage in having access to raw data the SSB-Hitotsubashi estimates for the 1950s are surprisingly similar to those of the Liu-Yeh study that rely on much guesswork. Wu's estimates are, however, much higher than both their results. Taking the current-price estimate for 1957 as an example, it is 105.1 and 106.8 billion yuan in Liu-Yeh and SSB-Hitotsubashi, respectively, but 126 billion yuan in Wu. It is difficult to explain the difference without necessary information. While both Liu-Yeh and SSB-Hitotsubashi results might have underestimated GDP due to no adjustment for price distortions, the overall effect of possible problems in Wu's estimates is not so clear. On one hand, Wu's estimates might also have understated GDP because the official GDP data that he uses to estimate the GDP-NMP relationship contain downward bias. On the other hand, his results might have overestimated GDP for the pre-reform period because his calculation is based on the relationship estimated for the post-reform period (1978–90). However, it may be reasonable to argue that the estimates of Liu-Yeh and SSB-Hitotsubashi could serve as the lower bound and Wu's the upper bound for gauging the "real" GDP level in the 1950s.

An extensive national account adjustment aimed at removing all price "distortions" was first attempted by Keidel in 1992.[3] Keidel's latest revision has raised Chinese GDP for 1987 by 34.3 percent (i.e. to 1,606 billion yuan from the official 1,196 billion yuan) (World Bank, 1994b), down from his earlier 55 percent upward adjustment (Keidel, 1992). The 34.3 percent increase in yuan GDP is a combined effect of adjustments for statistical shortcomings (scope adjustment plus a minor consistency adjustment) of 13.6 percent and price distortions (valuation adjustment) of 18.3 percent (note that $1.136*1.183 = 1.343$).

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 transitional economies. For example, to adjust price distortion he re-estimates profit rates in all sectors to reflect a more uniform rate of return to productive assets and land, assuming resources could have moved freely. 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, p. 153), for a huge, very self-contained economy, which had only half emerged from central planning (especially in the late 1980s), 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. Moreover, 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.

Another problem is that, without strong assumptions, such a single-year level adjustment is difficult to extend to other years in the past, especially over the long run when both the undercoverage and price distortion problems changed and thus the extent to which output estimates were biased also tended to change.

[3]The World Bank China Report No. 13580-CHA (1994b) was prepared by Keidel and was an extension of Keidel's initial work in 1992.

Maddison (1998) has also made an attempt to reconstruct China's GDP for 1987. He mainly adjusts agricultural and "non-productive" service output for possible scope deficiencies rather than for undervaluation. For industrial output he adopts the estimates by Wu (1997). For construction, transportation and telecommunication, commerce and restaurants he adopts the estimates in SSB-Hitotsubashi (1997). His results have raised China's GDP by 10.3 percent for 1987 to 1,319 billion yuan (from the official 1,196 billion).

III. Reassessing China's GDP Growth Rate

The Upward-Bias Hypotheses for China's GDP Growth

Two major hypotheses have been put forward to explain why China's GDP growth rate might have been exaggerated. The first one is based on *the under-deflation effect* due to China's practice of the Soviet-style "comparable price" system adopted in constructing GDP deflators in the early 1950s (Maddison, 1998; Woo, 1996; Rawski, 1993; Keidel, 1992; Perkins, 1988). Under this system the GDP deflator is assembled from several sets of administrative "constant prices" that are derived from the base-year average prices of "representative products." There is an about a ten-year interval between the base years after 1957.[4] A typical substitution bias problem in Laspeyres index, which tends to exaggerate China's GDP growth, arises from assuming constant weights to commodities whose prices will actually fall (rise) and consumption will actually rise (fall) over such a long period (see Allen, 1975, pp. 62–65).

Enterprises are required to report their output in both current and constant prices with price manuals which specify prices for (currently) 2,000 items in the base year (currently 1990). This system also tends to understate inflation and thus exaggerate growth, because (1) enterprises tend to report new products in "constant prices" that are similar to current prices as it is very complicated to turn new products that did not exist in the base year and thus were not included in the price manuals into something equivalent in that year; (2) enterprises, especially small-sized, non-state enterprises, many of which might not have begun their business in the base year, tend to report similar figures in both "constant" and current prices for convenience or just of ignorance;[5] and (3) there is no detailed information about how the "representative products" are chosen and how the average prices are computed to construct the "constant prices," and some researchers (e.g. Maddison, 1998) believe that there are coverage biases towards (low) state listed prices and insufficient coverage of the (high) prices of other transactions that are mainly influenced by market.

[4]There are five sets of "constant prices" with 1952, 1957, 1970, 1980 and 1990 as base years, respectively.

[5]According my personal interviews with SSB statisticians in several occasions in 1998–99, most rural enterprises, especially those at or below the village level, only report their output in current prices. The reported output figures are adjusted afterwards to "constant prices" by the upper level statistical offices based on the "real" growth rate of small-sized SOEs that report their output in both current and "constant prices." However, this treatment is *ad hoc* and leaves room for further adjustment, which may serve special policy purposes.

Even SSB statisticians have questioned the reliability of the growth rate based on this "comparable-price" approach. A study carried out by the Industrial Division of the SSB Hunan Province Branch (1989) has constructed an independent industrial index for Hunan for the period 1983–87 and found that the so-estimated annual growth rate (9.2 percent) was systematically lower than that based on the comparable price approach (13.5).

The second upward-bias hypothesis for China's GDP growth is based on the *institutional effect.* Even after extensive reforms the Chinese Government still sets high growth targets and intervenes in various aspects of the management of state-owned enterprises (SOEs) in order to achieve these targets. In China, growth statistics are important not only for propaganda, but also for the performance assessment of enterprises, sectors and regions. As argued by Maddison (1998), this system by its nature leads to underestimating inflation, exaggerating output and quality improvements. Despite penalties for falsification, there are substantial possibilities for exaggerating the volume of output when new products are incorporated into the reporting system at the "comparable prices," which are not easy to detect. Woo (1996) points out that enterprises have strong incentives to oblige their supervising bureaux by overreporting output growth since high growth performance could be interpreted as evidence of superior management ability from the upper management level. Rawski (1993) has also observed that local governments have strong incentives for exaggerating growth because they will be rewarded with special privileges if the economies under their governing have surpassed certain threshold levels of industrial output set by the Government.

