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Accounting for China's Growth in 1952-2008: China's growth performance debate revisited with a newly constructed data set

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Accounting for China's Growth in 1952-2008：
China's growth performance debate revisited with a newly constructed data set

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Abstract

Using a "data fundamentalist approach," this study revisits the long debate about China's growth performance by seriously tackling the existing data problems that have been the major obstacles to a proper assessment of China's growth performance. First, this study examines and adjusts the serious break in the official employment statistics in 1990. Second, it provides an adjustment for the numbers employed by a human capital effect. Third, it tests the sensitivity of Maddison's (1998a) "zero labor productivity growth" assumption in gauging the real growth of the so-called "non-material (including non-market) services." Fourth, it further improves the author's earlier physical output-based production index for the industrial sector (Wu, 2002a) by using multiple weights and time-variant value added ratios obtained from the Chinese input-output tables. The likely problem of "product quality" in such a physical measure is examined and rejected. Fifth, it provides a new set of estimates of capital stock for the aggregate economy using alternative deflators and depreciation rates, crosschecked by the author's industry-level capital stock estimates (Wu, 2008b). This completely new data set is used in a Solow-type growth accounting exercise with different factor income share assumptions. The new results—under the full adjustment scenario for the post-reform period using input-output table income weights—show that the estimated annual TFP growth rate is 0.3 percent, which is substantially lower than the estimate of 3.1 percent derived from the official data without any major adjustment. A range of TFP estimates is also provided for each sub-period under different assumptions.

Keywords: national production accounts, estimation of capita stock, measuring employment and human capital, and measuring aggregate productivity.

JEL Classification: E10, E20, O47

[1] Part of this research was conducted when I worked with Angus Maddison in 2006-2009 to update our earlier data work and reassess China's long-run economic performance, and part of it was conducted at The Conference Board (TCB) China Center in 2009-2010 when preparing the China data for the TCB Total Economy Database. I am indebted to helpful comments and suggestions made by the late Angus Maddison, Bart van Ark, Kyoji Fukao, Alan Heston, Marcel Timmer, Ximing Yue, and Vivian Chen, as well as participants at the 2010 AEA Meeting and at seminars organized by the Research Institute of Economy, Trade and Industry (RIETI), Tokyo, and the Groningen Growth and Development Center (GGDC), Groningen University, The Netherlands. I would like to thank Xiaoqin Li for timely data assistance. This research has been supported, in part, by RIETI's China Industrial Productivity (CIP) Project. I am solely responsible for any remaining error or omission. harry.wu@ier.hit-u.ac.jp

1. Introduction

The sources of China's post-reform remarkable growth performance have been the subject of a heated debate. It draws a particular attention whenever the China model of reform and development is questioned. The center of the debate is whether China's growth during the reform period is attributed mainly to productivity growth or to factor accumulation. Despite more and more studies have participated in the debate, the debate has remained inconclusive. Using the estimated total factor productivity (TFP) for the Chinese economy in the literature, which is a productivity measure in the neoclassical growth accounting framework that is considered crucial for the quality of an economy's growth and its sustainability in the long run, we may approximately categorize the existing studies into two opposite groups, namely, an "optimistic camp" versus a "pessimistic camp".

The optimists may be represented by the most recent studies by Perkins and Rawski (2008) and Bosworth and Collins (2008) both attributing over 40 percent of China's post-reform growth to TFP, that is, 3.8 percent of annual TFP growth for the period 1978-2005 in the former and 3.6 percent for 1978-2004 in the latter.[2] The pessimists may be represented by Young's study (2003) which only accounts for 1.4 percent of annual TFP growth for the period 1978-1998. Since Young only covers the non-agricultural economy, one may argue that his estimate for the TFP growth would have been even lower if agriculture were included, that is, at best TFP contributed not more than 15 percent of the growth in that period.[3] There are, however, estimates that stand in between including e.g. Wang and Yao (2002) who estimated 2.4 percent of annual TFP growth for 1978-1999.[4]

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[2] There are studies that obtain the estimates of annual TFP growth rate around 3 percent including the work by Ren and Sun (2005) which estimated an annual TFP growth at 3.2 percent for 1980-2000, Maddison's revised estimate (2007a) of 3 percent for 1978-2003, and an estimate of about 3 percent by He and Kuijs (2007) (an approximate average of 3.3 for 1978-93 and 2.8 for 1993-2005), though the periods covered in these studies are less comparable.

[3] Kalirajan et al. (1996) found that TFP growth in Chinese agriculture was negative in 16 of China's 29 provinces in 1984-87 after a positive performance in almost all provinces in 1978-84. Mao and Koo (1997) found that 17 out of China's 29 provinces experienced a decline in "technical efficiency" in 1984-93 in agricultural production.

[4] Cao *et al*. (2009) also provided a similar moderate estimate of annual TFP growth by 2.5 percent for 1982-2000.

One may argue that different time horizon and coverage present some difficulty when directly comparing the results of the previous studies. There are in fact more contradictory findings for shorter but more comparable periods. For example, for the reform period up to the mid-1990s, China's annual TFP growth rate is estimated at 3.8 and 3.9 percent for the period 1979-94 in Borensztein and Ostry (1996) and Hu and Khan (1997) and even as high as 4.2 percent for 1978-1995 in Fan *et al*. (1999). These results can be compared with a very low estimate at 1.1 percent for 1979-1993 by Woo (1998). Some studies stand in between, such as Maddison's earlier estimate (1998a), which shows 2.2 percent for 1978-1995.[5]

Other examples can be found for the next period between the mid-1990s to the early and mid 2000s. An optimistic estimate of the annual TFP growth rate for this period can be as high as 3.9 percent (1993-2004) in Bosworth and Collins (2008) compared with a very pessimistic result of only 0.6 percent (1995-2001) by Zheng and Hu (2005) or even a negative value of -0.3 percent (1994-2000) by Cao *et al*. (2009). The estimate of 2.8 percent (1993-2005) by He and Kuijs (2007) stands in between the extreme results.

Drawn on these very different findings, two conflicting views about the productivity performance of the Chinese economy have emerged in the debate. On one side, Bosworth and Collins (2008) concluded that their findings had set China "apart from the East Asian miracle of the 1970s and 1980s, which was more heavily based on investment in physical capital," and hence suggesting that "China stands out for the sheer magnitude of its gains in total factor productivity (p. 53)." On the other side, Young (2003) concluded that the productivity performance of China's nonagricultural sector during the reform period is, while respectable, not outstanding. Krugman (1994) believed that China would face a limit on growth sooner or later, since it depended heavily on a massive increase in input with only small improvement in productivity, just as in the case of other Asian economies.

How much have we learnt from this debate based on such conflicting empirical findings? If the findings by the "optimistic camp" are accepted, how to explain the contrast between such a high TFP contribution to growth in the post-reform China and

[5] In this literature review here I concentrate on results based on the growth accounting approach. But there are some studies that opt for the regression approach, e.g. one by Chow and Li (2002) which arrives at an estimate of 3 percent for 1978-98.

the poor TFP performance in other East Asian economies as found by Young (1992, 1994a, 1994b, 1995) and Kim and Lau (1994) among others, which also pursued a similar export-oriented development supported by government policy? Some may argue that China's central planning past may be able to explain the distinction between China and other Asian economies. However, it is never clear that through what mechanism has the central planning legacy found its way to help achieve such a high TFP growth in China? If so, then what does the TFP mean?

Moreover, there is ample evidence suggesting that China's rapid economic growth has been subsidized or externalized in that the costs of labor, land, energy and environment have been substantially underpaid in a government-engineered growth race. While it is not difficult to understand that any underpayment of production costs will encourage overinvestment, hence causing inefficient use of capital that results in premature diminishing returns to capital, it is never clear about how such a negative externality of production cost can logically explain a remarkable TFP growth!

On the other hand, if the findings by the "pessimistic camp" are correct, can we jump to a conclusion that China is just another example of the "East Asian miracle" that relied mainly, if not completely, on perspiration (working hard) and gained little from inspiration (working more smartly) (Krugman, 1994)? Then, where have the new technology, new knowledge in management and marketing, and institutions that have been brought by foreign direct investment gone? However, the same question can also be asked for other East Asian economies in their post-war industrialization.

Then, what has gone wrong so that it results in such contradictory results and hence different conclusions? A proper answer is unlikely related to the methodology used in these studies because all adopted the standard neoclassical growth accounting approach. Although the relevance of the neoclassical orthodoxy in the case of China is highly questionable for its institutional and behavioral assumptions, it cannot help settle down the current debate. The only acceptable reason for the contradictory results is the problems in Chinese official statistics, from inconsistencies in definition and classification to substandard indicators influenced by the legacy of MPS (the material product system for national accounts under central planning) or because of methodological problems, and to data fabrication. Regrettably, despite over two decades of significant efforts in accounting growth for China, researchers still have to get back to such fundamental questions: how to understand deficiencies in official statistics and hence the likely biases they may cause, how to choose appropriate approaches to tackle the problems, or how to justify the reasons for ignoring them.

2. TOWARDS A "DATA FUNDAMENTALIST" APPROACH

While getting back to the data fundamentals does not sound exciting, it is the only way to settle the debate with the given theoretical framework. This is what I call a "data fundamentalist" approach in solving the problem. It certainly does not mean that data issue is the only or the most important one but they are essential *given* that all the theoretical and methodological issues are in no significant controversy. A "data fundamentalist" approach in the growth accounting is not new. Researchers in this field should have remembered that there were many dedicated "data fundamentalist" economists whose careful studies on data and measurement issues in accounting for the US economy growth settled (though arguably) the intense debate about the productivity performance of the US economy from 1950s to 1980s (see Jorgenson, 1990, for a comprehensive review of the contribution of the related studies).[6]

There are some principles that a "data fundamentalist" should follow in the growth accounting exercise. First, a targeted data problem should be fully discussed with necessary evidence and proper reasoning in theory and in the practice of the country case in question. Second, any assumption that is adopted to solve the data problem should be compared with its alternatives by sensitivity test. Third, data work for any sector of the economy must be checked in terms of accounting identity and intersectoral coherence in a SNA framework. Fourth, adjustment that affects growth rate in any given period must be empirically justified for the flow-on-stock effect in time (an adjustment in the growth rate will inevitably affect the related level over the period concerned). Fifth, if possible, any adjustment of an aggregate indicator should be checked by its "micro foundations" or available sub-levels of information. Last but not least, all kinds of data work must be made transparent and available for repeating the same exercise.

Data problems have indeed been treated as a fundamental issue in some studies on accounting for China's growth and productivity performance. Instead of taking

[6] Also see other articles on this topic in the same book edited by Ernst Berndt and Jack Triplett (1990).

official data for granted or simply filling data gaps by official information, researchers have made significant efforts in assessing official statistics, identifying and acknowledging data problems, investigating the nature of the data problems, and proposing alternative estimates. Examples of such efforts include studies by Maddison (1998a), Wu (2002 and 2008a) and Maddison and Wu (2008) on output level and growth, Young (2003) on human capital, Woo (1998), Ren (1997) and Young (2003) on prices, Chow (1993), Holz (2006b and 2006c) and Wu (2008b) on investment and capital stock.

There are, however, still unsolved data problems that have been an obstacle to a proper assessment of the Chinese economy. First, as discussed in Maddison and Wu (2008) there is a serious inconsistency between two official estimates of total employment appearing in two different tables of the same statistical yearbook, that is, a 17-percent jump in one estimate in 1989-90 compared with only a 1.5-percent increase in another estimate.[7] It is believed that this is caused by a serious inconsistency between population census and sample survey-based employment estimates and annual estimates of labor statistics based on regular statistical reports (Yue, 2005 and 2006). Any serious growth accounting exercise should tackle this problem.

Second, the Chinese official statistics show that the labor productivity of the so-called "non-material services" (including all non-market services, a term used in the MPS as "non-productive production") grew at an astonishing rate of 6.1 percent a year in 1978-2008 that has never been observed in human history in normal situations.[8] Labor productivity growth in such services is usually very slow if not stagnated because of its highly labor intensive nature. However, in adjustment for the likely overstatement of the real growth in this sector, Maddison's "zero labor

[7] As discussed in Maddison and Wu (2008, p. 34), in the 2006 *China Statistical Yearbook* (pp. 128 & 130), the three-sector total for 1990 (end-year) was 647.5 million whereas the actual total for the 16 sectors was 567.4 million—a discrepancy of 80.1 million. For 2002, the discrepancy had risen to 99.6 million. Instead of explaining it, the *Yearbook* disguised the discrepancy by showing the same "total" for the 16 sector breakdown as for the three-sector aggregate.

[8] The calculation of the official real growth rate for these "non-material" services is based on national accounts data including nominal value added and constant price growth rates from various issues of *China Statistical Yearbook* (for example, see NBS, 2009, pp. 42-47). The same calculation provides an annual growth of 1.9 percent for the pre-reform period 1952-78, which is also higher than the experience of many other countries.

productivity growth" assumption (1998 and 2007) has been hotly debated with no conclusion (Maddison 2006 and Holz, 2006a).

Third, it is evident that the Chinese official statistics on the industrial value added have exaggerated the real growth of industrial GDP as suggested by a series of studies including my physical output-based production index approach (Wu, 1997 and 2002) that was used in Maddison and Wu (2008) and by a more recent evidence that shows the sum of the value added by enterprises at and above the "designated size" exceeds the total industrial GDP in the national accounts (Appendix A). Criticisms on my approach include the problem of assuming a constant input-output technology and a fixed ratio of gross value added to gross value of output, the typical problem of the Laspeyrse index number that causes consumer selection bias (see a test for the bias in Wu and Yue, 2000), and the likely underestimation of quality improvement that produces a downward bias in the approximation for the real industrial growth (Holz, 2006a; Rawski, 2007). There has since been extended work in this area that intends to answer these questions (Wu, 2008b) but it has not been incorporated in a growth accounting exercise for China.

There are also other measurement problems as an obstacle to the settlement of the China TFP performance debate including the measurement of income shares of labor and capital, services of labor and capital, human capital, prices of fixed assets and capital consumption.

This paper is organized as follows. Section 3 explains why the official practice in estimating GDP may have introduced upward biases. Section 4 adjusts the huge break in 1989-90 in the official employment statistics by three scenarios. Section 5 provides alternative GDP estimates for "non-material services" compared with Maddison's estimates based on his "zero labor productivity growth" hypothesis. Section 6 provides time series estimates on the average years of schooling of the workforce as a proxy for the human capital stock. Section 7 improves my earlier physical output-based production index for the industrial sector by introducing multiple weights and time-variant value added ratios. It also examines the problem of "quality change" in such a physical output based exercise. Section 8 estimates a new set of annual estimates of capital stock for the aggregate economy using alternative deflators and depreciation rates, crosschecked by industry level capital stock estimates. Section 9 reports and discusses alternative growth accounting results for the Chinese economy in 1952-2008. Section 10 concludes the paper.

3. Problems of the Official Estimates of China's GDP Growth

Why may MPS exaggerate growth?

Since China's statistical practice is still influenced by "many central planning legacies" (Xu, 2002a, p. 205), it is necessary to discuss the key differences between MPS and SNA and their implications for measuring the real GDP level and growth rate in a more rigorous way. Before progressing ahead, it should be noted that our approach is a value-added one, which constructs output from the production-side of the national accounts. Besides, for simplicity our discussions and mathematical expressions below are in real terms.

By the MPS standard of industrial classification, there are five material sectors in Chinese statistics including agriculture, industry, construction, transportation and telecommunication, and commerce, of which construction, transportation and telecommunication, and commerce are the so-call "material services". Such grouping was common in the practice of all former centrally planned economies. It should be however noted that the material service sectors only cover the services that are used for production or producer services. Consumer services, e.g. passenger transportation, are excluded because they are considered "unproductive" in the Marxian orthodoxy.

Perhaps contrary to the common theoretical perception, the MPS does not completely ignore the contribution by "non-material services". In calculating NMP (net material product), the "non-material services" that are used (and hence paid) by the material sectors are kept together with the newly added value by "material production", for example, banking or financial services, research and development, and legal and business consulting services. However, the rest of the "non-material services", such as residential services and most of government services, is ignored in the national accounting practice under the MPS.[9]

[9] Taking the national accounts statistics for 1991 in nominal terms as an example (the earliest data available with details of 2-digit services), if assuming 100% of the value added by scientific research services, 70% of the value added by financial services, and 20% of the value added by all other "non-material services" are used for producers, there would be above 60% of "non-material services" for consumers that were ignored under the MPS (NBS, 2001, Table 3-5).

As shown by the formula below, the gross value of output of “non-material services” C_t^{ns} consists of two components:

(1) $$C_t^{ns} = C_t^{ns1} + C_t^{ns2}$$

where for a given reporting period *t*, C_t^{ns1} stands for the gross value of the “non-material services” used (paid) by the material sectors and C_t^{ns2} stands for the gross value of the rest “non-material services” used by consumers that are excluded from the MPS.

Now, for all the material sectors under the MPS, let the value of material inputs be C_t^m, the value of depreciation of fixed capital be D_t^m,[10] and (net) value added from the material production be V_t^m, we therefore define GMP (gross material product) for the total economy as:

(2) $$\text{GMP}_t = C_t^m + V_t^m + D_t^m + C_t^{ns1}.$$

Here, C_t^{ns1} is paid by the material sectors. Next, we can obtain the standard measure of the NMP by subtracting C_t^m and D_t^m from Eq. 2, which equals to the sum of the net value added (V_t^m) and payments to the “non-material” services (C_t^{ns1}), that is:

(3) $$\text{NMP}_t = \text{GMP}_t - (C_t^m + D_t^m) = C_t^{ns1} + V_t^m$$

Neither GMP nor NMP is compatible with the SNA concept of gross value added or GVA (= GDP), which includes net value added and depreciation of all productive activities (as defined by SNA), that is, to follow the above notations:

(4) $$\text{GVA}_t = (V_t^{*m} + D_t^{*m}) + (V_t^{ns1} + D_t^{ns1}) + (V_t^{ns2} + D_t^{ns2}).$$

The three components on the right hand side of Eq. 4 given in brackets are: 1) gross valued added by the material sectors under the MPS *plus* the missing “material services” for consumers, which is identified by adding * to the previous notations ($V_t^{*m} + D_t^{*m}$), 2) gross value added by the “non-material services” paid by the material

[10] Strictly speaking, depreciation is one component of the income approach equation rather than the production or value added approach framework. However, it can also be considered part of the value added because some output is to compensate for capital consumption in the current period.

sectors under the MPS ($V_t^{ns1} + D_t^{ns1}$), and 3) gross value added by the rest of "non-material services" that is missing under the MPS ($V_t^{ns2} + D_t^{ns2}$).