Constructing GDP Growth Index Using Physical Output Data

Due to limited, and often distorted information on prices, some researchers have attempted to construct physical output indices to obtain an alternative growth assessment that is independent from official statistics. Such attempts made prior to the mid-1980s (Rawski, 1980; Field, 1973; Cheng, 1971; Chao, 1965) encountered enormous difficulties because not only were the data on physical output insufficient, but there was also little information that could suggest proper weights for aggregation. Although the findings of these studies have appeared to support the upward bias hypothesis, they are questionable due to the often strong assumptions made to bypass the difficulties.

Using the newly available data on about 200 major industrial products and value added weights from China's 1987 Input–Output Table, Wu has, after a series of efforts, constructed a Laspeyres quantity index for 15 manufacturing branches plus mining and utilities (Wu, 1997, 1998 and 1999). Wu's estimates show that China's industrial sector grew by 9.2 percent per annum in 1952–97, compared with the official (SSB) estimate of 11.8 percent per annum, which have, on a more solid ground, systematically supported the hypothesis that official estimates have overstated China's industrial growth (Table 1).

There are still problems in Wu's study. Firstly, Wu was unable to adjust his estimates for quality improvement over time. Secondly, Wu's Laspeyres quantity index approach assumes that the ratio of value added to gross value of output remains constant over time. However, since Wu's estimates might have been

TABLE 1

OFFICIAL AND ALTERNATIVE ESTIMATES OF CHINA'S TOTAL AND INDUSTRIAL GDP GROWTH INDEX AND ANNUAL GROWTH RATES

Year	Growth Indices for Total GDP (1985 = 100)							Growth Indices for Industrial GDP (1985 = 100)			
	Official/SSB (Comparable prices)	Maddison (Volume movement*)	Ren (ICP–U.S.$ deflator)	Ren (ICOP–U.S.$ deflator)	Ren (Price index by sector)	Adams–Chen (Energy)	This Study (Official CPI)	Official/SSB (Comparable prices)	Wu (Physical output)	Adams–Chen (Energy)	This Study (Official IPPI**)
1978	51.8	58.5				72.5	52.6	51.0	61.7	76.7	52.3
1979	55.8	63.0				75.2	58.0	55.4	65.6	79.2	56.8
1980	60.1	65.5				78.1	60.3	62.4	67.9	83.0	63.7
1981	63.3	68.6				79.8	63.3	63.5	68.5	83.5	65.3
1982	69.0	74.6				83.2	67.6	67.1	73.3	85.3	69.0
1983	76.5	80.9				87.3	74.3	79.5	79.5	88.5	75.9
1984	88.1	90.5				93.8	87.4	84.6	88.4	93.5	87.9
1985	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986	108.9	106.5	107.4	109.6	108.1	104.3	106.9	109.7	107.2	103.6	110.8
1987	121.5	115.7	117.4	119.1	116.7	110.2	116.8	124.2	118.9	108.8	118.7
1988	135.1	125.1	123.6	129.3	124.3	116.3	122.7	143.1	133.4	115.1	130.1
1989	140.6	127.8	118.9	123.4	125.6	118.6	117.7	150.4	135.0	117.3	123.1
1990	146.0	131.9	127.6	130.0	128.7	120.9	125.3	155.4	135.2	118.8	125.1
1991	159.5	139.6	144.7	142.7	142.9	126.4	141.2	177.8	149.5	125.0	138.9
1992	182.2	152.9	169.1	164.7	162.9	135.3	163.5	215.4	171.4	135.4	165.3
1993	206.7	167.8	193.7	172.1	173.1	144.2	185.4	258.7	197.6	146.2	183.4
1994	232.9	184.5	207.4	187.8	180.2	152.6	201.7	307.6	233.1	156.1	210.0
1995	257.4	199.9					215.4	350.8	298.0		233.4
1996	282.1						230.9	394.6	284.3		266.9
1997	306.9						246.3	439.2	300.5		298.3
Annual growth %	9.81	7.49	8.44	7.25	6.76	4.76	8.46	12.00	8.69	4.54	9.59

Note: Derived from Maddison (1998, Table C-5), Ren (1997, Table 5.3), Wu (2000a, Table 4), Adams and Chen (1996, Table 4) and SSB (1998). * Maddison's sector-based "volume movement" approach is *ad hoc*, aiming to remove the influence of real price movement in particular sector that is not fully reflected by official deflators, justified by theoretical considerations and empirical knowledge. ** Industrial Producer Price Index as used in Ren (1997).

downward biased because of quality improvement and upward biased due to the widely observed decline of the value added ratio (van Ark, 1996), one may assume that the two effects might have been to some extent canceled off by each other. After all, Wu's work is completely independent of any official growth estimates.

Maddison (1998) is the first researcher who constructs a constant-price GDP time series by sector for China for the period 1952–95. His result is obtained by incorporating his own estimates for agriculture and "non-productive" services based on the latest available statistical information, with the estimates for the industrial sector by Liu-Yeh (1965) and Wu (1997) and the estimates for construction, transportation and telecommunication, and commerce and restaurants by Liu-Yhe (1965) and SSB-Hitotsubashi (1997). It appears reasonably robust and should be considered more reliable than official estimates and the best derived to date, even though it excludes military activity and perhaps still undervalues housing. According to Maddison's estimates, China's GDP grew at 4.4 percent per annum in the pre-reform period 1952–78, against the official 6 percent, and at 7.5 percent per annum in the post-reform period 1978–95, against the official 9.9 percent (Table 1).

Using Foreign Prices to Explore China's "Real" Growth Rate

In economic studies, there has been a long history of using other countries' prices to measure economic growth in a country whose prices were distorted by protective measures and therefore could not reflect opportunity cost of production factors. For example, Gerschenkron (1962) attempts to measure the growth of Soviet heavy industrial output with a U.S. dollar index for 1927–37 when the "comparable price" approach was also in use. Ren (1997) does a similar exercise for the period 1986–94 with his benchmark (1985/1986) PPP GDP estimates for China. He arrives at an annual GDP growth of 8.4 percent for his expenditure PPP GDP estimates and 7.3 percent for his production PPP GDP estimates, both lower than the official 9.8 percent (pp. 127–30).

However, as noted by Ren (1997), the underlying assumption for this approach is that the U.S. weighting system is similar to China's at the time of comparison. This is obviously a strong assumption because the two economies have very different economic structures and factor costs. The only way to get around the problem, as suggested by Bhagwati (1984), is to use the world market prices instead of U.S. prices and make a range of estimates of growth rather than single estimate.

Using Official Price Indices as Alternatives

Researchers have also used various Chinese official price indices to gauge China's growth performance because these indices are not directly influenced by "comparable prices" upon which the GDP deflators were constructed, although some argue that these price indices have also substantially underestimated China's inflation (Chen and Hou, 1986; Feltenstein and Ha, 1991).[6]

[6]The objective of the studies by Chen and Hou (1986) and by Feltenstein and Ha (1991) is different from that of other researchers concerned in this study. Rather than gauging the "real" output growth, both attempt to measure China's repressed inflation using a monetarist approach, specifically, demand for money. Both suggest a very high degree of repressed inflation in China, ranging from 6 percent per annum for 1978–83 in Chen and Hou, and 8 percent per annum for 1978–88 in Feltenstein

There are mainly three alternative price indices available in the Chinese official statistics, namely, farm (and sideline) products procurement price index (FPPI), industrial producer price index (IPPI) and consumer price index (CPI). Ren (1997, pp. 106–9) applies FPPI to agricultural GDP, IPPI to industrial GDP and CPI to service GDP in nominal terms and derives an annual GDP growth of 6 percent for the period 1985–94, even lower than his estimates using the U.S. price index (7.3 to 8.4 percent) (Table 1).

One problem is how to justify the price index-derived estimates without the knowledge of how these price indices are constructed. There are two (urban and rural) SSB survey teams and the State Price Bureau (SPB) that have been involved in price surveys in China. Although local SSB branches are technically subordinate to the SSB headquarter in Beijing they are administratively controlled by local governments whose target is high growth with low inflation. If it is reasonable to believe that local governments have incentives to underreport inflation, the price indices constructed by local SSB branches might have contained downward biases. As for SPB, it is a relatively new government body that was established nationwide in the early 1980s to monitor price levels and investigate misconduct in pricing. With a specially assigned task to fight inflation, it may have incentives to exaggerate inflation with biased samples. There is no sign of how SSB and SPB surveys are reconciled.

Despite the difficulties in assessing the official price indices, one can still use them to gauge China's "real" growth rate. We have produced an official CPI-implied real GDP growth index for the entire post-reform period in Table 1, which does suggest a slower growth than that by the official GDP growth index, even though CPI should not be considered as a proper deflator for GDP.

Gauging The "Real" Growth with Energy Consumption

Many studies show that the growth of energy consumption closely follows the growth of GDP (Chern and James, 1988). Rawski (1993) suggests that one should look into the physical measurement of the Chinese energy consumption as a way to evaluate the growth of "real" GDP. He notes significant inconsistencies in productivity data and energy consumption statistics. This has stimulated a more rigorous empirical work by Adams and Chen (1996) who establish a regression model to estimate the elasticity of energy consumption with respect to GDP in China. Their findings demonstrate that the GDP elasticity of energy consumption for China is 0.45 on average in 1978–94, much lower than the Asian average 1.12 (in 1974–93). A similar pattern is found for electricity consumption in general (0.94 versus 1.63) and in industry in particular (0.63 versus 1.67).

There might be three possible explanations for such a low response of energy consumption growth to the GDP growth, as argued by Adams and Chen (1996). The first one is that in China low energy-intensive sectors have grown faster than high energy-intensive sectors, which seems groundless in the context that the most energy consuming industrial sector has grown most rapidly since the economic

and Ha. Theoretically, such repressed inflation is related to the misvaluation (overvaluation as a net effect) of various output items. Therefore, their estimates should not be taken as the "true" price changes that could be used as proper deflators for China's output in current prices.

reform. The second possibility is that in China the efficiency of energy consumption has been improving sharply over time, which also lacks evidence. The last explanation is in line with the widely accepted hypothesis that has been discussed so far, that is, the Chinese official statistics have exaggerated Chinese GDP growth. Using the Asian average elasticity as the reference, Adams and Chen estimate China's total and industrial GDP growth in 1978–94 as 4.8 and 4.7 percent per annum, respectively, the lowest estimates we have seen so far (Table 1).

One possible problem in the Adams–Chen study might be the underreporting of the Chinese energy production. The main sources of the underreporting may be the energy output for self-consumption and the output (particularly for coal) produced by small-sized, non-state mining enterprises in rural areas. The government policy of restricting the development of small and inefficient mines since the 1990s might have led to some underreporting of the production by these mines. However, it is difficult to gauge to what extent the underreporting affected the result by Adam and Chen.

IV. Measuring Chinese GDP with PPP Converters

Measuring a country's output in an international perspective and its potential for productivity catch-up with the leading countries requires a conversion factor to express output values in a common currency unit. Due to the well-known deficiencies of the exchange rate approach in output conversion (Maddison and van Ark, 1988), the purchasing power parity (PPP) approach has been developed as a better alternative. There have been several important attempts to estimate PPP GDP for China. However, difficulties in obtaining China's basic product-level quantity and price information and pitfalls in the available Chinese official data have made estimates vary in a wide range.

The Expenditure PPP GDP Estimates for China

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 what can be bought with one unit of the currency of a base country (Kravis, Heston and Summers, 1982).[7] This approach is highly useful for the analysis of expenditure patterns and income levels across countries. The actual work of the China–U.S. comparison from the expenditure side includes two main steps. First, for each category within the Classification System of the International Comparisons Program (ICP) the analyst chooses a sample of items and matches their qualities and prices for the two countries to calculate PPP for each item, and then aggregates the PPPs to the category level. Second, the analyst aggregates category-level PPPs to the sector level using the respective expenditure weights of the two countries. The Fisher Index, or the geometric mean of the PPPs with the

[7]The prevailing international income comparisons 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 Program) phases by Kravis (1976, 1984), Kravis, Heston and Summers (1978, 1982), Summers and Heston (1988, 1991).

Chinese weights (Paasche) and the U.S. weights (Laspeyres), is then calculated for each sector, and used to convert sectoral GDP in national currency into a common value unit, say the U.S. dollar (Appendix B).

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. It should be noted that estimates can be very sensitive to the sampling of products, prices, regions and periods.