Clearly, GMP has serious double counting because it includes the intermediate inputs of all the material sectors (C_t^m). Both GMP and NMP ignore the contribution by a major part of the "non-material services" ($= V_i^{ns2} + D_i^{ns2}$) as well as the "material services" for consumers ($= (V_i^{*m} + D_i^{*m}) - (V_i^m + D_i^m)$). Besides, NMP also has a double counting problem because it includes the gross value of output rather than the gross value added of the "non-material services" used by the material sectors (note that $\frac{C_t^{ns1}}{V_t^{ns1} + D_t^{ns1}} > 1$). Finally, NMP seriously underestimates national income by ignoring capital consumption.

The differences between MPS and SNA imply that firstly, in measuring the real GDP growth, GMP (as well as NMP but to a much less extent – see the double counting problem in the NMP measure as above discussed) tends to exaggerate the real GDP growth if the growth of intermediate inputs is faster than that of the value added. In other words, using our notations, if C^m grows faster than V^m (holding the growth of D_t^m constant), the GDP/GMP ratio will decline over time and, consequently, GMP will have a higher growth rate than GDP. Scholarly studies have shown that this is indeed the case for typical centrally planned economies (e.g. see the case of the Soviet Union by Maddison, 1998b). Wu and Yue (2000) and Wu (2008) have also shown that the Chinese economy has experienced a declining value added ratio over time.

Secondly, if the excluded "non-material services" tends to grow less rapidly compared with the rest of the economy, especially manufacturing, which is widely observed at the earlier stages of economic development in general and in centrally planned economy in particular that tends to sacrifice services, the real growth rate will also be exaggerated.

Criticisms on the Chinese official GDP estimates

Prior to 1992, China's statistical authorities used the Soviet MPS which included double counting and excluded a large part of service activity, therefore systematically overstated growth. There were also serious deficiencies in the basic reporting system. Scholarly work has suggested that official estimates underestimate GDP level while overestimating GDP growth. As various studies have suggested, the underestimation of GDP level was due to the undercoverage effect due to the nature of MPS (see the previous section) and the price distortion effect attributed to government industrial policy under central planning, whereas the overestimation of GDP growth was because of underdeflation of prices while overreporting of output (see Keidel, 1992; Rawski, 1993; World Bank, 1994; Woo, 1996; Maddison, 1998a; Wu, 1997, 2000 and 2002).

As discussed in Wu (2000, pp. 479-480), China's long practice of the Soviet-type "comparable price" approach[11] underestimates inflation because it requires enterprises to report their output at some "constant prices" provided in a price manual specifying 2000 items that was set ten years ago, which tends to create some "substitution bias" especially since China's price reforms.[12] It also tended to ignore the new products subsequently emerged after the benchmark year. Since new products could be over-priced in the absence of reference products, this created leeway for enterprises to exaggerate their real output by categorizing more products as new products and specifying their market prices to be the same as or close to their "constant prices" that were not provided in the price manual. (See Appendix B for a further elaboration of the price problem.)

Institutionally, heavy government intervention in business decision making and the administratively managed data reporting system induced distorted incentives for firms and local officials to exaggerate their growth performance. Reports at the basic level reach NBS through several levels of aggregation in the administrative hierarchy.

[11] China's statistical authorities applied the "comparable price" approach mainly to the traditional "material" sectors such as agriculture, industry and "material services" such as transportation and post-telecommunication. There have been five sets of "constant prices" that were used for constructing real output at "comparable prices", namely, 1952, 1957, 1970, 1980 and 1990 "constant prices" (see SSB, 1997, p. 73; Xu and Gu, 1997, pp. 5-12). Traditionally, only state enterprises and collective enterprises at or above the township level (re-defined as designated size after 1998) were required to make regular report on their output at both "comparable" and current prices as required by this system. The "1990 constant prices" were used till 2002. Afterwards, the prices of the previous year constant-price output were used as the constant prices for the current year output, but this new approach has not been explicitly explained by NBS.

[12] In a market system, commodities whose prices increase more rapidly turn to be substituted by commodities whose prices increase less rapidly or decline. If prices are fixed over a period that is long enough to experience significant price changes, the constant price measure will turn to exaggerate growth after the benchmark year. In the Chinese case, prices have changed or been corrected by the market-oriented reforms especially since the 1990s, yet the official "1990 constant prices" (as part of the long-practiced "comparable price system" developed under MPS) were in use till 2002.

This transmission train provides opportunities for officials at different levels to adjust their reports to reflect favorably on their management. NBS makes crosschecks, but they are necessarily limited in scope.

These problems justify using available *volume movements* to gauge the real growth since it can bypass the official problematic price measures as well as the upward bias due to the institutional problem. However, in the current practice except for two sectors (agriculture and transport), growth measures are not checked or revised based on quantitative indicators of volume movement.

There have been a number of important studies attempting to make alternative estimates using various approaches, such as physical output index (Wu, 2002a), alternative price indices (Jefferson et al., 1996; Ren, 1997; Woo, 1998; Young, 2003), and energy consumption approximation (Adams and Chen, 1996; Rawski, 2001). Despite different results, all appear to be supportive to the upward bias hypothesis for the official data. Rawski (2001) concentrated on the performance in the 1990s and was very critical of the official measure for 1997-98 which reflected "government objectives rather than economic outcomes". In fact, estimates for 1997-98 by Wu (2008) and Maddison and Wu (2008) indeed show the same discrepancy from the official measure. Shiau (2004) re-estimated growth using the expenditure approach and found significantly slower performance than the official measure for 1978-2000. Keidel (2001) also made estimates of GDP growth from the expenditure side for 1979-2000 which show substantial annual divergence from the official measure by industry of origin. His main motivation was to cross-check annual movement of the official figures rather than comment on longer term growth.[13]

4. A NEW ESTIMATION OF CHINESE EMPLOYMENT

China's official data on employment not only have conceptual problems (see Wu, 2002b) but also suffer from structural breaks. Specifically, the official total number of employment jumped from 553.3 million in 1989 to 647.5 million in 1990, suggesting an astonishing 17 percent or 94.2 million increase in one year (Table A3)! This new

[13] There is also a very useful recent evaluation of the literature on official national accounts in the volume edited by Dev Pant (2007) for the Asian Development Bank, which also supports the views by the earlier studies.

total is available with three sector breakdowns (primary, secondary and tertiary) linking to the same breakdowns prior to 1990, but not with estimates at industry level. However, the existing industry level estimates, which follow the pre-1990 tradition, suggest an 80.1 million shortage in the total compared with the new estimate in 1990. The post-1990 data series is then built on this new level of total employment, hence creating a continuous gap with the underlying trend if based on the pre-1990 data series. When the traditional industry level estimation was discontinued in 2002, the gap rose to 99.6 million (NBS, 2009, Table 4-5). Two decades have passed since the gap first emerged, yet there has been neither explanation nor adjustment for the inconsistency by the statistical authority. This has been a serious obstacle to a proper measure of both the level and growth of labor productivity in China.

In this section I adjust the 1989-90 employment data break by investigating the nature of the break and examining the fundamental forces that might affect the demand and supply of labor at the time when the break appeared. Meanwhile, I integrate the adjustment with a new work on estimation of missing military personnel in "non-material services" prior to 1990 – a factor that played an important role in Maddison's value added estimates for such services (Maddison, 1998a and 2007).

Adjustment to the 1989-90 Break

A quick look at the 1989-90 structural break against the background of labor supply and macroeconomic situation gives an impression that the break is rather artificial. On the one hand, the change of working-age population around that time was stable, i.e. no any significant deviation from the trend, and on the other hand, it was impossible for the demand for labor to have any above normal increase in the middle of a serious growth slowdown – by official statistics the growth of GDP dropped to 3.3 percent in 1989 and stayed at around a similar rate (3.2) in 1990 from 10.5 percent in 1988, which was the slowest growth since the reform (Table A6).

As discussed in Yue (2005), the gap is caused by inappropriately liking the results of the 1990 Population Census to the annual estimates that is based on a regular employment registration and reporting system. The population census discovered a large numbers employed who had been missed by the regular reporting system, yet the NBS was not able to integrate the results with the annual estimates at industry level. Nonetheless, without any good reason to ignore the census results, between 1990 and 2002 the NBS continued its census-based estimation for total employment supported by annual population sample surveys and published the results in parallel to annual industry level estimates in a way that disguised the huge underlying inconsistency between the reported totals and the implicit sum of industries.

If this 1990 Census-discovered additional workforce (i.e. 80.1 millions in 1990) did not appear suddenly in 1990, which is a reasonable assumption, a logical inquiry should be whether it had always existed in the economy but never covered by the labor statistical system or it began from a certain period when policy or institutional changes allowed some new types of employment to emerge but not picked up by the registration system. A proper investigation should be conducted on two grounds: checking earlier or pre-1990 population censuses or sample surveys and examining employment policy changes.

China only conducted three population censuses before the 1990 Census, namely 1953, 1964 and 1982. Unfortunately, the available data from the 1953 and 1964 censuses do not contain employment information. However, the 1982 Population Census reports China's total number of employment as 521.5 millions, or 68.6 millions more than the annual estimate of 452.9 millions for that year. Additional information from the 1987 one-percent population sample survey gives an estimate of 584.6 millions or 56.7 millions more than the annual estimate of 527.8 millions (see Tables A2 and A3). It is clearer now that the structural break *at least* started in 1982 rather than in 1990.

My next question is when this additional employment began to exist. There has been ample research suggesting that the government began relax its employment regulation in the early 1970s to give room to the development of rural (then commune and brigade) enterprises and to allow "outside plan" hiring in cities (Wu, 1994). However, new jobs were created in an informal way and many of the new workers were temporal and seasonal in nature and could be engaged in multiple jobs, hence they were insufficiently covered by the reporting system. Therefore, it is reasonable to assume that the discrepancy began in the early 1970s.

In my alternative adjustment scenarios, the two above effects are separately or jointly considered. Before proceeding further, the official employment estimates have to be revised by taking into account the results from the 1982 Population Census and the 1987 Population Sample Survey. I use the total numbers of employment for 1982 and 1987 (sample survey results are multiplied by 100) as the control totals for the two years and use the annual movements between the benchmarks of 1982, 1987 and 1990 to construct a series of control totals between the benchmarks. Consequently, and not surprisingly, the 1990 break is pushed back to 1982 and results in 19.3 percent in 1982. The revised estimates are reported in Table A2 (referring figures from 1982-89, which may be compared with original official estimates for the same period in Table A3).[14] I then propose three scenarios for adjusting the 1982 employment data break.

Scenario 1: The adjustment under this scenario uses a simple smoothing procedure to the problem. It assumes that the employment growth in 1982 follows a linear trend between 1981 and 1983, or 2.9 percent (i.e. an average of 1981 and 1982 growth rates, 3.2 and 2.7 percent, respectively) instead of 19.3 percent. This lifts up the level of employment from 1981 back to 1949, yet maintaining the original official growth rates of that period. As a result, the total employment is raised by 69.3 millions to 506.6 millions in 1981. In the case of 1949, the total employment is raised by 28.7 millions to 209.5 millions. This scenario assumes that all the employment data prior to the 1982 population census are underestimated to the same extent as suggested by the 1982 break. It is the employment reporting system rather than the change of employment policy that underestimated the total numbers of employment.

Scenario 2: This scenario assumes that the "gap" identified by the 1982 census began only from the early 1970s (set it from 1971) when the government began to relax its control over employment especially in rural areas. In the adjustment, the growth rate between 1981 and 1982 is set as 2.9 percent, which is the same as in Scenario 1, to raise the level of employment in 1981, then the annual deviation from the original growth trend in 1970-82 is applied to a new trend over the same period,

[14] The adjustment is made at sector level, including four sectors, namely, agriculture, industry, construction and services. Only the 1982 Census provides sectoral and industry level employment data. However, the number of agricultural employment in the 1982 Census (384.2 million) looks too high – almost the same as that of the 1990 Census (389.1). Its share in the total employment is 74 percent, which is much higher than what suggested by the reporting system (68 percent). This is unreasonable given that the Census is supposed to pick up more non-agricultural employment that is not covered by the reporting system. I then reduce the agricultural employment by 10 percent and reallocate the difference to other sectors by existing weights. The results look plausible with agriculture accounting for 66.3 percent, industry 18 percent, construction 2.2 percent, and services 13.5 percent.

which adds additional employment to each year of the period. The so-added number of employment for 1971-81, which is 69.3 million for 1981 but 4.8 million for 1971, is allocated to each sector as in the case of Scenario 1.

Scenario 3: For the level adjustment this scenario is the same as in Scenario 2. However, instead of allocating the additional employment into each sector according to the existing structure of the economy, it approach assumes that more of the additional employment is engaged in labor intensive non-farming activities. Based on this assumption, the amount of the additional employment that is allocated to the farm sector is assumed only 60 percent of its existing share in the total employment and the rest of the additional employment is allocated to the industrial and the "material services" sectors. The "non-material" services are excluded in this adjustment simply because the additional laborers are least-educated hence unlikely to engage in financial, governmental, healthcare and education services.[15] The full results are based on this scenario and reported Table A2 (Appendix).

TABLE 1
CHINESE EMPLOYMENT DATA ADJUSTED FOR THE 1989-90 STRUCTURAL BREAK: ALTERNATIVE ESTIMATES COMPARED WITH OFFICIAL STATISTICS
(Annual percentage change)

	Working-age Population	NBS Original	NBS Revised	Scenario 1 Results	Scenario 2/3 Results
1949-50	5.6	5.6	5.6	5.1	5.1
1969-70	3.0	3.6	3.6	3.9	3.9
1970-71	2.8	3.5	3.5	3.5	4.2
1971-72	2.5	0.7	0.7	2.0	3.4
1980-81	2.9	3.2	3.2	3.2	4.5
1981-82	*3.1*	*3.6*	*19.3*	*3.1*	*3.8*
1982-83	3.2	2.5	2.7	2.8	2.8
1988-89	2.0	1.8	3.5	3.5	3.5
1989-90	*1.8*	*17.0*	*3.3*	*3.4*	*3.4*
1990-91	1.5	1.1	1.1	2.2	2.2

Sources: Data for working-age population and official employment are from NBS (2009). See the text for the distinction of two NBS series and explanation for the three scenarios. Official statistics refer to end-year numbers whereas the adjusted data are in mid-year estimates. For a comparison with the NBS estimates the adjusted data do not include military personnel. The complete adjusted (including military personnel) and official employment estimates are reported in Tables A2 and A3, respectively.

[15] Strictly speaking, the census-discovered additional employment should be adjusted by part-time hours and allocate these hours into the most labor-intensive manufacturing industries and services based on *industry level* information, which is being conducted in another research project. However, ignoring this fact will not change the current results as they are for the aggregate economy and its broad sectors.

Table 1 shows the alternative adjustments to the official employment statistics for selected time points that are used as benchmarks and their adjacent years. All the estimates refer to the aggregate economy. The annual growth rate of the working age population for these time points is also included to show the potential supply of labor. The NBS revised estimates show the effect of the 1982 Census-based revision that shifts the break backward from 1989-90 to 1981-82. The results of the three scenarios are shown from 1981-82 backward (note that Scenarios 2 and 3 are the same at the aggregate level). Scenarios 2 and 3 have significantly raised the annual growth rate in the period 1970-81 as shown by the three benchmarks and they look plausible considering the changes of the working-age population. Note that differences between my estimates and the NBS estimates in other benchmark years are the effects of my adjustment that changes from end-year to mid-year employment.

Adjustment to "Non-material Services"

My adjustment to the "non-material" service employment is motivated by Maddison's earlier work (1998a) to include military personnel into the non-material services as a standard practice in national accounts for labor employment. As argued by Maddison, the exclusion of military personnel may significantly lowered the service output estimation especially for the earlier period when the military employment was high after the war and engaged in many economic activities.[16] Because of lack of information, Maddison added a fixed 3 millions of army personnel to each year's "non-material service" employment.[17]

My new work is based on a more careful and detailed information gathering (well documented in Appendix C, Table A1). It begins with reconciliation between two sets of employment statistics: the one categorized as "material" and "non-material" and the other classified into major economic sectors. The categorization of "material" and "non-material" employment is just like the official output statistics under the MPS. This practice stopped after 1993, but enough for our purpose because the adjustment

[16] Apart from defense service, military personnel also engaged in construction, transportation, farming and government services in the early period of the People's Republic. Assuming they only engaged in "non-material (and non-market) services" may exaggerate the input and output of these services, but it will not affect aggregate analysis.

[17] Maddison did not change this strong assumption based estimation in the later revision of his work on China's growth performance (2007), which was also maintained in Maddison and Wu (2008).

only focuses on the period prior to the early 1990s. This reconciliation ensures the compatibility of the two employment series over time, and hence ensuring the consistency of the employment of the "non-material services" where military personnel belong to.

The available evidence shows that China's military personnel were not included before 1990. By the time when they were counted into the official employment statistics in 1990 there were about 3 million military personnel in service. However, the missing military personnel prior to 1990 were not a constant of 3 million over time as Maddison assumed. China's armed forces were numbered at about 5.5 million in 1949. After four rounds of demobilization between 1950 and 1956, the number reduced to 2.4 million by the end of 1958. It, however, rose again from the mid 1960s to the mid 1970s because of the bounder tension and conflict with Soviet Union and India. By the end of 1975 it increased to 6.8 million which was the highest in the post-war era. Two new rounds of demobilization were conducted in the post-Mao period promoted by Deng who aimed at maintaining smaller but more modernized armed forces at around 3 million from the end of the 1980s (see Appendix C for details).

The effect of adding the newly estimated military personnel to the existing "non-material services" employment is much stronger for the earlier period than for the later period. After the adjustment, the military personnel accounted 67 percent of the "non-material service" employment in 1949, 27 percent in 1975 and only 5 percent in 1989. This implies that any employment-based level estimation for the earlier period, such as value added based on labor compensation, will be substantially raised and the growth rate will be significantly reduced. For example, compared with Maddison's estimate of 6.3 percent annual growth in "non-material service" employment in 1952-1962, my estimate is only 4.5 percent.