There have been a few studies that apply the expenditure PPP approach to China. They all have to rely on limited and distorted data, especially price data. Special treatments by researchers to data problems might be the primary sources of the wide range of the results as shown in Table 2.

TABLE 2

VARIOUS ESTIMATES OF CHINA'S PER CAPITA PPP GDP AND IMPLIED PPP EXCHANGE RATE, 1990

Reference of Research	Conversion Approach	Per Capita GDP (1990 G-K$)	PPP Exchange Rate (Yuan/G-K$)
Kravis (1981)**	ICP	$4,264	0.38
Summers & Heston (PWT 5.5) (1993)**	ICP	$2,700	0.61
Summers & Heston (PWT 5.6) (1995)	ICP	$1,536	1.06
Ren-Chen (1994)**	ICP	$1,749	0.93
Ren (1997)	ICP	$1,699	0.96
World Bank—WDR (1992)	ICP	$1,950	0.84
World Bank—WDI (1999)	ICP	$1,390	1.18
Maddison (1998)	ICOP*	$1,858	0.88
Ren (1997)	ICOP*	$1,484	1.10
Garnaut and Ma (1993)	Food-implied	$1,100	1.36
Taylor (1991)**	Mixed	$1,135	1.44
Official yuan figures for 1990, SSB (1995)	—	1,634 yuan	4.78 yuan = $1.00

Note: * Incomplete ICOP approach, mixed with ICP. ** Updated by Maddison (195).

The first expenditure-PPP exercise for China in comparison with the U.S. conducted by Kravis (1981) is a "reduced information" exercise because the amount of details on prices and expenditure in China are significantly less than normally required by the ICP standards. After an adjustment to the Geary-Khamis prices (Geary, 1958; Khamis, 1972), Kravis arrives at a Chinese per capita GDP 12.3 percent of that in the U.S. in 1975. Maddison (1995) updated this result to 1990 using his estimate of per capita GDP growth in 1975–90, arriving at $4,264 in 1990 G-K dollars (Table 2), which implied a PPP exchange rate of 0.38 yuan per dollar, compared with the official exchange rate of 4.78 yuan per dollar, unacceptably high compared with estimates of other studies.

Following the procedure similar to that of Kravis (1981), Ren and Chen (1994) conduct an expenditure-PPP comparison between China and the U.S. for 1986, using over 314 items compared with 93 items in Kravis. They obtain an estimate of per capita PPP GDP $1,044 for 1986. Maddison (1995) updates the Ren-Chen estimate to 1990, yielding $1,749 in 1990 G-K dollars (Table 2). The spread between the estimates at the Chinese weights ($571) and the U.S. weights ($1,818), or Paasche-Laspeyres Spread (PLS)—an important indicator to justify the reliability of PPP estimates (to be discussed later), is large (three-fold) but not as wide as Kravis found for 1975 (four-fold). Ren's latest study (1997) with more information on difficult items like housing and government services suggests a per capita GDP of $1,699 for 1990 (Table 2), only slightly different from the Ren-Chen results obtained in 1994.

China has not officially participated at any phase of ICP, but it has been included in the Penn World Tables (Mark 3) since 1984. However, prior to the 1993 version of the Penn World Tables (Mark 5.5) all estimates for China were simple extrapolations of the Kravis estimates. A significantly modified version of the Kravis estimates is used in the Penn World Tables Mark 5.5 (Summers and Heston, 1993). It is based on official consumption deflators together with a geometric average of PPPs derived from Ren and Chen (1994). The so-estimated PPP GDP per capita for China is G-K$2,700 for 1990 (Table 2). One can reasonably believe that frequently updated but by no means reliable information from the Chinese official sources has made the ICP estimates for China only temporary. For example, this estimate is substantially adjusted down to G-K$1,536 in Mark 5.6 version of the Penn World Tables (Summers and Heston, 1995) (Table 2).

In the early 1990s the World Bank adopted the ICP expenditure-PPP approach for its per capita GDP estimate, reported parallel to its traditional *World Bank Atlas* market exchange rate (MER) approach. For countries like China that have not participated any phase of ICP, it has taken a regression approach to derive PPP GDP using MER GDP and secondary school enrollment (ENROL) as rough proxies of intercountry wage differentials for unskilled and skilled human capital, respectively. This is because, following Isenman (1980), the ICP and conventional estimates of GDP differ mainly because wage differences persist among nations due to constraints on the international mobility of labour.[8]

However, the World Bank ICP PPP estimates for China have been very different from other ICP estimates and so inconsistent over time that it is difficult to reconcile later revised estimates with early ones. Still taking 1990 as an example, the World Bank's new estimate gives per capita PPP GDP for China as $1,390, a 30-percent downward adjustment from its early estimate of $1,950 (Table 2). Similar to the even bigger downward (45 percent) adjustment in Summers and Heston (1996), this clearly suggests that PPP estimates for China are very sensitive to changes in the sampling of products, prices, regions and periods.

The Industry-of-Origin PPP GDP Estimates for China

Since the expenditure PPP approach only applies to final output, it provides no industry perspective because a final product is a result of the production of various industries/sectors. For international comparisons by industry the industry-of-origin approach is more useful. It involves a comparison of real output (value added) in major sectors and of branches within the 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. It also identifies

[8]This can be given as $\ln(GDP_{PPP}) = \ln(GDP_{Atlas}) + \ln(ENROL) + \varepsilon$ (World Bank, 1995, p. 244).

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. It therefore allows the analysis of productivity, structural change and comparative advantage across countries (Maddison and van Ark, 1988).[9]

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 value by the corresponding quantities obtained from each country's production census or survey. These are in fact the prices used in the standard ICOP study. In bilateral comparisons, say comparing China with the U.S. (the base country), two UVRs are derived at every level of aggregation, one at the Chinese quantity weights (Paasche) and the other at the U.S. quantity weights (Laspeyres). Finally, a Fisher index approach is used to average the two UVRs to obtain ICOP PPPs (Appendix C).

There have been some important studies following the standard industry-of-origin PPP approach. We shall concentrate on the China–U.S. agricultural comparison by Maddison (1998) and Ren (1997) and the China–U.S. manufacturing comparison by Szirmai and Ren (1995) and Wu (2000b).[10]

Comparing unprocessed agricultural products between two countries has almost no serious quality-matching problem as usually found in manufactured goods comparisons. In the above mentioned studies, Maddison makes 60 product matches for 1987 representing 89 percent of gross value of agricultural output for China and 94 percent for the U.S., compared with only 23 matches by Ren for 1985 with a coverage ratio of 66 and 88 percent for China and the U.S., respectively (Maddison, 1998, Table A.24; Ren, 1997, Table 3.A.15). The estimated yuan/USD PPPs in Maddison are 2.31 at the Chinese quantity weights and 3.01 at the U.S. quantity weights for 1987, implying a Fisher average of 2.64, whereas the corresponding figures in Ren are 1.84, 2.28 and 2.05 for 1985. Interestingly, both estimates imply the same relative price level of 71 percent, defined as the Fisher PPP divided by official exchange rate. However, with a PLS equal to 0.77 for Maddison and 0.71 for Ren, Maddison's results appear relatively more robust than Ren's.

Turning to the China–U.S. comparison in manufacturing, Szirmai-Ren study (1995) makes 67 industrial 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 gross value of output in China and 18.9 percent in the U.S. The estimated yuan/USD PPP for the 1985 benchmark is 1.15 at the Chinese quantity weights and 1.84 at the U.S. quantity weights, implying a Fisher average of 1.45, compared with the official exchange rate of 2.9 in 1985. Wu (2000b) makes 66 product/product group matches in 39 sample industries, representing 14 of 15 ICOP manufacturing branches. The matched value of output in Wu is similar to that in Szirmai-Ren, representing 35.7 percent of the gross

[9]This approach is also called the ICOP, a methodology that was developed by the International Comparison of Output and Productivity Project at the University of Groningen. An extensive description of this approach can be found in Maddison and van Ark (1988) and van Ark (1993).

[10]We focus on the studies on agriculture and manufacturing as they have relatively less data problems compared with other sectors. For ICOP PPP studies on service sectors, see Ren (1997).

value of output in China and 17.2 percent in the U.S. Wu's yuan/USD PPP for the 1987 benchmark is 1.97 at the Chinese quantity weights and 4.92 at the U.S. quantity weights, implying a Fisher average of 3.11, compared to the official exchange rate of 3.72. One reason to explain why Wu's PPP exchange rate is higher than Szirmai-Ren's is that the overall price level for producer goods in 1987 increased by nearly 20 percent from 1985 after several significant price reforms in 1985–87 in China (SSB, 1999).

As measured by the PLS index, the reliability of the estimated PPPs for manufacturing is lower than for agriculture. Compared with the estimates by Szirmai-Ren that give a PLS of 0.63, estimates by Wu with a PLS of 0.40 appear less robust. As many factors could affect the PPP estimates at either weights, it is difficult to explain the difference between Szirmai-Ren and Wu. Although the two studies use the same methodology there is one major difference in data. Wu uses China's newly available ex-factory prices for 1987 to match the unit values derived from the U.S. Census of Manufacturing in the same year. Szirmai and Ren use the data from the Chinese and U.S. censuses for 1985 and 1987, respectively. To derive unit values for 1985 they have to adjust all the U.S. data for 1987 to a 1985 basis using other information. However, since there were some significant price reforms between 1985 and 1987, using 1987 rather than 1985 as the benchmark may be better simply because the former has relatively less price distortions than the latter. Further research is necessary to improve our understanding in this area.

Compared with the expenditure PPP approach, fewer studies have attempted to estimate China's total GDP using the standard industry-of-origin PPP approach, largely due to the difficulties in obtaining industry/sector-specific data required for calculating the unit value of inputs and outputs. The earlier attempt by Taylor (1991) applied only a pseudo industry-of-origin PPP approach. One may be sceptical about Taylor's results because only the Chinese weights are used to derive sectoral PPPs, which could produce an upward bias in the dollar GDP estimates for China. Another important source of error in Taylor's study is the use of average PPPs of the industrial and agricultural sectors, which include most tradable products, to generate PPPs for services which consist of mainly non-tradable products. This can, on the other hand, overestimate China's PPP exchange rate in terms of the U.S. dollar. Taylor's estimate of per capita PPP GDP is much lower than other estimates, \$788 for 1986, which can be updated to G-K\$1,135 for 1990 (Maddison, 1995, p. 168) (Table 2).

Ren (1997) makes an ICOP-type comparison between China and the U.S., using mainly the results from Szirmai and Ren (1995) and Ren and Chen (1994).[11] Ren estimates China's per capita industry-of-origin PPP GDP as \$886 for 1986. If updated to 1990 at 1990 prices following Maddison (1995), it should be G-K\$1,484, compared with Ren's expenditure PPP of G-K\$1,699 (Table 2).

[11]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.

Maddison (1998, Table C2) follows a sector-of-origin approach, incorporating his ICOP PPP estimates for the agricultural sector with studies mainly by Liu-Yeh (1965), Wu (1997) and SSB-Hitotsubashi (1997). His so-estimated per capita PPP GDP for 1987 is 1,217 yuan, implying G-K$1,858 for 1990 (Table 2). Maddison's estimate is about 25 percent higher than Ren's (G-K$1,484), partially because Ren does not adjust for the possible downward bias in China's official GDP.

We may argue that despite significant differences in all these ICP and ICOP PPP estimates, they could still provide useful boundaries for researchers to gauge the "real" values and hence assess China's "real" living standard. However, given the data problem, one may give preference to the estimates using the ICOP approach. As argued by Gilbert and Beckerman (1961), to maximise the reliability of comparison, the choice of method for any pair of countries must depend largely on relative quality of industry and final product data for manufactured goods. The Chinese industrial census data used in Szirmai-Ren (1995) and physical output data of major manufactured goods in Wu (1997) are better than the final product data used in most expenditure PPP studies.

Deficiencies of the PPP Approach in Measuring China's GDP

The first problem in the PPP approach is the conventional approach of obtaining PPP converters, that is, two sets of PPPs are calculated for China, using the Chinese weights (Paasche PPPs) and the U.S. weights (Laspeyres PPPs), respectively, and then are averaged using the Fisher index approach. Therefore, the U.S. weights become part of the conversion of the Chinese GDP to dollars. The Fisher index approach is to come up with a neutral statistic to compare each currency's purchasing power. However, the reliability of a Fisher PPP depends on its ability to reflect the true index as defined in economic theory (Allen, 1975). Hill (1999) argues that this ability diminishes with an increasing spread between the Paasche and Laspeyres indices (PLS). As observed by many researchers (Maddison and van Ark, 1994; van Ark, Monnikhof and Timmer, 1999), the gap between the two indices is generally widest for comparisons between less developed countries like China and advanced countries like the U.S. This is because they have very different income or productivity levels and quantity structures in production, known as the Gerscherkron effect (Gerscherkron, 1951). In such a case, a Fisher PPP will certainly give an unrealistic average.