5. AN ADJUSTMENT FOR THE GROWTH OF HUMAN CAPITAL

There has not been sufficient work in this area of research for China due to limited data. Studies using industry data estimate human capital input through changes of labor composition weighted by a labor compensation matrix (see Cao et al, 2009; Wu and Yue, 2010). This kind of studies relies on population census and sample survey data. Since the available censuses and surveys are limited in number and not designed for proper cross-classification by human capital and demographic attributes and do not include labor compensation data, a Mincer type of earnings regression is often used to estimate quality change of labor. It is even more difficult to extend such a study back to the pre-reform period and to cover the whole economy.

In order to capture the human capital effect on output growth over such a long period, this study follows a school of researchers who rely on a measure of education attainment as a proxy for human capital input. Data on education attainment are relatively easy to obtain. There are two sets of education data that are available in the annual Chinese statistics, i.e. numbers enrolled and numbers graduated per annum by level of education. Because of limited information on annual drop off and repeat rates as well as the breakdown of the education system due to political reasons (the decade long Cultural Revolution as an extreme case), which affect the average schooling cycle of each education level, I therefore prefer the use of graduation data to the use of enrollment data.

The annual number of graduates at different levels of education, after a proper adjustment, reflects the newly increased human capital through education that is added to the existing human capital stock. However, it should be noted that the existing human capital stock also contains the knowledge accumulated through on-job training and work experience. Due to little information a human capital measure based on education implicitly assumes, rather strongly, that it fully represents the ability of human capital accumulation through work related training and experience.

I adopt a working hypothesis that the average schooling of the working age population was 1.7 years for 1950, which is the same as Madison's estimate for 1950 but much higher than Wang and Yao (2002)'s estimate of 0.9 years. Maddison used the enrollment data, which might exaggerate the actual annual increase in educated human capital, whereas Wang and Yao used the graduation data. However, to estimate the initial stock for China, Wang and Yao applied the Indian schooling structure in 1960 from Barro and Lee (1997 and 2000), which might underestimate the average years of schooling in China.

Next, I convert annual graduates of different education levels into a measure that is primary schooling-equivalent using arbitrarily assigned impact factors as in Maddison (see notes to Table 2) with an adjustment. That is, the number of graduates at each level is multiplied by its standard years of schooling (see notes to Table 2) and then by its impact factor. For graduates of any level of education only the current level of (not accumulated) years of schooling is counted to avoid double counting.

To set up the initial stock, I first assume the knowledge learnt through school education depreciates by a constant rate of 1 percent a year, which means that about 25 percent of the knowledge will be lost or obsolete 30 years after graduation from high school (at this level it is equivalent to 14.25 years of primary schooling). It follows that given the assumed average years of schooling for 1950 and the size of working-age population, the initial human capital stock is 500 million years of primary school-equivalent education prior to 1950. This is comparable to the total education output (508.8 million years of primary school-equivalent) between 1950 and 1965 after taking the knowledge depreciation into account, which is plausible given that the modern school system had only existed in China for about a half a century[18] in which there were four decades that were heavily affected by nation-wide wars, hence interrupting education and industrialization.[19,20]

[18] The beginning of the modern school system in China could arguably be dated back to as early as 1861 when China's self-strengthening movement (*yangwu yundong*) started.

[19] Thanks to Marcel Timmer's suggestion that a life-table approach using population census data may be used to backward estimate the initial human capital stock in the early 1950s. The quality of the available Chinese population censuses and the possibility of applying the life-table approach will be explored to improve the present study.

[20] Another approach to estimate the initial human capital stock is to assume the annual growth of (primary equivalent) graduation between 1900 and 1949 is the same as that in 1949-52. However, the difficulty is how to take the shocks due to regime change and war damages into account when justifying the plausibility of the results.

TABLE 2

ESTIMATED AVERAGE YEARS OF PRIMARY SCHOOL-EQUIVALENT SCHOOLING PER WORKING-AGE PERSON AND PER EMPLOYED PERSON

Year[1]	Annual flow of education investment[2]	Stock of educated human capital	Working-age population (16-64)	Average schooling per person of working-age population	Number of employment	Average schooling per employed person
	(ml. years of primary-equivalent)	(ml. years of primary-equivalent)	(ml.)	(year)	(ml.)	(year)
Initial value		500				
1950	6	501	298.2	1.68	190.6	2.63
1960	52	728	377.3	1.93	262.8	2.77
1973	139	1,671	497.0	3.36	375.7	4.45
1978	233	2,595	560.4	4.63	426.3	6.09
1992	173	4,613	785.1	5.88	661.2	6.98
1999	225	5,616	851.6	6.60	712.9	7.88
2008	271	7,340	966.8	7.59	774.7	9.47

Sources: Basic graduation data are from NBS (2009 and earlier volumes).

Notes: 1) Most of the reference years are selected to match Maddison (1998a, Table 3.8) and Wang and Yao (2002, Appendix Table). 2) The standard schooling is 6 years for primary, 3 for junior secondary, 3 for senior secondary, 4 for tertiary (including polytechnic institutions), 3 for vocational school and 10 for special school. To convert all levels of education into a primary schooling equivalent standard, which is equal to one, the impact factor is set up as 1.25 for junior secondary, 1.5 for senior secondary, 2 for tertiary education, 1.5 for vocational schools and 1.5 for special schools. See similar set up in Maddison (1998a, Table 3.8).

As shown in Table 2, using the working-age population as the denominator my results show a 3.7 percent of annual growth rate of the educated human capital stock for the pre-reform period and 1.7 percent for the post-reform period (with 1978 as the reform benchmark). My results give a slower growth rate than those by Maddison (1998a) and Wang and Yao (2002). Referring to the same reference years as in Maddison and in Wang and Yao, between 1950 and 1973, my results suggest that the average years of school increased from 1.68 to 3.36 per person or grew by 3.1 percent per annum compared with 0.91 to 2.51 years per person or grew by 4.9 percent per annum in Wang and Yao (2002) and 1.60 to 4.09 years or grew by 4.2 percent per annum in Maddison (1998a). By 1992, my estimates show that the average years of schooling increased to 5.88 compared with 8.50 years per person in Maddison and 5.29 years in Wang and Yao. In the period 1973-92, I show an annual growth of 3 percent whereas the growth rate by Maddison is 4.1 percent and by Wang and Yao is 4.5 percent.

To compensate for the missing information on human capital through on-job training and work experience, I further assume that all educated human capital is used by the workforce as shown in the last column of Table 2. This is not less reasonable if we assumed that an educated working-age person is more likely to be employed. In doing so, since the effect of any type of withdrawal from the workforce is already taken into account, I do not have to account for the age specific mortality of the working-age population (implicitly I assume the age specific mortality rate of the working-age population is the same as in the workforce). Therefore, my estimated average years of schooling are not fully compatible with those by Maddison (1998a) and Wang and Yao (2002). See Table A4-1 and A4-2 for the full estimated results.

6. Estimation of Value-added by "Non-material" Services

In this section, we discuss how the new results are used in the exercise of estimating value added for the "non-material (including non-market)" sector based on Maddison's "zero labor productivity change" assumption and its alternatives proposed in the study.

Based on the labor intensive nature of "non-material" services and evidence of nil or very slow labor productivity growth in the OECD countries (van Ark, 1996, p. 109-115), Maddison argued that the official estimate of gross value added (i.e. GDP) for this sector was implausible because it implied an abnormally high labor productivity growth in such service activities. He showed that the official estimate of GDP growth by "non-material" services was 11 percent per annum for the reform period 1978-2003 (Maddison, 2007a, Table C.6). Together with the relevant official employment data, this means that this sector's labor productivity growth would be at 4.2 percent per annum, which appeared to be too high to be true. It is very likely due to insufficient measure of price changes that exaggerated GDP growth, which has been a long problem in China, particularly in services.[21]

Drawn from the experience of economic history, Maddison used a "zero labor productivity change" assumption in his estimation for China's "non-material" service value added, which meant that the value added would grow along with the growth of

[21] The wage increase of service employees has been much slower than the price increase of services. However, the NBS estimates of the value added in services are based on the income approach.

the employment in this sector. He arrived at an annual value added growth of 5.5 percent in 1978-2003, just a half of the official estimate of 11 percent (10.9 for 1978-2008, Table 3). The impact of this adjustment on China's total GDP growth is about 0.9 percentage points.[22] Consequently, the TFP will be affected by this adjustment but only slightly, *ceteris paribus*.

In this study Maddison's results are revised using my new employment estimates for this sector as discussed in the earlier section. As shown in Table 3, my revision has a slightly downward effect on his original estimate. Both the original and revised Maddison estimates are presented in the table and are compared with the official estimates.

Maddison's "zero labor productivity" assumption has been challenged by some researchers (see Holz, 2006a) who argued that higher GDP growth for this sector is possible. Maddison's rebuttal to Holz (Maddison, 2006) is justifiable at least for the pre-reform period. The official data as presented in Maddison (Table C.6, 2007a) show that there was virtually no labor productivity growth in this sector on average between the early 1950s and the early 1980s. However, there is room to improve Maddison's adjustment by incorporating annual labor productivity movements around the trend (deviation from the trend) as observed in the official data even if the trend has a zero growth. This adjustment is introduced to the pre-reform period in my two alternative estimates in this study. For the reform period, which is redefined for my adjustment as beginning in 1982 when labor productivity started to rise, I assume that it increased by one percent per annum throughout the period 1982-2008 (Alternative I, Table 3). To test how sensitive if this assumption is changed, I further raise the annual labor productivity growth to two percent from 1993 (Alternative II, Table 3) when China adopted the "socialist market economy" policy that deepened the reform and hence speeded up the restructuring of the economy. This assumption may be too strong if not outrageous because a faster growth of "non-material services" following the reform-induced marketization does not necessarily mean an increase in labor productivity in those services. Economic history shows that a transition towards services will lead to a decline in productivity in general.

[22] This impact measure is obtained based on the average share of this "non-material" service sector in the nominal GDP for this period which is 16.8 percent.

TABLE 3
GROWTH OF VALUE ADDED BY "NON-MATERIAL" SERVICES IN CHINA: ALTERNATIVE ESTIMATES COMPARED WITH OFFICIAL ESTIMATES
(Annual percentage change)

	Official	Maddison Original*	Maddison Revised	Alternative I**	Alternative II**
1952-57	9.5	5.5	3.0	3.4	3.4
1957-65	7.1	4.4	5.2	6.7	6.7
1965-71	2.0	1.2	2.0	0.7	0.7
1971-78	4.8	5.1	4.6	3.2	3.2
1952-78	***5.7***	***4.1***	3.9	3.7	3.7
1978-84	11.9	6.6	6.4	9.8	9.8
1984-91	10.5	5.5	5.8	3.3	3.3
1991-01	10.3	5.0	6.3	8.4	9.3
2001-08	11.8	4.0	3.2	4.6	5.7
1978-08	***11.0***	***5.5***	5.5	6.6	7.1

Sources: Official output and employment data used for the estimation are from *China Statistical Year 2009* and earlier issues. Official output data prior to 1978 are from Maddison (2007). See Maddison (1998 and 2007) for his approach and original results.

Notes: Revised Maddison estimates are based on the new employment estimates of "non-material" services in this study. See text for alternative assumptions. Annual growth rate is calculated as arithmetic average of log differences. *The period covered by the original Maddison results is 1952-2003. **The alternative adjustments cover the period from 1982 onwards because official data show the labor productivity of "non-material services" only started to rise in 1982.

My two alternative estimates (I and II) in Table 3 show higher volatility in the planning period with an overall downward effect on Maddison's original results by 0.6 percentage points. Greater volatilities are also observed in the reform period when the alternative assumptions are introduced. They both give a higher growth rate than Maddison's earlier estimates for the reform period as a whole but slower growth for the planning period. The impact of the two alternative adjustments on the real GDP growth rate in the reform period (not shown in Table 3) is a downward effect of 0.78 percentage points with Alternative I and 0.70 percentage points by Alternative II compared with 0.93 by Maddison's original result (adjusted for annual movements). The full results are presented in Table A5 which can be compared with the official GDP estimates in Table A6.

7. A REVISION OF THE WU INDEX FOR CHINESE INDUSTRIAL VALUE ADDED

Earlier studies proposed the upward bias hypothesis against the official estimation for Chinese industrial growth including Adams and Chen (1996), Keidel

(1992 and 2001), Maddison (1998a), Ren (1997), Woo (1998) and Rawski (1993 and 2001). This hypothesis has been supported by various empirical studies, especially by my own work (Wu, 1997 and 2002a) using the physical output of major industrial products or product groups weighted by the input-output table value added weights for 1987 (implying 1987 constant prices). My earlier estimates for 1952-1995 (Wu, 1997) were incorporated in Maddison's re-estimation of China's post-war GDP growth (1998a). In 2002, I further improved the estimates by increasing the number of products and by introducing intra-industry value weights using detailed commodity price data from the National Bureau of Statistics (NBS).[23] A preliminarily simple update of my industrial index was reported in Wu (2007). A refined version of the results was adopted in Maddison (2007a) and Maddison and Wu (2008). The update suggests that the official estimate of China's industrial GDP growth may have been overestimated by 1.75 percentage points for the period 1978-2003, i.e. the official estimate of 11.50 percent per annum compared to my estimate of 9.75 percent per annum. For the pre-reform period 1952-78, the official estimate may have been exaggerated by 1.32 percentage points, i.e. 11.46 percent per annum compared to my estimate of 10.14 percent per annum. For the period 1952-2003 covered by Maddison and Wu (2008), if only the NBS industrial GDP estimates are replaced by my estimates, the impact on the NBS estimate of GDP growth rate is –0.8 percent per annum for the post-reform period and +0.1 percent per annum for the pre-reform period.[24]

My quantity output index approach is not unchallenged. A challenge has come from Holz (2006a).[25] However, his challenge missed the right target or the main deficiency of the approach and ignored the likely bias in the results that are in fact already warned in Wu (2002a). Instead, not only did he carry on the problem of the approach but also simplified it by applying it to a cross country case, meanwhile completely ignored the underlying classical index number problems. As we show in

[23] The industrial classification follows the 1987 input-output table. The intra-industry structure is identified by industry specific almanacs published by relevant national industrial associations together with the commodity price data.

[24] Readers can work out the impact of the Maddison-Wu sectoral adjustment on the GDP growth using the data provided in the paper (2008).

[25] See Maddison's rebuttal to Holz in the same issue of the *Review of Income and Wealth* (2006) where Holz's paper is published. However, the key issues discussed in this study were not sufficiently discussed in Maddison's short reply.

this study, Holz's oversimplified work implies neither the official estimates of industrial growth rate are flawless[26] nor my estimates are implausible.

In Maddison and Wu (2008), we recapped two likely biases in my earlier estimates though we did not tackle them. The first one is the strong assumption that value added ratio or the ratio of gross value added (GDP) to gross value of output (=GVA/GVO) in the 1987 input-output table remained unchanged. However, if the ratio has increased over time, growth would be underestimated; if it declined, growth would be exaggerated. Based on data on net material product (NMP), Wu and Yue (2000) already show that for the industrial sector as a whole the ratio remained stable before the mid-1980s but declined afterwards (p.92, Table 2). However, more detailed information from China's input-output tables suggests that the ratio declined generally over the entire post-reform period. In 1987, the ratio was 0.32 if measured by the NMP approach as in Wu and Yue (2000) or 0.31 by the value added approach (Wu, 2002a, p. 193). It declined to 29 in 1995 (Wu, 2002a, p.193) and had maintained at about this level by 2002 (28 in 2000, NBS, 2004, pp. 71-73; 30 in 2002, DNA, 2006, pp. 84-89). The ratio experienced a further decline along with a new wave of export-oriented growth following China's WTO entry at the end of 2001. By 2007, it dropped to 23 according to China's 2007 Input-Output Table. Therefore, my earlier estimates using the 1987 benchmark may have still exaggerated China's real GDP growth for the post-reform period.

A second potential problem is the so-called substitution bias that is also well known as the Gerschenkron effect (1951). The demand theory suggests that if consumers are rational, changes in prices are negatively correlated with changes in quantities demanded. A quantity index based on prices after the base year would fall short of an index using the base-year prices. In other words, the fixed-weight quantity index will overstate growth rate for the years after the benchmark and understate the earlier growth before the benchmark. In a preliminary exercise in Wu and Yue (2000) showed that if the benchmark were changed from 1987 to 1992, using the 1992 input-output table weights while keeping all others unchanged, China's industrial growth rate would be further lowered by about 1 percent per annum for the period 1978-97,

[26] However, in his recent short article, Holz changed his view and argued that, yet with little empirical support, the growth estimates by local governments were more reliable and closer to the true growth rate than the work by NBS (Holz, 2008).

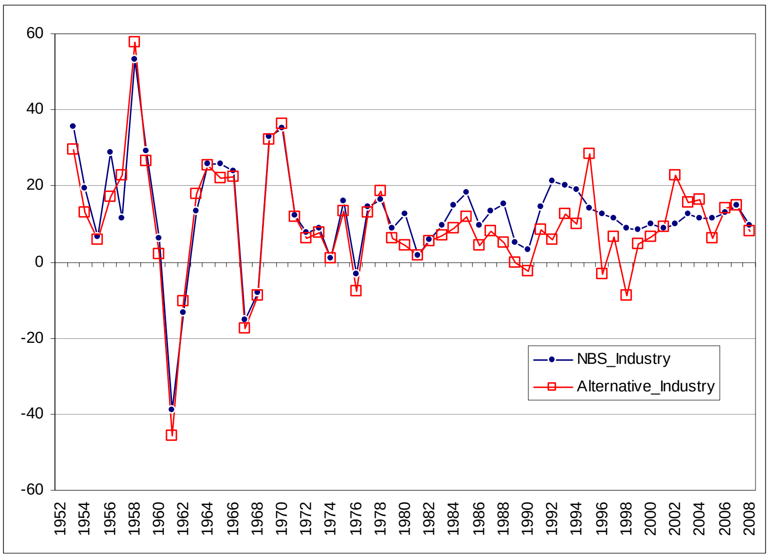
yet raised by 0.1 percent for the period 1952-78. Apparently due to the price controls under central planning, the Gerschenkron effect appears to be evident only in the post-reform period.

In the present study, with an updated and revised commodity series covering the entire period 1949-2008 I first construct three GVO series by industry (4 mining, 19 manufacturing and 1 utilities) using the 1987, 1992 and 1997 input-output table weights, respectively. The results show a clear Gerschenkron effect for the period beginning in 1980 and in 1993 in particular. Taking the industrial sector as a whole for the period 1993-2008 as an example, the so-estimated annual GVO growth rate reduced from 15.3 percent based on the 1987 weights, to 14.1 percent based on the 1992 weights and further to 12.0 if the 1997 weights are used. For the period 1980-1993 the Gerschenkron effect is also downward but by 0.6-0.7 percentage points only. As for the period 1949-80, there is only a trivial upward effect if changed from the 1987 to the 1992 weights, but it becomes downward by 0.3 percentage points if the 1997 weights are used.