Obviously, compared with the U.S. China has a very different economic structure, productivity and income level. The differences are due to not only the different stages of economic development but also the price distortions inherited from the central planning period, even though price controls over most products have been gradually relaxed since the reform. Since price reform measures have been introduced in a piecemeal way and their effects vary on different products in different periods, the results of a PPP exercise for post-reform China can be very sensitive to the selection of the benchmark year. As discussed above, the difference between Szirmai-Ren and Wu in China's manufacturing PPP estimates might partially be due to their choice of different benchmark years. It may be argued that after a several rounds of significant price reforms in 1985–86 there should be less price distortions in Wu's benchmark year 1987 than in Szirmai-Ren's benchmark year 1985.

The second problem is how to overcome quality-matching difficulties between countries like China and the U.S. This is a major challenge facing all PPP comparisons, but it is more crucial for China. Usually, products with a heterogeneous nature (such as machinery and vehicles) are more difficult to match than those with a homogenous nature (such as vitamin tablets and non-ferrous ingots). Exported products are understandably less problematic than those not for export, as their quality is already "measured" by the world market.

Almost in all PPP exercises for China and the U.S. price data are from official price lists. Products on the U.S. list are 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 leads to upward-biased dollar PPP GDP estimates for China.

Studies like Chen-Ren (1994) follow an "equivalence in use" rule in quality-matching exercise, that is, the matched items are considered the same or similar so long as they serve the same basic function, even though they are not of the same quality. For example, this practice ignores the better quality and greater degree of packaging and processing of many food items in the U.S. markets than in the Chinese markets, and for furniture it ignores enormous price variation with quality and style between the two countries and the fact that furniture in the U.S. is generally much higher quality than in China. These factors will result in a higher dollar price than would otherwise be the case for an identical Chinese equivalent (World Bank, 1994b).

V. Important Implications of the New Estimates

After critically reviewing most recent studies designed to improve the measurement of the Chinese national income level and growth performance in both historical and international perspectives, one may ask: What do these new estimates imply? Could they challenge the conventional views about the Chinese economy and its role in the world economy? Issues that are most significant for China include the real output of the economy and then the standard of living, degree of openness, productivity performance and potential for catch-up.

The Real Output of the Chinese Economy and Standard of Living

The primary purpose of the PPP-based income comparison is to evaluate a nation's real standard of living 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 seem to have added confusion to already controversial estimates, it can be argued that continuously improved data and estimation techniques have now made estimates more realistic. We may accept that the Chinese per capita PPP GDP level is probably between $1,500 and $2,000 for 1990 (in 1990 international dollars), which is about half of the estimate made by Summers and Heston in the early 1990s (Table 2). This suggests that the "real" output of the Chinese economy was between $1,703 billion and $2,270 billion for 1990 in 1990 international dollars, or equivalent to about 30 to 40 percent of the U.S. GDP.

In a poverty assessment for China, following its new ICP estimate of per capita PPP GDP $1,800 for China in 1992 (or about $1,500 in 1990), the World Bank (1996b) has nearly tripled its previous estimate of the percentage of the Chinese population living under the international poverty line U.S.$1 per day (in 1985 prices).[12] By this international yardstick, China's poverty incidence is now estimated to be 27 percent in 1994, compared to 7 percent by the old measurement. Obviously, more reliable forecasts of future living standards depend on more reliable measurements of China's current income and past growth. While the new, lower per capita income estimates for China have more closely reflected reality, they have prolonged the interval necessary for China to catch up with advanced countries.

Degree of Openness

The trade dependency ratio, i.e. value of trade divided by total GDP, is often used to reflect the openness of an economy. It is sensitive to the measurement of the GDP denominator. If measured by the official exchange rate, China's exports-to-GDP ratio is 21 percent for 1995 (SSB, 1996). The same ratio for the U.S. is, however, only 8 percent (OECD, 1997, pp. 62–6). Some researchers (Lardy, 1994; Ren, 1997) have argued that such a trade dependence ratio for China has painted an unrealistic picture of a very open Chinese economy, because GDP is not properly measured.

Measuring "trade" as half of the sum of official export and import values at official exchange rate and dividing it by his ICOP PPP GDP estimates, Ren (1997) arrives at a "trade dependency" ratio of 5.8 percent for China in 1994 (p. 129). Maddison (1998) shows a result of 4.3 percent for 1995 by taking the "trade dependency" ratio as export value at official exchange rate to his ICOP PPP GDP estimates (p. 154). Both follow a similar approach and provide a substantially lower-level openness measurement for the Chinese economy.

However, this approach seems to have a conceptual problem. If the trade value is measured at the market (official) exchange rate, which reflects the international purchasing power of the yuan, it is inconsistent with the PPP-measured GDP as the denominator, which comprises the domestic purchasing power of the yuan.

Growth Rate and Total Factor Productivity (TFP) Performance

Total factor productivity (TFP) 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

[12]U.S.$1 a day (1985 prices) is an international poverty threshold set by the World Bank using PPP conversion rates (World Bank, 1996d, Box 3).

is overstated on account of insufficient deflation of output, China's TFP would be similarly overestimated, assuming that capital and labour are accurately measured (Borensztein and Ostry, 1996). Given inputs, a remeasured growth rate would alter the estimate for TFP performance, i.e. a slower GDP growth implies a poorer TFP performance.

Woo (1996) decomposes China's TFP growth into a labour reallocation effect and a net TFP (technological progress) effect, after correcting for the possible overstatement of industrial output and the inconsistent use of base years in calculating growth deflators. He arrives at a labour reallocation effect of 1.1 percentage point and a net TFP growth from 1.1 to 1.3 percentage points for the post-reform period (1979–93). Assuming that his calculations for the growth of capital and labour inputs are acceptable, even one percentage-point downward adjustment to the GDP growth rate will significantly change the estimate for China's TFP performance as shown in Table 3. Using Maddison's estimates to further correct the GDP growth rate and leaving the residual to mainly explain the resource reallocation effect, there will be little room left for technological progress in the post-reform China. This could possibly be close to reality because the labour reallocation effect reflects the existence of a large amount of labour employed in agriculture and the success of the post–1978 reforms in creating jobs in the industrial and service sectors. This implies that China's post-reform economic growth may have largely been driven by input increase and institutional changes.

TABLE 3

WOO'S DECOMPOSED CHINA'S TFP PERFORMANCE AFTER CORRECTED FOR OVERSTATED GROWTH, AND FUTHER ADJUSTED BY MADDISON'S GROWTH RATES (PERCENT PER ANNUM)

Decomposition of GDP growth	1978–93	1984–93
Official GDP growth rate	9.3	9.7
—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
Input growth rate	6.2	6.6
—Capital accumulation	*4.9*	*5.5*
—Labour force	*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 estimated by Maddison	7.3	7.1
Derived overall TFP growth using Maddison	1.1	0.5

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

Comparative Labour Productivity Performance and the Scope for Catch-up

Labour productivity performance determines the long-run growth of any economy. The potential for productivity catch-up depends on the gap in productivity levels between leading and following countries. Only comparisons of the size of the actual gaps rather than the growth rate can provide the information about the scope for catch-up. The PPP GDP estimates for China have made international comparisons of labour productivity level possible for China.

TABLE 4

LABOUR PRODUCTIVITY IN CHINA AND SELECTED COUNTRIES/ECONOMIES, AN ICP-PPP BASED ESTIMATION

Country/Economy	ICP-PPP GDP per hour worked (1990 international dollars) 1950	1973	1992	Rank by 1992	Labour productivity growth (percent per year) 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	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
U.S.S.R./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

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

PPP studies have suggested that there exists a large gap between China and the U.S. in labour productivity in general. However, China's economic reform begun in 1978 has not only speeded up its labour productivity growth, but also narrowed down its productivity gap with leading countries like the U.S. In Table 4, we have, based on Maddison (1995, Table J–5), selected some of China's Asian neighbours and some advanced countries to compare with China in terms of expenditure-PPP GDP per hour worked for 1950, 1973 and 1992. As a result of faster labour productivity growth (3.67 percent per annum) in 1973–92 than in 1950–73 (2.06 percent), China's comparative labour productivity (with the U.S. as 100) increased from 5.6 in 1973 to 9.6 in 1992, altering the downward trend observed in 1950–73. This indicates that the gap between the two countries narrowed down, though China was still ranked the second from the bottom in 1992. Clearly, Table 4 shows that there is still a huge distance before China catches up with leading economies and whether China is able to do it depends partially on whether it can continue to pursue appropriate economic policies in order to overcome social constraints on catch-up (Abramovitz, 1989).

The ICOP PPP studies by Szirmai and Ren (1995 and 1997) and Wu (2000b) have provided detailed analyses of China's comparative labour productivity in manufacturing. Both studies suggest that there exists an enormous labour productivity gap between China and the U.S. For example, with the U.S. as the base (=100) China was only about 6.2 in 1992 as estimated by Szirmai and Ren (1997), and 7.1 in 1997 as estimated by Wu (2000). However, the studies have different estimates in terms of the ICOP catch-up accounting for China's manufacturing. Szirmai-Ren estimates show that China's comparative labour productivity in manufacturing stagnated at about 6 (U.S. = 100) during the period 1980–92. Based on these findings, they argue that post-reform China's manufacturing has featured a process of "rapid growth without catch-up" (Szirmai and Ren, 1997).

By contrast, the study by Wu (2000), which covers a much longer period (1952–97) than Szirmai-Ren, has found a clear catch-up process during the post-reform period, rising from 3.7 in 1977 to 7.13 in 1997 (U.S. = 100), compared with a stagnation at about 3.5 over the period 1955–76. A more clear catch-up is found in the later reform period 1992–97 (5.17 up to 7.13). This coincided with the time when the Chinese economy had switched from a "planning-market hybrid" to a more market-oriented system, though still "socialist" in name. Following Abramovitz (1989), one may argue that this catch-up was largely attributed to the further relaxation of the social and institutional constraints to the economy.

Such catch-up accounting can only be justified with correct estimates of the level and growth of both inputs and output. As both studies used a single-benchmark PPP converter that could only affect the output level estimate, and similar manufacturing employment data, the main factor behind the difference is perhaps the approach with which the manufacturing output index is constructed in each study. In this aspect Wu's estimates may be more acceptable than Szirmai-Ren's because Wu's output index is based on physical output and is therefore independent of the official GDP deflators (refer to Section III).

VI. Concluding Remarks

This paper examines recent studies that attempt to measure China's GDP level and growth performance and discusses important implications that can be drawn from these studies. It is not an exaggeration to conclude that researchers in this field have made significant progress in the short period since the 1990s. Their estimates for China's (renminbi) GDP level and PPP GDP, and real growth performance have filled important gaps in our knowledge and provided alternative measures to the doubtful official figures. Their findings, though many of them are still subject to further justification, have enabled better understanding of China's long-run economic performance for both the central planning and market-oriented reform periods. We conclude this study with the following remarks.

Firstly, due to the deficiencies of China's national accounts and statistical practice that had been significantly influenced by MPS, China's (renminbi) GDP level may still be underestimated. The extent of the underestimation is at least 10 percent of the official GDP figures. Further output revaluation of the housing sector and improvement of data collection techniques may reduce the gap in the future.

Secondly, most researchers have agreed that China's official "comparable-price"-based GDP deflator has understated China's inflation and thus overstated China's real income growth. Various methods used in these studies have shown that the degree of overstatement for the post-reform period is perhaps 2 to 4 percentage points. Such differences can certainly lead to a good deal of difference in output level backward estimation, future growth projection and catch-up accounting.

Thirdly, with newly available information and refined approaches studies have tended to support the view that China's official exchange rate-based per capita GDP should be adjusted by a factor of about 4 to a PPP-based per capita GDP if 1990 is used as the benchmark. This means that renminbi-PPP dollar exchange rate should be around one yuan compared with the official exchange rate of 4.8 yuan in 1990. However, one should be aware that PPP estimates can be very sensitive to the sampling of products, prices, regions and periods, particularly in transitional economies like China where price distortions to some extent still exist and prices are affected by reform policies in a piecemeal manner.