Next, to derive the GVA series by industry, I multiply each of the constructed GVO series by the input-output table value added ratios (GVA/GVO) interpolated between benchmarks starting from 1987 when the first Chinese SNA input-output table became available and extrapolated backward from 1987 to 1949 based on the series of the NMP ratio constructed in Wu and Yue (2000). Taking the total industry in the period 1993-2008 as an example, this value added ratio-based adjustment gives an estimate of the annual industrial GVA growth at 12.4 percent if using the 1987 weights, 11.4 percent if using the 1992 weights and 9.5 percent if using the 1997 weights. This means that the adjustment has a substantial downward Gerschenkron effect for this period ranging from 2.5 to 2.9 percentage points by different weights. For the period 1980-1993, it is even stronger ranging 2.9 to 3.3 percentage points. As for the period prior to 1980, it reveals an upward effect of about one percentage point no matter which benchmark weights are used.[27]

[27] One problem in this type of value added adjustment is that it implicitly applies a single deflation approach, i.e. deflating GVO and GVA by the same deflator. It cannot be easily improved because the volume movement approach has bypassed the effect of price changes.

FIGURE 1
CHINA'S INDUSTRIAL VALUE ADDED GROWTH: OFFICIAL VERSUS ALTERNATIVE ESTIMATES
(Percent per annum)



Sources: In constructing the alternative industrial GVA index, commodity data are from DIS (2009) and DITS (2008 and earlier volumes), price data are from a Hitotsubashi University price database (IER, 1999), and the benchmark year (1987, 1992 and 1997) weights are from Chinese input-output tables. Chinese industrial GDP data are from NBS (2009 and earlier volumes).

Finally, I construct a single industrial GVA index by linking the three aggregate industrial GVA indices into one series. Figure 1 presents the annual growth of my alternative Chinese industrial GVA in comparison with that of NBS. This new exercise has further confirmed my previous findings (Wu, 2002a; Maddison and Wu, 2008) with a slower but more volatile industrial growth for the post-reform period. Interestingly, for most of the recessions (negative growth) or significant downturns my commodity-based alternative estimates show a worse situation than what reported by the official statistics. Moreover, my results show the industrial growth was indeed negative at the time of the Asian Financial Crisis in 1998 as hypothesized by Rawski (2001), which resulted in a negative growth in the aggregate GDP (Table A6). My results have confirmed some of the earlier hypotheses that the overheating in 1995 was much more serious than official data suggested and the austerity program imposed in 1996 was by no means a "soft landing". China gained a mild recovery in 1997 but caught in the worst recession in 1998 since the reform.

The full results are reported in Table A5. Table 4 presents a comparison of my and official estimates and the effect of my adjustment on the total GDP growth. The impact of my adjustment is positive by 0.5 percentage points on the growth of planning period but negative by 1.6 percentage points on the growth of the reform period. Besides, my results show a faster growth in the period 2001-08, which is perhaps questionable because the official industrial growth is already very high. Given the nature of high growth volatility in industry, this could be due to partially a relative slow growth basis in the previous period and partially some smoothing procedure in the official statistics.

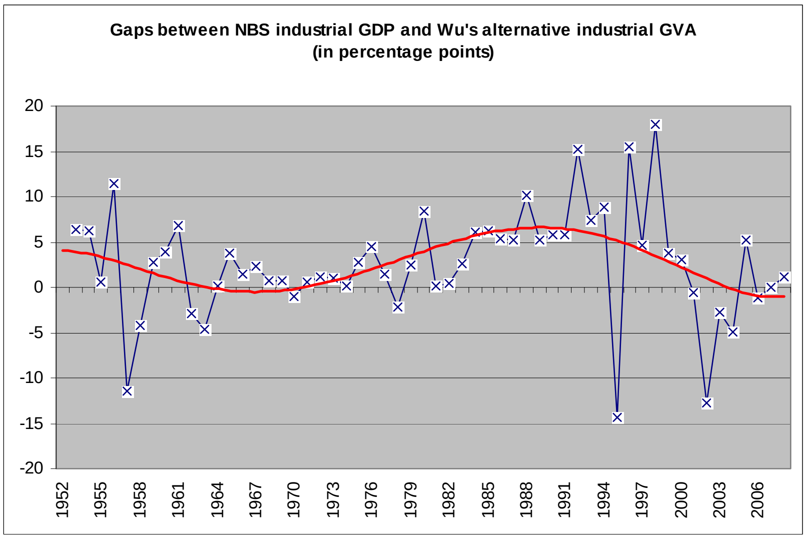
TABLE 4
ALTERNATIVE ESTIMATES OF GROWTH OF INDUSTRIAL VALUE-ADDED IN CHINA
(Annual percentage change)

	Industrial Gross Value Added Growth		Total GDP Growth		
	Official Estimates	Alternative Estimates	Official Estimates	Adjusted Estimates*	Effect of Adjustment
1952-57	19.8	17.4	6.7	7.6	0.8
1957-65	9.0	7.5	2.5	3.0	0.5
1965-71	11.8	10.8	5.3	6.0	0.7
1971-78	8.5	7.1	4.8	4.9	0.1
1952-78	***11.5***	***10.0***	4.6	5.1	0.5
1978-84	8.8	5.5	8.9	7.5	-1.4
1984-91	11.2	4.9	8.3	6.1	-2.3
1991-01	13.3	6.9	10.3	7.6	-2.7
2001-08	11.9	13.9	11.1	11.6	0.5
1978-08	***11.6***	***7.7***	9.8	8.1	-1.6

Source: Table A5.

One of the main criticisms to my commodity-based output index is that it has missed the effect of quality change, that is to say the real quality change was implicitly counted as the price effect and hence removed in the exercise (Holz, 2006a; Rawski, 2008). It is indeed hard to maintain homogeneity of the commodities in the exercise. However, there are many products used that are homogenous in nature e.g. coal, iron oar, salt, basic metals and basic chemicals, and semi-conductors; pressed steel products are measured by types rather than aggregate tonnage, similar products including chemical fertilizers and refined oil products; product groups such as fabrics are measured using available intra-industry information taking into account the quantity and unit value of different fabrics; different types of television set are also made "standardized". Changes of benchmarks in the present exercise have also captured some effect of quality changes.

FIGURE 2
DOES WHAT MISSED REALLY SUGGEST QUALITY CHANGE?



Source: Figure 1.

To see if there is an obvious underestimation of growth by my industrial output index due to insufficient representation of quality change, I derive a series of the differences between the NBS and my alternative estimates. Its filtered trend is intended to get rid off noises. It is reasonable to expect that quality improvement should be steady along with economic development rather than highly volatile as shown in Figure 2. There is simply no meaningful pattern that can be seen from the chart or its filtered trend. If the critique were correct and the gap indeed captured the missing quality changes, Chinese industry seemed to have experienced a continuous quality improvement from the early 1970s to the mid 1980s but significant quality deterioration since the mid 1980s, which is implausible. The findings here simply do not support the critique.

8. ESTIMATION OF CHINA'S AGGREGATE CAPITAL STOCK

Since there are no official estimates for China's aggregate capital stock,[28] researchers have to construct it using available investment statistics. Caution is needed to avoid conceptual pitfalls. Historically, there have been three different official investment series available, i.e. "fixed assets investment (FAI)", "accumulation of national income (ANI)" and "gross fixed capital formation (GFCF)". FAI has a long history dated back to the beginning of the 1950s. It was designed as a comprehensive indicator that measures the size, structure and growth of investment to reflect the economic achievement and to facilitate the central planning.[29] The data collection for FAI is conducted through the investment monitoring authorities at different administrative levels and published by DFAIS (Department of Fixed Asset Investment Statistics, NBS). By contrast, both ANI and GFCF are the concepts of national accounts but in very different national accounting systems. ANI is a MPS concept that began in the 1950s and stopped by 1993 when China shifted to the SNA in principle. Under the Chinese SNA, GFCF replaces ANI. The Department of National Accounts of NBS (DNA) has also revised the historical ANI at least for three times to reconstruct China's historical GFCF (see DNA, 1997, 2004 and 2007).

A good understanding of the differences between these indicators is essential in an effort to construct China's capital stock. Studies before GFCF became available could only use ANI statistics (Chow, 1993; He, 1992). The ANI under the MPS is in a sense a "pure" concept of investment in the material sectors of the economy in that it does not include the depreciation of fixed assets. On the other hand, it is a dirty indicator that includes everything produced under the MPS that is not consumed (mixed of actual investment and inventory) while leaving all "non-productive" investment uncovered. It has no theoretical underpinning by simply adding up the

[28] The NBS indeed provides one capital stock indicator, i.e. end-year fixed asset at original value (historical costs) (FAOV) for mining and manufacturing industries at or above the township level before 1998 and changed to those at or above the designated size afterwards. This poorly designed indicator (mixed of prices at various times) has incomplete coverage and inconsistencies. It is impossible to estimate the aggregate capital stock using this indicator. It is also a big challenge to the estimation of capital stock at industry level (see Wu, 2008b).

[29] FAI consists of three categories that distinguish FAI by nature, namely, "construction and installation", "purchase of equipment", and "other expenses" that are largely consumables to facilitate the above two activities. FAI is also available in eight types: "capital construction", "replacement and upgrading", "real estate development", "other fixed asset investment", "fixed asset investment by urban collectives", "fixed asset investment by rural collectives", "urban private fixed investment", and "rural private fixed investment" (DFAIS, 1997, pp. 444-445).

annual ANI to build up the “stock”. Most would expect the problems of ANI have been carefully tackled when it is converted to GFCF. As discussed below, GFCF under the Chinese SNA is not problem-free.

Another often made mistake is the *direct use* of China’s FAI as the investment variable to estimate net capital stock with the perpetual inventory method (Ho and Jorgenson, 2001; Young, 2003; Huang et al., 2002; Hu and Khan, 1997; Li at el, 1992). By the official definition, FAI is less qualified than GFCF. It excludes any fixed asset investment project that is smaller than 50,000 yuan and any intangible asset; rather it covers the transaction of existing assets (including land transaction).

In China, land belongs to the state or to semi-state organizations in the case of farm land. There is no ownership transfer-based trade of land, but exists the trade of “land use rights”. However, the government (both central and local) controls the primary release of land use rights according to land size, location, price and timing. There have been increasing criticisms on land-revenue and land-financed local public spending and the so-called “(local) government-developer conspiracy” that is considered highly, if not solely, responsible for China’s property bubbles.

There is another problem that affects FAI first and then to some extent carried on in GFCF. FAI is measured as the “workload” in construction and purchase of fixed assets in money terms (NBS, 2001, p.220; DFAIS, 1997, p.444). As correctly noted in Chow (1993, p.816), the work performed as recorded in FAI may not produce results that meet production standards for fixed assets in the current period. In fact, some of the work (investment projects) may take many years to become qualified for fixed assets and some may never meet the standards, hence be completely wasted, which is a typical phenomenon in all centrally planned economies.

The nature of the problem shows the conceptual and practical difference of China’s national accounts from the SNA. The SNA principle governing the time of recording and valuation of GFCF is “when the ownership of the fixed assets is transferred to the institutional unit that intends to use them in production” (CEC *et al*, 1993, p.223). Xu (1999, pp.62-63) notes that in the SNA a plant construction is counted as inventory if it cannot be sold to a buyer (investor) or cannot be used in production but it is included in FAI. The problem is aggravated in the case of a large project that needs several stages (years) to complete in which the investment "workload" is counted at each stage but the project cannot be used for production before all stages are completed.

Nonetheless, even the reported data for this conceptually problematic FAI can be flawed. The "workload"-based accounting system for fixed assets investment has a tendency to exaggerate the real investment. As observed at localities, to fulfill annual growth target the FAI statistics are manipulated: some non-investment spending are reported as fixed asset investment; some previously completed projects are repeatedly reported; some planned future investment reported as actual spending.

In constructing GFCF as part of the national expenditure accounts, now available together with inventory, consumption and net export since 1952, the DNA of the NBS made tremendous efforts and conducted at least three major rounds of adjustment to the historical FAI statistics. But the adjustment procedures have not been made transparent. One can reasonably believe that the underlying problems cannot be easily fixed. In other wards, GFCF still exaggerates investment by including unfinished projects especially in the case of the state sectors. However, it is a better alternative to FAI.

The following questions are how to make an assumption for the initial capital stock, how to deflate the annual investment flow as given in GFCF, and how to determine the rate of capital consumption. Before proceeding ahead, it should be made clear that my estimation of China's aggregate capital stock will exclude the value of land while including the value of residential housing. Strictly speaking, the amount of land asset in an economy can be assumed constant. Thus, whether land should be included in a production function analysis depends if there is significant investment in land that improves the quality of land. Compared with a well developed economy, it is more reasonable to include land in the analysis in the case of a developing economy. However, there is little information for measuring the real change of land quality in China. Residential housing is not productive asset. It is a consequence of the investment in productive assets rather than the investment itself. It is also a central planning tradition for enterprises and government units to provide housing in China.[30] However, how to properly pill off the housing investment from the FAI that satisfies the logic of national accounts is a future task. Information on

[30] Although this system has been substantially changed since China's housing reform in the early 2000s, government units still provide cheap housing for public servants.

housing and non-productive structures is only available at industry level within the industrial sector with incomplete coverage (above the designated size), yet no such information for services.

Existing studies have given very different estimates for China's initial (1952) capital stock ranging from 60 to 250 billion 1952 yuan (He, 1992; Chow, 1993; Ren and Liu, 1997; Maddison, 1998a; Tang, 1999; Wang and Fan, 2000; Young, 2003; Huang *et al*. 2002; Zhang, 2003). In many cases it is never clear how the estimates are made and if they are justifiable by the available sectoral information or the situation of the macroeconomy. The works by Maddison (1998a) and Young (2003) are theoretically sounder. Maddison (1998a) relied on a hypothetical capital/output ratio (0.9) justified by the lower bound of the international standard and some pre-war estimates by Yeh (1968 and 1979). Young (2003) estimated the initial capital stock by assuming that the growth of fixed asset investment is to satisfy the need for output growth and to compensate for capital consumption. By contrast, Chow (1993) relied on some internal information on capital accumulation, Zhang (2003) used data for Shanghai to gauge (rather heroically) the national level of capital stock, and He (1992) applied a regression approach in his exercise.

In the present study, I first estimate the initial capital stock using an approach that is similar to Young (2003) as below:

(5)
$$K_0 = \frac{I_0}{\bar{g} + \delta_0}$$

where K_0 denotes the initial capital stock; $\bar{g}$ is an average output (GDP) growth rate over a (stable) period; δ_0 is a depreciation rate used for the initial stock estimation; I_0 is the investment taking place in the initial year. The net capital stock is then constructed by the standard perpetual inventory method:

(6)
$$K_t = I_t + (1-\delta)K_{t-1}$$

To solve for K_0 of Equation 5 the national accounts GFCF in 1952 for I_0, two measures of the average GDP growth for the period 1952-56 are used for $\bar{g}$ based on NBS and my alternative estimates respectively, and δ_0 is assumed to be 2 percent based on the information from the 1951 national asset census (explained below).

Directly using the unadjusted NBS data including the national accounts implicit deflators, I obtained an initial capital stock of 82.6 billion in 1952 constant yuan. However, if using my alternative estimates for these variables and choosing a 5-percent depreciation rate, the results would be 68.5 billion in 1952 yuan (=171 billion 1990 yuan). Below I explain why the estimate using the official data should be used as the initial level capital stock.

I evaluate the above estimates by some seldom used information from the 1951 National Asset Census verifying and evaluating China's stock of fixed assets, only available for publication in 2000 as a collection of achieve planning documents and papers by SETC (2000, Vol. 1, pp.1543-4). It shows that by the end of 1951, the total market replacement value of fixed assets was 128.3 billion in 1952 yuan. Taking off the accumulated depreciation value of 39.2 billion, the net stock would be 89.1 billion 1952 yuan. The census also gives an annual depreciation rate by sector base on which a weighted average of 1.94 percent can be calculated (I then decided to use 2 percent).[31] My estimate of 82.6 billion using the NBS data comes out quite close to the census result of 89.1 billion. Additional information that can be used for crosschecking is the share of the industrial net capital stock in the total stock. The share is 11.6 percent (for 1951) by the census. If using my estimate for Chinese industry in 1952 (Wu, 2008b), including the residential housing owned by the industrial sector, this share would be 10.9 percent. I am thus convinced that this estimate of 82.6 billion 1952 yuan should be used as the initial stock. This by no means suggests that alternative depreciation rates should not be used in the construction of the capital stock based on this initial level of the stock.

Based on Equation 6 two sets of net capital stock series are constructed. They both use the same set of depreciation rates from on my earlier work on industries, but use very different deflators. My depreciation rates (δ) are based on my earlier work on industrial capital stock (Wu, 2008b). Following Hulten and Wykoff (1981), I assumed $\delta=R/T$ where T stands for asset lives that are based on official accounting regulations (State Council, 1985; Ministry of Finance, 1992) and R is the declining balance rate of fixed assets using the empirical findings by Hulten and Wykoff (1981). The so-

[31] This depreciation rate seems too low given the impact of the wars in China in the first half of the twentieth century. However, it should be noted this depreciation is based on survived assets. Given the severe shortage of capital, producers who managed to keep their production and survived should try hard to prolong asset life and reduce capital consumption.

estimated depreciation rates are ranged from 5 to 7 percent across industries. The present study sets different annual depreciation rates as 5, 6 and 7 percent, respectively, to estimate alternative net capital stocks using the geometric depreciation function. Besides, taking into account an increasing market influence on firms' depreciation decision that may have speeded up the depreciation process of fixed assets, I also introduced a multiple δ depreciation process in the present exercise assuming 5 percent for the pre-reform period, 6 percent for the early reform period 1978-92 and then 7 percent for the period from 1993 onwards. This alternative treatment does not satisfy the theory of economic depreciation; however it is justifiable for reflecting the shifts of policy regime and hence changes in firms' depreciation practice.

The only difference between the two estimates of capital stock is deflator. One uses the NBS expenditure accounts implicit investment deflator that is obtained with nominal investment and growth index of investment at constant price. The other exercise employs an alternative deflator based on my estimation. Two price indices are used in the estimation, namely, producer price index (PPI) for construction materials and PPI for machinery and equipment. The construction materials PPI is a weighted index of non-metallic materials and basic and fabricated metals and the machinery and equipment PPI is a weighted index of seven industries.[32]

TABLE 5
ESTIMATED ANNUAL GROWTH OF NET CAPITAL STOCK BY OFFICIAL AND ALTERNATIVE DEFLATORS AND BY DIFFERENT DEPRECIATION RATES
(Annual percentage change)

	By NBS Deflator			By Alternative Deflator		
	δ=0.05	δ=0.07	Multiple δs	δ=0.05	δ=0.07	Multiple δs
1952-57	10.8	9.3	10.8	8.9	7.4	8.9
1957-65	9.6	8.8	9.6	8.6	7.8	8.6
1965-71	7.5	7.3	7.5	7.4	7.2	7.4
1971-78	9.0	9.0	8.8	9.7	9.8	9.5
1952-78	***9.2***	***8.6***	***9.1***	8.7	8.1	8.6
1978-84	8.3	8.2	7.6	9.2	9.2	8.6
1984-91	9.0	9.0	8.8	9.7	9.7	9.4
1991-01	11.2	11.3	10.6	15.0	15.4	14.7
2001-08	12.8	13.0	12.9	13.7	13.7	13.6
1978-08	***10.5***	***10.6***	***10.1***	12.3	12.4	11.9

Source: Table A7.

[32] They include ordinary and special purpose machinery, transportation equipment, electrical and electronic equipment and office equipment. Machinery as consumer goods cannot be separated.

Table 5 presents the annual growth rate of the official and alternative estimates of China's net capital stock by different depreciation scenarios (results for δ =0.06 are not shown). The full results are reported in Table A8. In general, the estimates using alternative deflator show a slower growth of net capital stock for the planning period but a faster growth for the reform period. The most significant difference between the two results is observed for 1991-2001 of the post reform period when the alternative deflator based estimates suggest an about 4 percentage point faster growth of China's net capital stock than what given by the national accounts implicit deflator for gross fixed capital formation.

TABLE 6
INVESTMENT-CAPITAL RATIO, CAPITAL INTENSITY OF OUTPUT AND "RETURN TO CAPITAL"
(Annual average)

			"Return to Capital"		
	I/K	*K/Y*	*Y/K*.6*	*Y/K*.4*	*Y/K*φ*
1952-57	0.12	0.58	1.04	0.69	1.05
1957-65	0.12	0.91	0.68	0.46	0.68
1965-71	0.12	1.04	0.58	0.39	0.56
1971-78	0.13	1.31	0.46	0.31	0.41
1952-78	***0.12***	***0.97***	***0.68***	***0.45***	***0.67***
1978-84	0.13	1.57	0.38	0.25	0.31
1984-91	0.14	1.86	0.33	0.22	0.27
1991-01	0.19	2.94	0.22	0.14	0.18
2001-08	0.18	4.79	0.13	0.08	0.09
1978-08	***0.16***	***2.85***	***0.25***	***0.17***	***0.21***

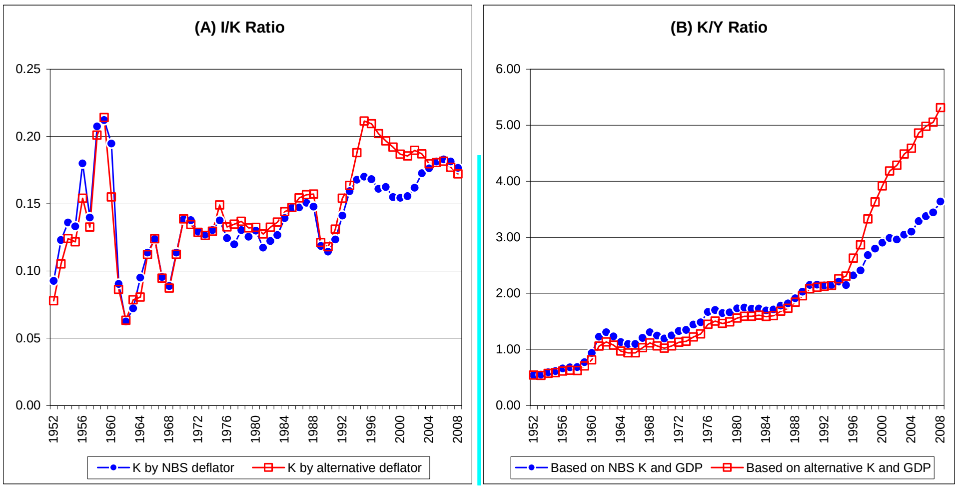
Sources: Tables A6 and A7.

Notes: *Y* refers to the estimates based on my alternative assumption for labor productivity of the "non-material services" (see Alternative II, Table 2); *I* refers to GFCF using the alternative deflator; *K* refers to the estimates based on multiple depreciation rates; the capital share of the national income is given as 0.6 following Chow (1993), 0.4 following Young (2000) and my time-variant estimates (φ) based on the Chinese input-output tables.

Table 6 presents the annual average of investment-capital stock ratio (I/K), capital intensity of output (K/Y) and "return to capital" (Y/K adjusted by the capital share of the total income) for both the planning and reform periods using alternative deflator. Figures 3 and 4 depict the annual series of these indicators compared with estimates using the NBS data.

The change of the I/K ratio suggests that an increasing investment is required for a given unit of capital stock in order to compensate for the capital consumption or to maintain an effective capital stock to support the output growth. The period average of I/K in Table 6 looks fairly stable prior to the 1990s whereas in it appears to be very volatile in Figure 3(A) with some huge shocks along with the shifts of policy regime and changes of macroeconomic situation. The K/Y ratio suggests that China evolved from a labor intensive to a capital intensive economy. It jumped from only 0.97 in the planning period to 2.85 in the reform period of which the sub-period 2001-08 saw the biggest increase (Table 6). As in the case of I/K, the K/Y ratio rose even more rapidly if based on my estimates (Figure 3(B)).

FIGURE 3
INVESTMENT-CAPITAL STOCK RATIO AND CAPITAL INTENSITY OF OUTPUT
1952-2008



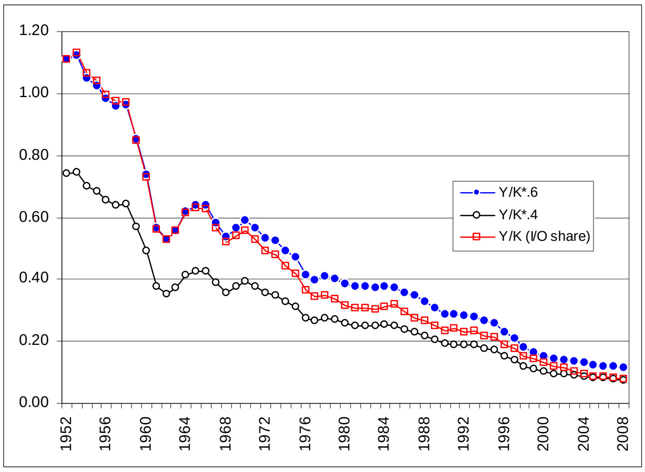
Source: See Table 6.

The estimated "return to capital" in Table 6 is gauged by applying three alternative capital shares of the national income (GDP), that is, 60 percent following Chow (1993) and Chow and Li (2001), 40 percent following Young (2003), and my time-variant estimates using information from the Chinese national accounts and input-output tables which show a decreasing capital share from 60 to 40 percent over time. As will be discussed in the next section, the estimated TFP is sensitive to the choice of the factor shares. All the three estimates suggest a significant diminishing "return to capital" with the fastest decline of the estimate using the time variant national accounts (input-output table) income shares.

FIGURE 4

ALTERNATIVE ESTIMATES OF "RETURN TO CAPITAL" IN CHINA

1952-2008



Source: See Table 6.

While the overall picture does not look encouraging, there are signs with interesting implications for further investigations (Figure 4). The central planning period experienced the most rapid decline in the history of the People's Republic indicating a very high cost of the growth under the central planning. The Cultural Revolution (1966-76) period was also very inefficient in terms of capital productivity. Beside, the central planning period saw greater volatilities in this ratio with unusual jumps in 1963-65 and 1969-70, apparently as a compensation for the unusual drops earlier – all can be explained by policy shocks. Yet, the economic reform has not turned around the general trend of the diminishing return to capital, but it indeed temporarily stopped the decline of the ratio in 1980-85 and 1990-95 likely due to positive policy and institutional effects. The decline of the ratio resumed since the mid 1990s and continued over the subsequent 15 years when China emerged as the "world factory".

9. CHINA'S PRODUCTIVITY PERFORMANCE REVISITED

Following the above discussion of the key data problems and the construction of alternative estimates for the variables required for the standard productivity analysis, this section provides TFP estimates using alternative data for the Chinese Economy.

As mentioned in the earlier discussion, to investigate whether it is the data problems that have caused the contradictory TFP estimates the present study applies the same Solow model used in almost all growth accounting studies on the Chinese economy. Therefore, I also begin with an assumption of a linearly homogeneous Cobb-Douglas aggregate production function with a Hick's neutral shift parameter:

(7) $$Y = A(t)K^{\alpha}L^{1-\alpha}$$

where Y, K, and L denote output, capital, and labor, respectively, α denotes the output elasticity of capital, and the Hicksian A, which is assumed to be a function of time t, measures the shift in the production function at the given level of capital and labor. With total (logarithmic) differentiation and then a little mathematical rearrangement, we could get the Solow residual:

(8) $$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \frac{\partial Y_t}{\partial K_t}\frac{K_t}{Y_t}\frac{\dot{K}_t}{K_t} - \frac{\partial Y_t}{\partial L_t}\frac{L_t}{Y_t}\frac{\dot{L}_t}{L_t}$$

Here comes the key link between the unobserved output elasticity of capital ($\alpha = \frac{\partial Y}{Y} / \frac{\partial K}{K}$) and labor ($1-\alpha = \frac{\partial Y}{Y} / \frac{\partial L}{L}$) and the observable income shares of capital and labor, which hinges on Solow's assumption that each input is paid its marginal product. As said, this is a theoretical as well as an empirical issue that will not be investigated in the present study.

However, while sticking to the Solow model one more important issue to discuss before we proceed further is how to determine the income shares of capital and labor. As a preliminary treatment, I opt for the direct use of the income shares from the input-output tables by simply taking the labor compensation as α and capital compensation as $(1 - \alpha)$ for each year, which gives a set of time-variant estimates for α.[33] There was a clear decline of α from about 0.59 in 1952 to 0.45 in 1978 and further to 0.41 in 2008. To compare my results with the income shares of factors typically used in most of other studies, I choose a fixed $\alpha = 0.6$ following Young (2000) and a fixed $\alpha = 0.4$ as in Chow (1993).[34]

In Table 7, I report three sets of estimates based on the three different assumptions of labor share ($\alpha = 0.6$, $\alpha = 0.4$ and α = time-variant IO shares); each set

[33] There is of course room to further improve the measure of labor compensation within the input-output framework. For example, taxes should be allocated to labor and capital by appropriate shares and more importantly labor share should be adjusted for self-employment (Gollin, 2002).

[34] A new estimate by Chow and Li (2001) gives an even higher capital share as 0.63 suggesting that the labor share is only 0.37.

contains results using both the official data and my adjusted data. It is clear that the adjusted GDP growth rate has the most impact on the reform period. Let us take the results based on the input-output table income shares as an example. Compared with the results using the official data, the results using the adjusted data raise annual GDP growth by 0.5 percentage points for the central planning period but reduce annual GDP growth by 2 percentage points for the reform period. For the growth of capital stock, compared the estimates using the national accounts implicit deflator, the estimates using my alternative deflator have trivial effect on the planning period but raise the growth by 0.9 percentage points per annum for the reform period. The impact of the adjusted labor is not significant for both periods.

TABLE 7

ESTIMATES OF TFP FOR THE CHINESE ECONOMY USING OFFICIAL AND ADJUSTED DATA WITH ALTERNATIVE INCOME WEIGHTS

(Percent change per annum)

	Data Used Based on Official Estimates[1]					Data Used Based on Adjusted Estimates[2]				
	GDP	Labor Quantity	Human Capital	Physical Capital	TFP	GDP	Labor Quantity	Human Capital	Physical Capital	TFP
Time Variant Input-Output Table Weights										
1952-57	4.7	0.9	0.1	3.4	0.3	6.3	0.8	0.1	2.8	2.6
1957-65	2.1	0.6	0.7	4.1	-3.3	3.4	0.6	0.7	3.7	-1.6
1965-71	5.1	0.9	1.0	3.6	-0.4	4.8	0.9	1.0	3.6	-0.6
1971-78	4.8	0.4	1.4	4.5	-1.5	4.4	0.7	1.4	4.8	-2.6
1952-78	4.1	0.7	0.8	3.9	-1.4	4.6	0.8	0.8	3.8	-0.7
1978-84	8.5	0.6	0.4	4.1	3.4	7.3	0.8	0.4	4.6	1.6
1984-91	7.9	1.0	0.1	4.6	2.2	4.7	0.6	0.1	4.9	-0.9
1991-01	9.8	0.3	0.4	5.2	3.9	7.1	0.3	0.4	7.0	-0.7
2001-08	10.1	0.2	0.5	6.8	2.6	9.6	0.2	0.5	7.1	1.9
1978-08	9.2	0.5	0.3	5.2	3.1	7.2	0.4	0.3	6.1	0.3
Fixed Labor Income Share as 0.60 (Young, 2000)										
1952-57	4.7	0.9	0.1	3.3	0.4	6.3	0.8	0.1	2.7	2.7
1957-65	2.1	0.7	0.8	3.7	-3.0	3.4	0.7	0.8	3.3	-1.4
1965-71	5.1	1.1	1.2	2.9	0.0	4.8	1.1	1.2	2.9	-0.3
1971-78	4.8	0.5	1.8	3.4	-1.0	4.4	0.9	1.8	3.6	-2.0
1952-78	4.1	0.8	1.0	3.3	-1.0	4.6	0.9	1.0	3.2	-0.4
1978-84	8.5	0.9	0.5	2.9	4.2	7.3	1.0	0.5	3.3	2.5
1984-91	7.9	1.4	0.1	3.4	3.1	4.7	0.7	0.1	3.6	0.2
1991-01	9.8	0.3	0.5	4.0	4.9	7.1	0.3	0.5	5.5	0.7
2001-08	10.1	0.3	0.6	4.8	4.3	9.6	0.3	0.6	5.1	3.7
1978-08	9.2	0.7	0.4	3.9	4.2	7.2	0.6	0.4	4.5	1.7
Fixed Labor Income Share as 0.40 (Chow, 1993)										
1952-57	4.7	0.6	0.1	4.9	-0.9	6.3	0.5	0.1	4.0	1.7
1957-65	2.1	0.5	0.5	5.5	-4.3	3.4	0.5	0.5	5.0	-2.5
1965-71	5.1	0.7	0.8	4.3	-0.7	4.8	0.7	0.8	4.3	-1.0
1971-78	4.8	0.4	1.2	5.1	-1.9	4.4	0.6	1.2	5.5	-2.9
1952-78	4.1	0.5	0.7	5.0	-2.1	4.6	0.6	0.7	4.7	-1.3
1978-84	8.5	0.6	0.3	4.4	3.2	7.3	0.7	0.3	4.9	1.4
1984-91	7.9	0.9	0.1	5.0	1.9	4.7	0.5	0.1	5.4	-1.3
1991-01	9.8	0.2	0.4	6.1	3.2	7.1	0.2	0.4	8.2	-1.7
2001-08	10.1	0.2	0.4	7.3	2.2	9.6	0.2	0.4	7.6	1.4
1978-08	9.2	0.4	0.3	5.8	2.7	7.2	0.4	0.3	6.8	-0.3

Source: Author's calculation.

Notes: 1) The official data include unadjusted GDP, unadjusted employment and estimated capital stock deflated by the national expenditure accounts implicit deflator. 2) The alternative data include adjusted GDP by the "Alternative II" approach (Table 3), adjusted employment of "Scenario 3" (Table 1), and the capital stock deflated by alternative deflator. 3) Multiple depreciation rates are used in the estimation of capital stock in both cases.

Consequently, assuming the input-output table income shares, the estimated TFP growth will be substantially reduced from 3.1 to 0.3 percent per annum if shifting from the official data to the alternative data, of which about 70 percent of this downward adjustment (2.8 percentage points) is attributed to the GDP growth adjustment and the rest 30 percent is mainly attributed to the investment deflator adjustment that affect the estimated capital stock. The estimated TFP is sensitive to the change of income share which can be examined by comparing different panels of the table. When the official data are used, the estimated TFP growth will be raised from 3.1 to 4.2 percent per annum with an assumed labor share of 60 percent, but it will be lowered to 2.7 percent with an assumed labor share of 40 percent. In the case of the adjusted data, the estimated TFP growth rate will be raised from 0.3 to 1.7 percent per annum with an assumed labor share of 60 percent, but it will be lowered to -0.3 percent if an assumed labor share of 40 percent is applied.

Obviously, none of these TFP values is unfamiliar in the existing literature as reviewed earlier. This confirms that the estimated TFP growth for the Chinese economy is very sensitive to how data are adjusted. If the discussed data problems are indeed problematic as discussed, the lower bound rather than the upper bound TFP estimates should be closer to the truth. The results also suggest that data problems are much more severe in the reform period than in the planning period.

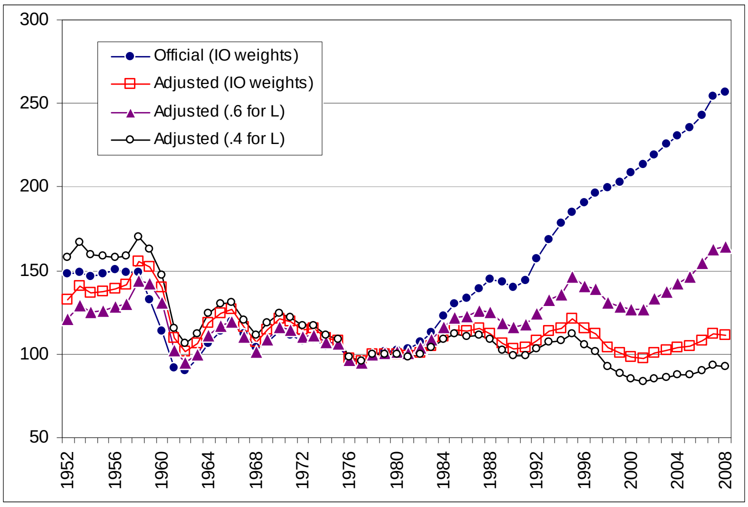
Change of the income shares of factors also has implications for the long-run performance of TFP level. Figure 5 presents alternative TEP level indices for China using my adjusted data with different income shares for labor compared with the estimate using the official data – all by the input-output table weights. It first shows that by any measure China's TFP level declined significantly during the planning era. By 1978 the "best scenario" that assigns 60 percent of income to labor and uses the revised data only arrives at 87 percent of the 1952 level.