Fourthly, the lower but more reliable estimates for China's post-reform growth rate have left little room for China's technological progress, *ceteris paribus*. This favours the view that China's post-reform economic development, similar to most fast growing Asian economies in the past two decades, has been almost entirely dependent on factor inputs, but benefited little from productivity improvement (Krugman, 1994). However, we should not jump to this conclusion too quickly. TFP measurement is very sensitive to both input and output growth measurement and it will not be reliable until the measurement for all these variables becomes reliable. Even if we can use better, alternative output growth estimates in growth accounting for China, we still have significant problems with the Chinese official data on labour and capital assets.

Finally, there have been only a couple of studies using the ICOP catch-up accounting approach to investigate whether there has been a catch-up process in labour productivity in the Chinese manufacturing, but no agreement has been reached. More studies with better data that allow both partial and total factor productivity catch-up analyses are certainly necessary. However, what is clear from the previous studies is that after three decades of heavy industrialisation under the central planning China's comparative labour productivity level in manufacturing is still well below 10 percent of that of the U.S. To realise its great growth potential China needs to improve efficiency by further removing institutional constraints or barriers to factor mobility and market integration within China and with the world.

Appendix

A. Theoretical Difference in Output Accounting Between SNA and MPS

The theoretical difference reflected by differences in the actual accounting process between the two systems can be clearly understood by comparing the definition for GDP and GVO or NMP. Let us start with the practice under MPS. Given a time period, for each sector i, let the value of material inputs be C_i^m, the value of non-material inputs be C_i^n, which can be measured as payments made by the "material" sectors to the "non-material" sectors, the value of depreciation of fixed capital be D_i^m, and newly added value from "material production" be V_i^m, the gross value of output or GVO, the most important national accounts concept under MPS, can be expressed as

$$\text{GVO}_i = C_i^m + C_i^n + D_i^m + V_i^m, \tag{1}$$

where the sum of V_i^m and C_i^n is the so-called net value of output or NVO, which is in fact the commonly used NMP (net material product by standard MPS terminology). Thus, from equation 1 NMP could be defined as

$$\text{NMP}_i = C_i^n + V_i^m = \text{GVO}_i - (C_i^m + D_i^m). \tag{2}$$

Obviously, both GVO and NMP differ significantly from the SNA concept of GDP defined in equation (3) which can be contrasted with equations (1) and (2):

(3) $$\mathrm{GDP}_i = D_i^m + D_i^n + V_i^m + V_i^n,$$

where the term V_i^n and D_i^n indicate net value added and the value of depreciation by "non-material production," respectively. Clearly, GDP is not compatible at all with either GVO or NMP. Both GVO and NMP contain double counting because C_i^m is intermediate inputs and C_i^n includes intermediate inputs in the non-material sector. NMP seriously undercounts national income by ignoring the value of depreciation of fixed capital. Directly matching the components of the two systems at sector level is not easy because the sector breakdown under SNA differs from that of MPS. The former includes both "material" and "non-material" sectors, while the latter includes only "material" sectors.[13] In practice, at aggregate level we could have the following relationships between components based on the definitions given above:

(4) $$\sum_i^k C_{i,\mathrm{MPS}}^n > \sum_i^k D_{i,\mathrm{SNA}}^n + \sum_i^k V_{i,\mathrm{SNA}}^n,$$

(5) $$\sum_i^k V_{i,\mathrm{SNA}}^m \cong \sum_i^k V_{i,\mathrm{MPS}}^m,$$

(6) $$\sum_i^k D_{i,\mathrm{SNA}}^m \cong \sum_i^k D_{i,\mathrm{MPS}}^m, \qquad \text{where } i = 1, 2, \ldots, k.$$

B. The Expenditure Approach to Derive PPPs

The following formulas give the aggregated PPPs for sector j for China (C) and the U.S. (U) using respective weights:

(7) $$\mathrm{PPP}_j^{\mathrm{CU(U)}} = \sum_{i=1}^n (P_{ij}^{\mathrm{C}} / P_{ij}^{\mathrm{U}}) \cdot w_{ij}^{\mathrm{U}},$$

(8) $$\mathrm{PPP}_j^{\mathrm{CU(C)}} = \left[\sum_{i=1}^n (P_{ij}^{\mathrm{U}} / P_{ij}^{\mathrm{C}}) \cdot w_{ij}^{\mathrm{C}} \right]^{-1},$$

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

C. The Industry-of-origin Approach to Derive PPPs (UVRs)

To express the procedures in formula, following van Ark (1993), firstly, the average PPP (i.e. UVR) for the industry j is obtained by weighting the unit value (P) of all matched items ($i = 1, 2, \ldots m$) belonging to j by the corresponding quantity weights of China and the U.S.:

[13]They are agriculture, industry, construction, transportation and telecommunication, commerce. Such grouping is consistent with the Marxian theory and common in the practice of CPEs.

(9) $$\mathrm{PPP}_j^{\mathrm{CU(C)}} = \sum_{i=1}^{m} (P_{ij}^{\mathrm{C}} Q_{ij}^{\mathrm{C}}) \Big/ \sum_{i=1}^{m} (P_{ij}^{\mathrm{U}} Q_{ij}^{\mathrm{C}}),$$

(10) $$\mathrm{PPP}_j^{\mathrm{CU(U)}} = \sum_{i=1}^{m} (P_{ij}^{\mathrm{C}} Q_{ij}^{\mathrm{U}}) \Big/ \sum_{i=1}^{m} (P_{ij}^{\mathrm{U}} Q_{ij}^{\mathrm{U}}).$$

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

$$\mathrm{PPP}_k^{\mathrm{CU(C)}} = \sum_{j=1}^{n} \mathrm{GVA}_{jk}^{\mathrm{C}} \Big/ \sum_{j=1}^{n} [\mathrm{GVA}_{jk}^{\mathrm{C}} / \mathrm{PPP}_{jk}^{\mathrm{CU(C)}}]$$

$$\mathrm{PPP}_k^{\mathrm{CU(U)}} = \sum_{j=1}^{n} [\mathrm{GVA}_{jk}^{\mathrm{U}} \cdot \mathrm{PPP}_{jk}^{\mathrm{CU(U)}}] \Big/ \sum_{j=1}^{n} \mathrm{GVA}_{jk}^{\mathrm{U}}.$$

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