For the reform era, it is the estimation using the official data (using the input-output table weights) that gives the highest level of TFP by 2008 as 256 percent of the 1978 level (=100).[35] However, if using the adjusted data and assigning 40 percent of income paid to labor, the level of TFP was only 92 percent of the 1978 by 2008. This

[35] Accumulated TFP from the initial level of 100 in 1978 gives different TFP growth rates from what reported in Table 7 because in the latter it is measured as the arithmetic mean of annual changes in a given period.

is changed to 164 if the labor share is raised to 60 percent. The time-variant input-output weights always arrive in an estimate of somewhere in between.

FIGURE 5
ALTERNATIVE ESTIMATES OF TFP LEVEL FOR THE CHINESE ECONOMY
(1978 = 100)



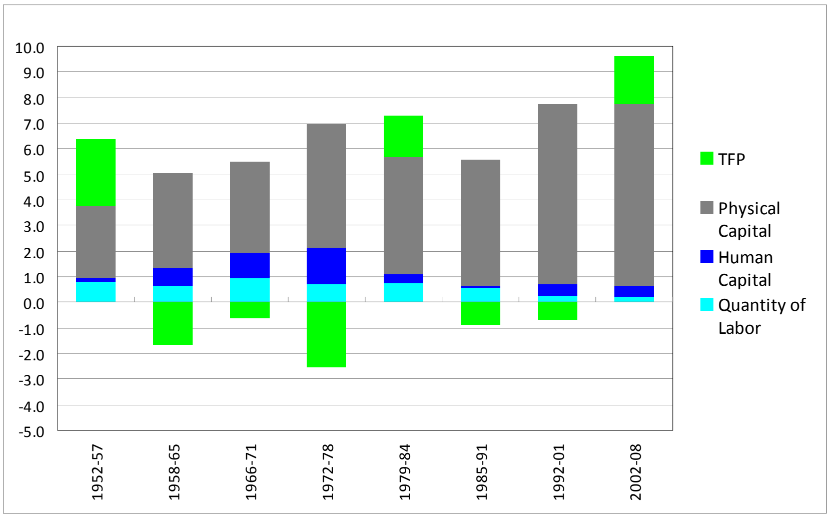
Source: Author's calculation. See notes to Table 7, and Appendix Tables A8 and A9.

In any set of the estimates in Table 7, the growth of capital stock (representing the capital services though arguably) is seen as the most important driver of China's both pre-and post-reform growth, and such an importance was increasing over time. The contribution by the quantity of employment declined significantly. As for the "quality of labor" with the growth of average schooling as a proxy, although it declined in general in the post-reform period compared with the pre-reform period, the trend was somehow reversed since the 1990s. In Appendix Table A8 and A9, sensitivity tests on TFP estimates for changes in GDP estimates and alternative depreciation rates are reported. They show that other things being equal, using Scenario 3 in the employment adjustment does not change the TFP estimate and using the multiple depreciation rates raises the TFP estimate by 0.2 percentage points. That is, choosing different delta within the range of my exercise does not change the result very much.

The estimated TFP performance does not suggest that there has been a stable improvement of productivity or efficiency over time. Figure 6 depicts the estimated TFP performance against the shift of policy regimes represented by periods adopting different policies, that is, the period implementing the Soviet-type central planning in

1952-57, the Maoist "Great Leap Forward" campaign and its aftermath in 1958-65, the early chaotic period of the Cultural Revolution in 1966-71, an attempt to catch up the lost time in 1972-78, the early reform period in 1979-84 focusing on agriculture, the dual-track price reform in industry in 1985-91, the deepening state enterprise reform following Deng's call for bolder reform that led to the official adoption of the "socialist market economy" in 1992, and the period following China's WTO entry in 2001 (assuming the WTO effect began in 2002).

FIGURE 6
SOURCES OF GROWTH OF THE CHINESE ECONOMY
(Percent per annum; period average)



Source: Table 7.

It is clear by a quick glance at the figure that the growth of TFP was not closely associated with the growth of investment. One may therefore be convinced that policy and institutional shocks were the best candidate for the explanation of the changes of TFP growth over different periods. Interestingly, two significant positive TFP gains are observed when China shifted to the central planning in 1952-57 and when China began to depart from the central planning system in 1979-84. One-off incentive gains due to institutional change could be the main reason. However, all major political campaigns, no matter aiming at economic growth, by ideological drive or political control during the pre-reform era resulted in severe negative TFP growth. The "modernization campaign" following China's reestablishment of its formal ties with the West and Japan in 1972-73 brought about the most rapid growth in investment and employment under central planning, but it seemed to be extremely inefficient because of wasteful investment together with deteriorating incentive problems. During the period 1972-78, 40 percent of growth vanished due to inefficiency (negative TFP growth by 2.5 percent).

On the other hand, perhaps contrary to that many may have believed, the earlier or pre-WTO reform measures between mid 1980s and the beginning of 2000s were not TFP growth-promoting. The industrial reform began in 1985 which operated on the backbone of the central planning system brought about a shock reflected by a negative TFP growth in 1985-91. In the following period 1992-2001, the fast ever physical investment made China enjoy the fastest economic growth in history. The efficiency of the economy slightly improved though the TFP growth still remained in the negative zone.

However, as shown in Figure 5, the only period that saw a significant positive TFP growth was the one following China's WTO entry, though not as substantial as that estimated using the unadjusted official data (Table 7). It means that China could benefit from its comparative advantage in labor intensive manufacturing through a substantially enlarged market. China found itself in a very competitive position given that there had been a huge investment and hence a huge production capacity had been built up, of which an increasing part had been underutilized (evidenced by China's persistent deflation from 1998 to 2002). The WTO is productivity promoting because it speeds up the learning by doing process through deeper and wider international market exposure and further institutional reforms pressured by such an exposure.

10. Concluding Remarks

This study is obviously heavily data driven by what I call a "data fundamentalist approach". It revisits the long debate about China's growth performance by seriously tackling the existing data problems that have been the major obstacles to a proper assessment of China's growth performance and the settlement of the debate.

First, it examines and adjusts the serious break in the official employment statistics in 1989-90. Second, it augments the numbers employed by a human capital effect using estimated average years of schooling. Third, it tests the sensitivity of Maddison (1998a)'s "zero labor productivity growth" assumption in gauging the real growth of the so-called "non-material (including all non-market) services" by proposing alternative assumptions using my new employment estimates for these services. Fourth, it further improves the author's earlier physical output-based production index for the industrial sector (Wu, 2002a) by using multiple weights and time-variant value added ratios obtained from the Chinese input-output tables. The likely problem of "product quality" in such a physical measure is examined and rejected. Fifth, it provides a new set of estimates of capital stock for the aggregate economy using alternative deflators and depreciation rates, crosschecked by the author's industry-level capital stock estimates (Wu, 2008b) and made use of China's first asset census in 1950-51. Base on these new data work, a range of TFP growth estimates have been obtained, compared and discussed.

Data tell the truth but they may also hide the truth. To make them truth-revealing one has to identify the problems that disguise the truth and then try to make proper adjustments accordingly. However, any data adjustment has to be transparent. The next is your knowledge about the economy and the institutions (and their deficiencies!) and the mechanism through which the data are produced by state agencies for the economy.

The above is said with the given methodology applied to the data and the underpinning theory. That is, to facilitate a sensible comparison with the existing studies, we have confined the current study to the well known neoclassical growth accounting framework that most of the existing studies explicitly or implicitly adopted.[36] As stated at the beginning of the paper, my purpose is to discover how data problems may affect the estimated TFP growth rather than exploring a new theoretical framework to gauge China's TFP performance. For this purpose, I use the same approach to the existing literature accounting for China's growth performance. The conclusion for the Chinese growth and productivity performance should be made by the reader.

Nevertheless, it is perfectly reasonable to argue that the neoclassical framework used in this study is questionable or unacceptable in terms of the discovery of the truth (Felipe, 1999). Emphasizing data problems does not mean that methodological problems are unimportant. Rather, methodological debate cannot be completely settled before major data problems are resolved.

[36] Despite the long debate about the real meaning of TFP and its usefulness, we still think it is a indispensable tool that provides benchmarks for assessing growth and productivity performance of economies. Interested readers may see a criticism by Felipe (1999) in a review of productivity studies on the East Asian economies.

Given China's increasing impact on the world economy because of its sheer size, fast growth and unique institutional settings for promoting the growth, a proper assessment of and explanation for China's growth performance is an inevitable challenge to the economics profession, not only in terms of empirical data and methodology but also in terms of theory.

My intended data tasks in future will include the followings:

1) Constructing sector level data following the approach used in this paper, but seriously tackling inconsistency problems that may emerge from such an effort especially in the estimation of capital stock.
2) Improving the estimation of the numbers employment by taking into account the actual hours worked by sector, which may give a more reasonable number count and distribution of the discrepancy since 1990.
3) Improving the estimate of the human capital of the workforce by incorporating population census based information.
4) Estimating capital services by adopting the user cost approach in principle and adjusted for data limit.
5) Improving the input-output table based income share estimation by adjusting for self-employed.

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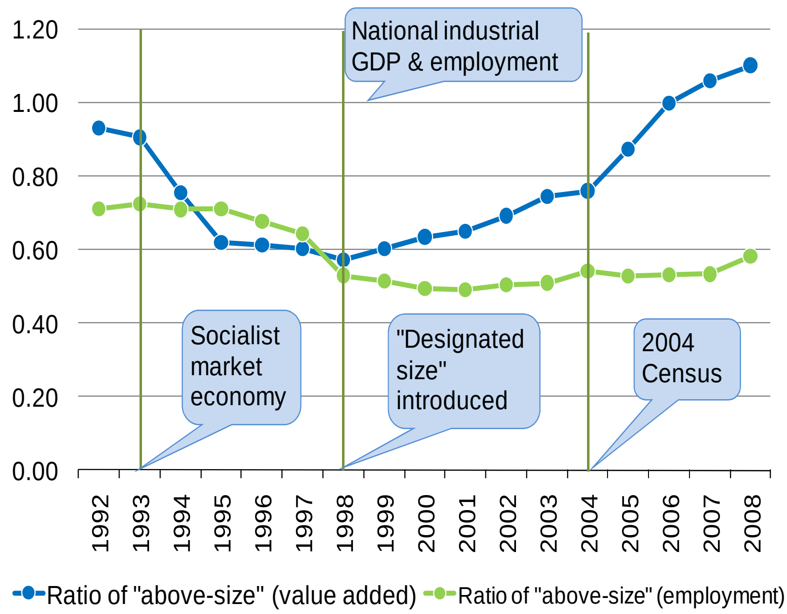
APPENDIX A

THE INCONSISTENCY BETWEEN NATIONAL INDUSTRIAL GDP AND VALUE ADDED BY INDUSTRY

Detailed industry statistics only available based on enterprises at and above the "designated size" through a regular (monthly, quarterly and annually) reporting system. Smaller "below size" enterprises are monitored by regularly conducted sample surveys. There is also workforce "outside the system" is only picked up by population censuses or annual 1% population surveys. The majority of the "outside system" workers is recorded by a loose definition (i.e. "performing one hour wage-earning job in the week of the survey) and mainly seasonal, temporal, multi-jobs, thus not equivalent to an average of those "within the system" (i.e. above & below the "designated size"). A serious inconsistency is found in the current statistical system, that is, the sum of value added of the "above size" began to exceed total industrial GDP estimated by the national accounts from 2005 (Figure A1).

FIGURE A1
VALUE-ADDED AND EMPLOYMENT BY INDUSTRIAL ENTERPRISES AT/ABOVE THE "DESIGNATED SIZE" COMPARED WITH NATIONAL INDUSTRIAL GDP AND EMPLOYMENT



Sources: National accounts data are from various volumes of *China Statistical Yearbook* and the "above size" industrial employment, growth value of output and value added data are from various volumes of *China Industrial Economy Statistical Yearbook*.

The benchmark line (=1) gives the national totals for both value added and employment. There appears to be lack of a system that accommodates all categories of inputs and outputs that make up the national totals. Especially, there is not a coherent balance for all industrial activities categorized as “at/above designated size”, “below size” and the rest (or “outside the system”). Official data show that the sum of the value added by “above size” enterprises was equal to the level of national industrial GDP in 2006 leaving 24 million employed of “below size” and 43 ml employed “outside the system” producing nothing or simply disappeared! However, this sum exceeded the total industrial GDP in 2007 (by 6%) and in 2008 (by 10%)!

At an internal joint workshop between The Conference Board and NBS in the late May 2010, NBS acknowledged three factors that might be able to explain the problem: 1) Inconsistency in the enterprises covered by the “system” with a criterion of 5 million yuan sales – the number of enterprises rose from 160,000 in 1998 to 420,000 in 2008;[37] 2) Double counting due to the so-called “headquarter effect”; 3) Data quality and data falsification. Mainly because of this problem, the Department of Industrial Statistics (DIS) of NBS that is responsible for handling the firm level data at/above designated size and producing estimates of gross output and value added for each industry at/above the size has stopped providing their value added estimates since 2008.

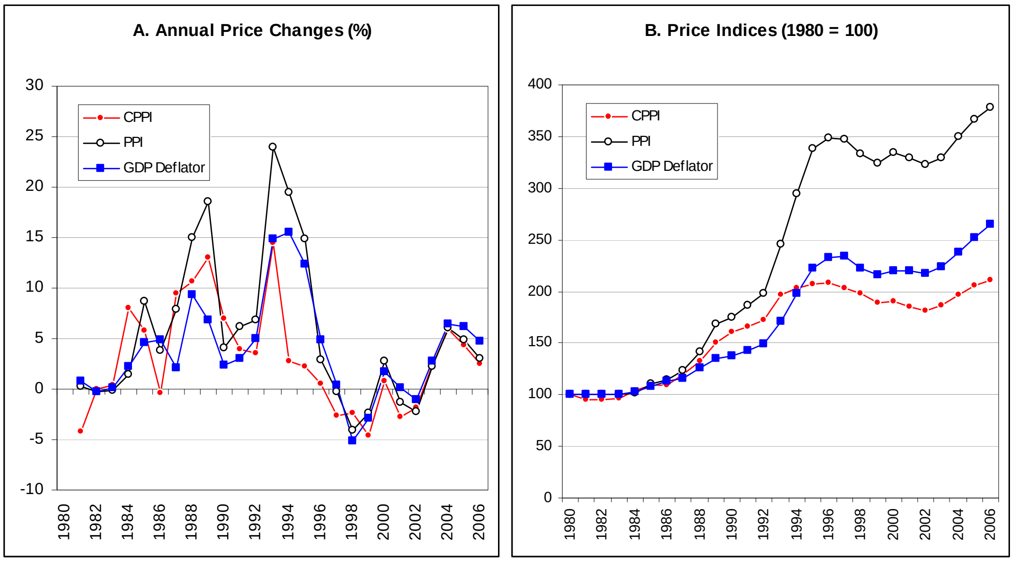
[37] NBS has decided to raise the cut-off line from 5 to 20 million from 2010, which will substantially increase the size of the enterprises covered while reducing the number of enterprises covered. A new inconsistency problem will then be followed.

APPENDIX B

DIFFERENT OFFICIAL MEASURES OF PRICE CHANGES

One of the motivations behind the this type of studies is that volume movements can better gauge the real growth since it can bypass official problematic price data or inflation measures as well as upward bias due to institutional problems in data reporting (exaggerating growth due to political reason). Despite of tremendous efforts made by NBS, problems in price measurement have not gone. Evidence has shown that the price problem has been further complicated by the recent adjustment of real growth rate following China's first Economic Census for 2004. I found that the NBS post-census time series adjustment bypassed deflator problem and was made directly to the real output, which implicitly "adjusted" underlying prices (Wu, 2007). After replicating the adjustment procedures using the standard interpolation approach, it is also clear that the NBS post-census adjustment arbitrarily modified the results obtained by the standard interpolation approach and deliberately left the original but debated estimates for 1998 intact.[38]

FIGURE A2
ALTERNATIVE OFFICIAL PRICE INDICES FOR INDUSTRIAL OUTPUT



Sources & Notes: Basic data for calculating comparable price index (CPPI) are from *China Industrial Economy Statistical Yearbook* (DITS, various issues) and data for calculating the implicit GDP deflator are from *China Statistical Yearbook* (NBS, 2007, pp.57 & 59). PPI data are directly from

[38] The problem of the post-census adjustment is more to do with services. However, we have reservations about the adjusted growth rate also because it is not clear whether the underreported services as discovered by the census only appeared after 1992. If the extent of underreporting was similar prior to 1992, no adjustment is needed, and if it was higher, which is not unlikely because one may reasonably assume that official statistical practices will improve over time, the growth rate should be downward rather than upward adjusted.

China Statistical Yearbook (NBS, 2007, p.330). CPPI is calculated using the "comparable price"-approach estimated industrial GVO and nominal GVO available at industry level. Such data were stopped after 2003. Internal source confirmed that NBS stopped using this approach at least in this part of statistics. To compare with other indices presented here, we assume that CPPI in 2004-06 follows the changes of PPI in all industries, and the so-derived changes for industries are used to estimate changes over this period for the industry as a whole. The implicit GDP deflator is simply derived as the difference between nominal and real growth indices of industrial GDP. The nominal growth index is calculated using NBS nominal GDP data and the real industrial GDP index is directly from the NBS source.

To demonstrate the complicity of the price problem in the estimation of real industrial output, in Figure A2 I present three official price indices for the industry as a whole (including manufacturing, mining and utilities), namely, the comparable price index (CPPI) adopted under the MPS and used until 2003, producer price index (PPI) and an implicit GDP deflator for industry. A note to Figure 1 explains where our data are obtained and how the indices are constructed. It should be noted that both CPPI and PPI refer to the gross value of industrial output, whereas the (implicit) GDP deflator refers to the industrial gross value added. The annual fluctuations follow a similar pattern but to different degrees. The CPPI appears to be the least volatile index while the PPI is the most. The GDP deflator stays in between. Intuitively, it follows that if the nominal output is given, the CPPI suggests the highest real growth, whereas PPI implies the slowest growth, leaving the GDP deflator again in the middle. It is never clear what deflation procedures that NBS follows to estimate the real industrial value added. However, Panel B implies that the (underlying) value added ratio must be high enough and rapidly growing to compensate for the high and rising input prices (reflected by PPI). This is certainly not the case as discussed in Section 7.

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APPENDIX C

ESTIMATION OF CHINESE MILITARY PERSONNEL

A country's armed forces provide national defense services, which are regarded as part of the government services, and hence should be included in the country's service employment. However, there has been little systematic information on China's armed forces. Given that China has maintained the world's largest armed forces through out its post-war history, and its size of military personnel was particularly large in the early 1950s, if military personnel were not counted, China's per capita GDP growth would be exaggerated. Therefore, before estimating China's service GDP we need to check whether the official service employment statistics have included military personnel.

The earliest information can be found in the first official publication on labour statistics, *Zhongguo Laodong Gongzi Tongji Ziliao* [*China labour and Wage Statistics*] *1949-1985* by DSS (Department of Social Statistics, NBS) in 1987. In that publication's "Indicator Explanation", it specifies that both "working-age population" and "general labour resources" indicators do not include military personnel (DSS, 1987, p.267). In one the statistical tables, it also confirms that the "working-age population" counted in China's first (1953), second (1964) and third (1982) population censuses do not include military personnel (p.4). This clearly implies that all official employment series back to 1949 did not include military personnel. The same definition was followed in the later DSS publication in 1989 updating the earlier data (DSS, 1989, p.323) and in the annual labour statistical publication, *China Labour Statistical Yearbook* (CLSY), which started in 1990.

For crosschecking this finding, we have also looked at the explanations for labour statistical indicators in the NBS's annual publication, *China Statistical Yearbook* (CSY), which was firstly released in 1981. I have found that prior to the 1988 issue, CSY did not explicitly explain whether military personnel were included (e.g. see NBS, 1985, p.657). However, it should be noted that CSY did use the same indicator "social laborers" as that used in DSS, which was in fact a sub-category of the "general labour resources" (DSS, 1987, p.267). My comparison of the data in the two publications shows that the statistics for total and service employees in the pre-1988 issues of CSY are the same as those in the DSS publications. In 1988, one year after aforementioned the first DSS publication, CSY adopted the same DSS definition (NBS, 1988, p.206).

An important change came with the 1994 issue of CLSY that for the first time indicated that military personnel should be included in the category of "other persons employed" (DPES and DCPW, p.587). This change also appeared in a collection of government policies on labour statistical indicators jointly published by NBS and Ministry of Labour in the same year (NBS and MoL, 1994, p.9). As for CSY, although it abandoned the DSS definition in the 1994 issue, it did not clearly indicate under what category military personnel should be recorded until 1997. The 1997 issue of CSY showed the same definition for "other persons employed" as that in the 1994 issue of CLSY. But this inconsistency in timing might not be an accident. In fact, a closer examination of the labour statistics show that there was not any change in statistics in 1994 associated with the change of the definition, neither in the total numbers employed nor in the numbers of service employment.

The first adjustment appeared in 1997 in both CLSY and CSY covering the data up to 1996, which only adjusted the previous employment statistics from 1990 to 1995 leaving the pre-1990 series untouched (DPES and DCPW, 1997, p.9; NBS, 1997, Table 4-1). A further adjustment was made in 2002, which revised the series since 1990 again (NBS, 2002). Note that the adjustment was not specifically made for the missing military personnel but for all major sectors of the economy.[39] Therefore the effect of the adjustment for the military personnel is implicit. Following the new definition, one could only say that the military personnel should be included in the "others" of the tertiary employment, but could not tell its actual size for any year of this period. However, one thing is clear that there has been no adjustment for the military personnel for the pre-1990 period.

In what follows, I attempt to construct a time series for China's military personnel using publicly available information. The procedures are presented in Table

[39] The adjustment in 1997 substantially raised the original estimates for employment in 1990-95. It began with the adjustment for 1990. For that year the total numbers employed was raised by 71.69 million from the previous estimation (567.40), of which 43.79 were in the primary sector, 14.96 in the secondary sector and 12.95 in the tertiary sector (NBS, 1997, Table 4-1). The second adjustment was made in 2002. For 1990 it further raised the total numbers employed by 8.4 million, of which 4.86 were in the primary sector, 2.02 in the secondary sector and 1.51 million in the tertiary sector. Note that all these adjustments were made after Maddison made his estimation based on the earlier official statistics (Maddison, 1998a).

A1. I mark the benchmark years with asterisk (*) for which information is available. I also provide the key assumptions for gauging the volume movement between the benchmarks. References for the information used in the estimation are also provided.

TABLE A1

ESTIMATED CHINA'S MILITARY PERSONNEL WITH THE INFORMATION FOR BENCHMARKS AND ASSUMPTIONS FOR THE MOVEMENT BETWEEN BENCHMARKS

(Thousands)

	End-year	Average	Benchmarks and Assumptions for Changes between the Benchmarks
1949*	5500	5500#	Official estimate of the size of the PLA at the end of the Chinese Civil War between the communists and the nationalists (CCSEC, 1994a, p.144)
1950*	4000	4750	China's first post-war demobilization, mainly cutting the size of the army while increasing the air force and navy, reduced the size of the military personnel by 1500 (CCSEC, 1994a, p.144).
1951*	6700	5350	There were large scale recruitments for the Korean War in this year, which increased the size of the military personnel to 6110 according to CCSEC (1994a, p.144). An estimate from other sources is 6270 (Zhang, 2006, p.23; and (Chen, *Youth Daily*, September 7, 2003). Taking an average of the two estimates and plus the armed "public security force" of 510 (CCSEC, 1994b, p.295), our estimate is 6700.
1952*	4700	5700	The second demobilization began in January when the Korean War entered a stage of stalemate. According to CCSEC, the military personnel was demobilized by 2000 (1994a, p.144).
1953	4700	4700	As a decision on a new round (the third) of demobilization was made in August 1953 aiming to complete it by the end of 1955 (CCSEC, 1994a, p.145), we assume there was no change for this year.
1954	4225	4463	Interpolated based on the size in 1953 and in 1955.
1955*	3750	3988	The third demobilization was carried out in 1954-55. We only know that by the end of 1955 the size of military personnel was cut by 21.2% from the level of 1953 (CCSEC, 1994a, p.155).
1956*	3750	3750	As given by CCSEC, at the end of the fourth demobilization (1958) the military personnel was cut by 36% from the 1956 level (1994a, p.155).
1957	3075	3413	Interpolated based on the size in 1958 and 1956.
1958*	2400	2738	The fourth demobilization began in October 1956. By the end 1958 the Chinese military force reduced to around 2400, reaching the smallest size since 1949 (CCSEC, 1994a, p.155). However, Zhang's source suggests 2370 (2006, p.23).
1959	2400	2400	Assume no change from 1958.
1960	2712	2556	No information, assuming constant growth rate interpolation between 1959 and 1965.
1961	3065	2889	Constant growth rate interpolation between 1959 and 1965.
1962	3464	3265	Constant growth rate interpolation between 1959 and 1965.
1963	3915	3689	Constant growth rate interpolation between 1959 and 1965.
1964	4424	4170	Constant growth rate interpolation between 1959 and 1965.
1965*	5000	4712	Based on CCSEC, see the information for 1971 (1994a, p.253)
1966	5154	5077	No information, assuming constant growth rate interpolation between 1965 and 1971.
1967	5313	5234	Constant growth rate interpolation between 1965 and 1971.
1968	5477	5395	Constant growth rate interpolation between 1965 and 1971.
1969	5646	5562	Constant growth rate interpolation between 1965 and 1971.
1970	5820	5733	Constant growth rate interpolation between 1965 and 1971.
1971*	6000	5910	As suggested in CCSEC, the increase of the military personnel had been out of control in the 1960s and by this year it reached a level that was 2.5 times the 1958 level, i.e. rising by 3600, or 120% of the 1965 level (1994a, pp.253-254).
1972	6185	6093	No information, assuming to follow the growth rate of 1965-71
1973	6376	6281	Assume to follow the growth rate of 1965-71
1974	6573	6474	Assume to follow the growth rate of 1965-71

1975*	6775	6674	Assume to follow the growth rate of 1965-71. However, Zhang shows that in 1975 the size of the military personnel increased to 6600 (2006, p.23). Since this figure is very close to our average estimate for this year, we stick to our result.
1976*	5854	6315	The fifth demobilization took place and cut the military personnel by 13.6% from the 1975 level (Chen, *Youth Daily*, September 7, 2003).
1977	5640	5747	By mid-point interpolation.
1978	5427	5534	By mid-point interpolation.
1979	5213	5320	By mid-point interpolation.
1980*	5000	5107	The sixth demobilization was conducted in the late 1980 and the seventh in 1982, together cutting the size by 1000 by the end of 1985, reaching 4000 (Chen, *Youth Daily*, September 7, 2003).
1981	4782	4891	No information, assuming constant growth rate interpolation between 1980 and 1985.
1982	4573	4677	Assume constant growth rate interpolation between 1980 and 1985.
1983	4373	4473	Assume constant growth rate interpolation between 1980 and 1985.
1984	4183	4278	Assume constant growth rate interpolation between 1980 and 1985.
1985*	4000	4091	See the entry for 1980. However, another source suggests the size was 4238 by the late 1985 (Zhang, 2006, p.22)
1986*	3000	3500	The eighth demobilization was decided by Deng in 1985 to cut 1000 by 1986 (CCSEC, 1994a, p.298; Zhang, 2006, p.22). The target was achieved.
1987*	3000	3000	As announced in a press conference in 1986, the PLA would maintain a size of 3000 and officer-soldier ratio 1:3.3 (CCSEC, 1994a, p.312).
1988-96	3000	3000	Assume maintained 3000 as announced in 1987 until 1998.
1997*	3000	3000	The decision on the ninth demobilization was made to cut 500 in the following three years as given in China's Defense White Paper 2000 (IOSC, 2000. p.25).
1998	2823	2912	Assume to be cut at a constant rate between 1997 and 2000.
1999	2657	2740	Assume to be cut at a constant rate between 1997 and 2000.
2000*	2500	2578	Assume to be cut at a constant rate between 1997 and 2000.
2001	2500	2500	Maintained at 2500 as given in China's Defense White Paper 2002 (IOSC, 2002. p.10).
2002	2500	2500	Maintained at 2500.
2003*	2500	2500	The tenth demobilization was decided to further cut 200 by 2005 (Zhang, 2006, p.22).
2004	2400	2450	Assume declined at a constant rate between 2003 and 2005.
2005*	2300	2350	The target of the tenth demobilization was achieved (IOSC, 2006).

Sources: See references in the table and the text.
Notes: Asterisk * marks the benchmark year that is supported by the available information. #Assuming the year average figure is equal to the end-year figure for 1949.

TABLE A2
ALTERNATIVE ESTIMATES OF CHINESE EMPLOYMENT, 1949-2008
(Mid-year estimates in thousands)

	Total	Agriculture	Industry	Construction	Services
1949	182,365	162,311	5,818	1,250	12,986
1950	190,647	167,636	7,213	1,599	14,200
1951	201,402	173,135	8,942	2,045	17,280
1952	209,909	174,314	11,323	2,563	21,709
1953	215,165	175,320	13,099	3,131	23,615
1954	220,443	179,490	14,373	3,612	22,968
1955	224,788	183,715	14,506	4,469	22,098
1956	230,480	185,680	13,874	8,031	22,895
1957	237,358	189,265	13,877	9,173	25,043
1958	254,593	173,995	29,081	17,009	34,508
1959	266,265	158,805	36,482	25,908	45,070
1960	262,821	166,435	29,298	18,272	48,816
1961	260,239	183,815	26,012	8,828	41,584
1962	260,765	205,115	19,644	4,931	31,075
1963	266,439	216,210	16,686	3,799	29,744
1964	276,050	223,835	16,637	4,468	31,110
1965	286,742	230,985	17,616	5,339	32,802
1966	297,452	238,465	19,011	6,029	33,947
1967	308,329	247,310	20,030	6,275	34,714
1968	319,040	256,140	20,620	6,400	35,880
1969	331,262	265,900	22,287	6,578	36,497
1970	344,018	274,640	25,869	6,871	36,638
1971	358,569	282,187	31,371	7,074	37,937
1972	370,723	286,848	37,053	7,064	39,758
1973	381,176	291,546	41,538	7,133	40,959
1974	394,355	298,738	45,705	7,329	42,583
1975	407,832	304,301	50,950	7,750	44,831
1976	420,755	307,990	57,520	8,301	46,943
1977	432,389	309,938	62,859	9,089	50,502
1978	445,275	306,522	72,669	9,340	56,744
1979	460,272	305,337	83,134	9,433	62,368
1980	478,803	312,272	89,689	10,251	66,593
1981	500,538	321,163	96,844	10,933	71,598
1982	518,955	335,917	96,437	11,829	74,772
1983	532,410	348,083	93,068	13,313	77,947
1984	548,320	349,537	95,645	16,283	86,854
1985	567,167	350,841	99,434	20,603	96,290
1986	583,376	354,460	103,328	23,989	101,598
1987	598,070	358,935	106,509	26,143	106,483
1988	613,437	366,085	107,627	27,791	111,933
1989	626,203	376,557	106,113	28,128	115,405
1990	637,803	386,034	107,532	27,729	116,508
1991	651,200	390,061	111,510	27,847	121,782
1992	658,215	388,985	113,032	28,818	127,379
1993	664,800	381,893	114,892	31,708	136,307
1994	671,315	371,539	117,021	34,365	148,390
1995	677,600	360,790	119,190	35,646	161,974
1996	685,075	351,748	121,880	37,411	174,036
1997	693,850	348,300	124,429	39,324	181,797
1998	702,285	350,087	123,828	41,908	186,463
1999	710,155	354,728	120,812	44,289	190,325
2000	717,395	359,054	117,652	45,547	195,142
2001	725,550	362,778	115,721	46,795	200,257
2002	733,825	366,915	113,072	47,248	206,590
2003	740,860	367,081	114,185	45,101	214,493
2004	748,160	359,075	123,142	41,845	224,099
2005	755,125	346,194	132,810	42,210	233,911
2006	761,125	332,655	141,061	45,484	241,925
2007	766,950	320,025	150,186	49,084	247,655
2008	772,350	310,490	156,803	51,887	253,170

Source: See Section 4, Scenario 3, for the method used. Official data in Table A3 are used as a base.
Note: Estimated military personnel for 1949-89 are included in services (see Table A1).

TABLE A3
OFFICIAL ESTIMATES OF CHINESE EMPLOYMENT, 1952-2008
(Mid-year estimates in thousands)

	Total	Agriculture	Industry & Construction	Services
1952	207,290	173,170	15,310	18,810
1953	210,465	175,320	16,230	18,915
1954	215,980	179,490	17,985	18,505
1955	220,800	183,715	18,975	18,110
1956	226,730	185,680	21,905	19,145
1957	233,945	189,265	23,050	21,630
1958	251,855	173,995	46,090	31,770
1959	263,865	158,805	62,390	42,670
1960	260,265	166,435	47,570	46,260
1961	257,350	183,815	34,840	38,695
1962	257,500	205,115	24,575	27,810
1963	262,750	216,210	20,485	26,055
1964	271,880	223,835	21,105	26,940
1965	282,030	230,985	22,955	28,090
1966	292,375	238,465	25,040	28,870
1967	303,095	247,310	26,305	29,480
1968	313,645	256,140	27,020	30,485
1969	325,700	265,900	28,865	30,935
1970	338,285	274,640	32,740	30,905
1971	350,260	281,040	37,540	31,680
1972	357,370	283,400	41,330	32,640
1973	362,530	285,700	43,840	32,990
1974	370,105	290,375	46,020	33,710
1975	377,685	293,370	49,320	34,995
1976	385,010	294,495	53,815	36,700
1977	391,055	293,915	57,210	39,930
1978	397,645	288,285	63,880	45,480
1979	405,880	284,750	70,795	50,335
1980	416,925	288,775	74,605	53,545
1981	430,430	294,495	78,550	57,385
1982	445,100	303,180	81,745	60,175
1983	458,655	310,050	85,125	63,480
1984	473,165	310,095	91,345	71,725
1985	490,350	309,990	99,870	80,490
1986	505,775	311,925	108,000	85,850
1987	520,325	314,585	114,710	91,030
1988	535,585	319,555	119,390	96,640
1989	548,315	327,365	120,640	100,310
1990	600,390	360,691	129,161	110,538
1991	651,200	390,061	139,357	121,782
1992	658,215	388,985	141,850	127,379
1993	664,800	381,893	146,600	136,307
1994	671,315	371,539	151,386	148,390
1995	677,600	360,790	154,836	161,974
1996	685,075	351,748	159,291	174,036
1997	693,850	348,300	163,753	181,797
1998	702,285	350,087	165,735	186,463
1999	710,155	354,728	165,102	190,325
2000	717,395	359,054	163,199	195,142
2001	725,550	362,778	162,516	200,257
2002	733,825	366,915	160,320	206,590
2003	740,860	367,081	159,287	214,493
2004	748,160	359,075	164,987	224,099
2005	755,125	346,194	175,020	233,911
2006	761,125	332,655	186,545	241,925
2007	766,950	320,025	199,270	247,655
2008	772,350	310,490	208,690	253,170

Sources: Various issues of *China Statistical Yearbook* and *China Labor Employment Yearbook*.

TABLE A4-1

CHINA'S SCHOOL GRADUATES BY LEVEL OF EDUCATION, 1949-2008

(Thousands)

	Total Number of Graduates	Of which: *Primary*	*Junior High*	*Senior High*	*Tertiary*
1949	947	646	219	61	21
1950	1,097	783	234	62	18
1951	1,469	1,166	225	59	19
1952	1,743	1,490	185	36	32
1953	3,437	2,935	398	56	48
1954	4,016	3,325	576	68	47
1955	4,254	3,229	870	100	55
1956	5,054	4,051	785	155	63
1957	6,335	4,980	1,112	187	56
1958	7,448	6,063	1,116	197	72
1959	7,354	5,473	1,491	320	70
1960	9,335	7,340	1,422	437	136
1961	8,391	5,808	1,892	540	151
1962	7,837	5,590	1,584	486	177
1963	6,948	4,768	1,523	458	199
1964	7,682	5,674	1,386	418	204
1965	9,098	6,676	1,738	498	186
1966	11,046	9,005	1,620	280	141
1967	11,252	8,995	1,864	268	125
1968	20,416	14,282	5,190	794	150
1969	19,039	14,895	3,614	380	150
1970	23,493	16,525	6,189	676	103
1971	23,120	13,760	8,350	1,004	6
1972	26,680	14,149	10,355	2,159	17
1973	28,311	13,490	11,294	3,497	30
1974	30,041	15,210	10,606	4,182	43
1975	35,063	19,994	10,477	4,473	119
1976	42,279	24,895	12,060	5,175	149
1977	47,380	25,739	15,586	5,861	194
1978	46,800	22,879	16,926	6,830	165
1979	44,811	20,879	16,579	7,268	85
1980	36,573	20,533	9,648	6,245	147
1981	37,398	20,757	11,542	4,959	140
1982	34,708	20,689	10,321	3,241	457
1983	32,315	19,807	9,603	2,570	335
1984	31,917	19,950	9,504	2,176	287
1985	32,681	19,999	9,983	2,383	316
1986	33,948	20,161	10,570	2,824	393
1987	35,357	20,430	11,173	3,222	532
1988	34,749	19,303	11,572	3,321	553
1989	33,790	18,571	11,343	3,300	576
1990	33,564	18,631	11,091	3,228	614
1991	33,616	18,967	10,855	3,180	614
1992	33,588	18,724	11,023	3,237	604
1993	33,682	18,415	11,342	3,354	571
1994	34,342	18,996	11,526	3,183	637
1995	35,969	19,615	12,274	3,275	805
1996	36,439	19,341	12,790	3,469	839
1997	38,600	19,601	14,424	3,746	829
1998	41,987	21,174	15,802	4,181	830
1999	44,228	23,137	15,898	4,345	848
2000	46,034	24,192	16,071	4,821	950
2001	47,191	23,969	17,070	5,116	1,036
2002	48,991	23,519	18,799	5,336	1,337
2003	50,493	22,679	19,956	5,981	1,877
2004	51,388	21,352	20,704	6,941	2,391
2005	52,687	20,195	21,065	8,359	3,068
2006	52,795	19,285	20,624	9,111	3,775
2007	52,659	18,702	19,568	9,911	4,478
2008	52,978	18,650	18,629	10,580	5,119

Source: Various issues of *China Statistical Yearbook*.

TABLE A4-2

ESTIMATES OF EDUCATED HUMAN CAPITAL STOCK IN CHINA, 1949-2008

	Years of Schooling (millions; mixed levels)	Years of Schooling (millions; primary-equivalent*)	Net Human Capital Stock (millions)	Working-Age Population (millions)	Numbers of Employed (millions)	Years of Schooling Per Working-Age Person	Years of Schooling Per Employed Person
1949	5	5	500	282	182	1.77	2.74
1950	6	6	501	298	191	1.68	2.63
1951	8	8	504	314	201	1.61	2.50
1952	10	10	509	324	210	1.57	2.43
1953	19	20	524	331	215	1.58	2.44
1954	22	23	542	339	220	1.60	2.46
1955	23	24	560	346	225	1.62	2.49
1956	27	28	583	354	230	1.65	2.53
1957	34	35	612	364	237	1.68	2.58
1958	41	42	648	372	255	1.74	2.55
1959	39	40	682	378	266	1.80	2.56
1960	50	52	728	377	263	1.93	2.77
1961	43	46	766	372	260	2.06	2.94
1962	40	43	801	374	261	2.14	3.07
1963	35	38	831	382	266	2.17	3.12
1964	40	43	866	390	276	2.22	3.14
1965	48	50	907	398	287	2.28	3.16
1966	60	62	961	411	297	2.34	3.23
1967	61	63	1,014	422	308	2.40	3.29
1968	104	110	1,114	434	319	2.57	3.49
1969	102	106	1,209	447	331	2.70	3.65
1970	120	126	1,323	460	344	2.87	3.85
1971	111	118	1,428	473	358	3.02	3.99
1972	123	134	1,547	486	368	3.19	4.21
1973	125	139	1,671	497	376	3.36	4.45
1974	136	150	1,805	508	386	3.56	4.67
1975	165	180	1,967	517	397	3.80	4.95
1976	202	219	2,167	532	408	4.07	5.32
1977	220	241	2,386	546	416	4.37	5.73
1978	209	233	2,595	560	426	4.63	6.09
1979	197	221	2,790	575	438	4.85	6.37
1980	171	189	2,950	589	453	5.01	6.51
1981	175	191	3,112	607	471	5.13	6.61
1982	167	181	3,262	625	490	5.22	6.66
1983	157	169	3,399	645	508	5.27	6.68
1984	156	167	3,532	665	528	5.31	6.69
1985	158	171	3,668	686	551	5.35	6.66
1986	163	177	3,807	702	572	5.42	6.66
1987	168	183	3,953	720	592	5.49	6.67
1988	163	179	4,092	735	614	5.57	6.67
1989	158	173	4,224	749	633	5.64	6.67
1990	157	173	4,355	763	643	5.71	6.78
1991	158	174	4,485	775	651	5.79	6.89
1992	158	173	4,613	785	658	5.88	7.01
1993	157	173	4,740	795	665	5.96	7.13
1994	161	177	4,869	805	671	6.05	7.25
1995	168	185	5,006	814	678	6.15	7.39
1996	168	187	5,142	822	685	6.25	7.51
1997	176	195	5,286	834	694	6.34	7.62
1998	191	212	5,446	843	702	6.46	7.75
1999	203	225	5,616	852	710	6.60	7.91
2000	212	235	5,795	889	717	6.52	8.08
2001	215	240	5,977	898	726	6.65	8.24
2002	219	247	6,164	903	734	6.83	8.40
2003	222	253	6,356	910	741	6.99	8.58
2004	221	257	6,549	922	748	7.10	8.75
2005	222	263	6,746	942	755	7.16	8.93
2006	220	265	6,943	951	761	7.30	9.12
2007	219	267	7,141	958	767	7.45	9.31
2008	220	271	7,340	967	772	7.59	9.50

Sources: Basic data are from Table A4-1.

Notes: See Table 2. *All “years of schooling” measured in this table are primary-level equivalent except for the first column.

TABLE A5

ALTERNATIVE ESTIMATES OF CHINESE GDP BY SECTOR, 1949-2008

(In million 1990 yuan)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1949	245,505	138,124	29,350	4,291	73,741	56,600
1950	252,776	143,449	30,623	4,477	74,227	56,423
1951	292,583	167,229	32,285	4,720	88,349	66,946
1952	317,736	176,512	32,285	4,720	104,219	80,329
1953	349,106	179,615	41,763	6,438	121,291	89,137
1954	353,271	182,499	47,248	6,220	117,304	83,909
1955	370,694	196,806	50,068	7,079	116,740	83,182
1956	399,479	205,832	58,622	11,919	123,105	85,587
1957	428,046	212,062	72,030	11,168	132,786	94,833
1958	513,907	213,289	113,506	16,752	170,360	126,398
1959	556,058	179,788	143,449	17,707	215,113	164,593
1960	546,681	150,587	146,568	17,955	231,571	181,516
1961	443,434	153,151	79,337	6,212	204,733	170,019
1962	417,553	160,338	71,106	7,691	178,419	147,310
1963	450,336	178,739	83,822	9,683	178,092	145,625
1964	514,178	202,189	105,217	12,162	194,611	158,787
1965	563,001	222,343	128,403	13,451	198,803	158,799
1966	604,724	238,817	157,088	14,715	194,103	147,617
1967	577,810	243,706	129,827	13,980	190,298	145,268
1968	557,207	240,362	118,168	11,337	187,340	145,370
1969	626,757	242,752	156,271	15,249	212,484	161,906
1970	713,597	261,889	212,810	19,885	219,013	162,289
1971	751,792	267,207	237,905	22,291	224,389	165,825
1972	770,222	265,318	253,082	21,822	229,999	166,102
1973	822,376	289,654	272,665	22,564	237,492	168,547
1974	839,207	302,109	275,074	23,963	238,061	169,858
1975	895,978	309,060	311,419	27,270	248,228	176,853
1976	868,348	304,124	287,942	28,443	247,839	178,470
1977	916,283	297,898	325,121	28,927	264,338	185,898
1978	1,023,620	310,648	385,323	28,761	298,888	207,264
1979	1,086,615	329,853	409,186	29,329	318,247	224,811
1980	1,152,160	325,442	426,692	37,171	362,855	244,438
1981	1,205,401	348,426	433,358	38,350	385,267	263,094
1982	1,294,990	388,896	456,364	39,662	410,069	283,717
1983	1,422,816	421,319	488,539	46,430	466,528	318,612
1984	1,585,599	476,264	531,689	51,469	526,177	362,210
1985	1,742,705	485,380	595,433	62,896	598,996	398,626
1986	1,836,844	501,699	620,576	72,878	641,691	409,521
1987	1,985,844	525,864	670,557	85,902	703,521	429,859
1988	2,075,163	538,783	704,563	92,766	739,051	443,523
1989	2,046,607	555,128	703,476	84,932	703,070	432,497
1990	2,075,673	595,832	685,800	85,940	708,101	434,317
1991	2,202,896	609,892	744,329	94,160	754,515	454,545
1992	2,430,161	638,637	788,879	113,960	888,684	525,637
1993	2,719,916	668,632	889,582	134,470	1,027,232	598,844
1994	2,976,006	695,502	979,776	152,860	1,147,868	660,895
1995	3,440,260	730,184	1,257,681	171,810	1,280,585	733,241
1996	3,575,413	767,365	1,219,739	186,430	1,401,879	807,960
1997	3,787,113	794,235	1,301,887	191,310	1,499,681	890,216
1998	3,805,046	822,043	1,184,722	208,560	1,589,721	925,301
1999	3,987,241	845,164	1,240,803	217,490	1,683,784	990,916
2000	4,196,480	865,473	1,324,351	229,820	1,776,836	1,044,687
2001	4,473,083	889,843	1,446,649	245,409	1,891,182	1,109,370
2002	4,994,075	915,776	1,775,319	266,975	2,036,005	1,185,489
2003	5,483,446	938,272	2,049,634	299,235	2,196,305	1,243,017
2004	6,049,793	997,383	2,385,222	323,563	2,343,624	1,312,834
2005	6,571,906	1,049,553	2,537,214	375,317	2,609,821	1,414,156
2006	7,366,567	1,102,031	2,891,708	439,976	2,932,852	1,531,198
2007	8,246,584	1,143,291	3,322,126	511,190	3,269,977	1,641,454
2008	8,776,138	1,204,783	3,596,862	559,763	3,414,730	1,631,465

Source: See Sections 6 and 7 for the estimation.

TABLE A6

OFFICIAL ESTIMATES OF CHINESE GDP BY SECTOR, 1952-2008

(In million 1990 yuan)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1952	218,734	156,385	13,264	4,720	44,365	20,475
1953	240,433	159,356	17,999	6,438	56,639	24,485
1954	245,778	162,065	21,473	6,220	56,019	22,625
1955	263,295	174,869	22,891	7,079	58,457	24,898
1956	291,353	183,087	29,437	11,919	66,909	29,392
1957	302,961	188,763	32,793	11,168	70,237	32,283
1958	339,726	189,518	50,305	16,752	83,151	39,189
1959	338,097	159,385	64,943	17,707	96,062	45,541
1960	321,343	133,246	68,905	17,955	101,237	51,181
1961	258,579	135,111	42,032	6,212	75,224	40,509
1962	253,577	141,191	36,442	7,691	68,253	37,144
1963	279,375	157,146	41,288	9,683	71,258	38,791
1964	323,965	177,417	51,858	12,162	82,527	46,704
1965	369,115	194,627	65,238	13,451	95,799	55,795
1966	397,417	208,640	80,764	14,715	93,297	46,812
1967	388,841	212,604	68,569	13,980	93,688	48,659
1968	378,155	209,203	62,946	11,337	94,668	52,698
1969	416,826	210,876	83,718	15,249	106,982	56,404
1970	474,536	227,114	113,187	19,885	114,350	57,627
1971	502,064	231,429	127,109	22,291	121,235	62,671
1972	515,163	229,346	136,770	21,822	127,225	63,327
1973	555,515	249,987	148,806	22,564	134,157	65,213
1974	570,883	260,237	150,294	23,963	136,389	68,187
1975	610,376	265,441	174,341	27,270	143,324	71,949
1976	602,035	260,663	168,936	28,443	143,993	74,623
1977	634,591	254,929	193,263	28,927	157,473	79,033
1978	697,810	265,490	224,935	28,761	178,624	86,999
1979	742,786	281,775	244,409	29,329	187,272	93,836
1980	807,994	277,597	275,343	37,171	217,882	99,465
1981	847,466	296,981	280,133	38,350	232,003	109,830
1982	917,617	331,220	296,302	39,662	250,433	124,081
1983	1,021,157	358,797	325,107	46,430	290,823	142,908
1984	1,164,404	405,012	373,397	51,469	334,526	170,559
1985	1,318,672	412,480	441,390	62,896	401,906	201,535
1986	1,440,974	426,168	483,949	72,878	457,979	225,809
1987	1,612,045	446,216	548,040	85,902	531,888	258,226
1988	1,769,700	457,569	631,629	92,766	587,736	292,208
1989	1,798,573	471,639	663,559	84,932	578,444	307,871
1990	1,866,782	506,200	685,800	85,940	588,842	315,059
1991	2,039,991	518,348	784,500	94,160	642,983	343,013
1992	2,355,985	542,715	950,570	113,960	748,741	385,693
1993	2,705,323	568,231	1,141,540	134,470	861,082	432,694
1994	3,068,902	590,964	1,357,420	152,860	967,658	480,685
1995	3,415,682	620,516	1,548,030	171,810	1,075,326	527,982
1996	3,751,889	652,168	1,741,620	186,430	1,171,672	577,753
1997	4,054,216	674,991	1,938,780	191,310	1,249,136	639,670
1998	4,376,145	698,610	2,111,330	208,560	1,357,645	693,225
1999	4,677,572	718,172	2,291,140	217,490	1,450,770	757,902
2000	5,044,515	735,408	2,515,350	229,820	1,563,938	831,789
2001	5,433,768	756,000	2,733,437	245,409	1,698,922	917,109
2002	5,914,265	777,924	3,005,974	266,975	1,863,393	1,012,877
2003	6,548,284	797,371	3,389,260	299,235	2,062,418	1,109,130
2004	7,201,992	847,606	3,779,364	323,563	2,251,459	1,220,669
2005	8,049,764	891,942	4,216,885	375,317	2,565,620	1,369,955
2006	9,101,666	936,539	4,759,855	439,976	2,965,296	1,563,643
2007	10,394,290	971,603	5,469,398	511,190	3,442,098	1,813,576
2008	11,381,661	1,023,861	6,012,531	559,763	3,785,506	2,002,241

Source: Nominal data are from various issues of *China Statistical Yearbook* and deflated by implicit national accounts sectoral deflators. The NBS post-2004 data have been adjusted according to the results of the Second (2008) National Economic Census.

TABLE A7

ESTIMATES OF CHINESE NET CAPITAL STOCK, 1952-2008

(In billion 1990 yuan)

	By NBS deflator	By Alternative Deflator		
	(δ=0.05)	(δ=0.05)	(δ=0.07)	(δ=Multiple)
1952	167	167	167	167
1953	181	177	174	177
1954	199	192	186	192
1955	218	208	198	208
1956	252	233	220	233
1957	279	256	238	256
1958	334	304	283	304
1959	403	367	342	367
1960	475	413	382	413
1961	496	429	392	429
1962	503	435	392	435
1963	515	449	400	449
1964	541	464	409	464
1965	579	496	436	496
1966	628	538	472	538
1967	660	565	493	565
1968	688	588	509	588
1969	737	629	544	629
1970	812	694	603	694
1971	895	761	663	761
1972	976	830	723	830
1973	1,062	903	786	903
1974	1,160	985	859	985
1975	1,278	1,099	963	1,099
1976	1,387	1,204	1,055	1,204
1977	1,497	1,322	1,159	1,322
1978	1,632	1,453	1,275	1,440
1979	1,769	1,586	1,392	1,559
1980	1,924	1,730	1,518	1,689
1981	2,063	1,876	1,643	1,820
1982	2,221	2,043	1,790	1,972
1983	2,402	2,234	1,957	2,146
1984	2,632	2,462	2,159	2,357
1985	2,908	2,720	2,390	2,597
1986	3,212	3,030	2,668	2,887
1987	3,561	3,382	2,986	3,218
1988	3,934	3,777	3,341	3,589
1989	4,209	4,053	3,572	3,838
1990	4,481	4,334	3,805	4,091
1991	4,816	4,696	4,118	4,425
1992	5,267	5,211	4,579	4,864
1993	5,867	5,834	5,142	5,408
1994	6,591	6,706	5,946	6,193
1995	7,416	7,914	7,073	7,303
1996	8,322	9,318	8,377	8,591
1997	9,260	10,875	9,814	10,013
1998	10,314	12,612	11,408	11,593
1999	11,390	14,544	13,172	13,344
2000	12,564	16,667	15,100	15,260
2001	13,873	19,065	17,274	17,423
2002	15,413	21,903	19,856	19,994
2003	17,323	25,087	22,746	22,874
2004	19,546	28,493	25,813	25,933
2005	22,179	32,379	29,318	29,429
2006	25,218	36,828	33,334	33,437
2007	28,626	41,671	37,684	37,780
2008	32,327	46,896	42,355	42,445

*Source*s: Investment data are from reconstructed official expenditure accounts. See Section 8 for details of the estimation.

TABLE A8

COMPARISON OF TFP ESTIMATES WITH ALTERNATIVE GDP ESTIMATES USING INPUT-OUTPUT TABLE INCOME WEIGHTS

(Percent change per annum)

	Official GDP			Maddison-Wu GDP			GDP as Alternative I			GDP as Alternative II		
	δ=Multiple	δ=0.5	δ=0.7	δ=Multiple	δ=0.5	δ=0.7	δ=Multiple	δ=0.5	δ=0.7	δ=Multiple	δ=0.5	δ=0.7
NBS Expenditure Accounts Implicit Deflator for Capital Stock												
1952-57	0.3	0.4	0.8	1.9	1.9	2.4	2.0	2.0	2.5	2.0	2.0	2.5
1957-65	-3.3	-3.3	-3.0	-2.4	-2.4	-2.1	-2.0	-2.0	-1.7	-2.0	-2.0	-1.7
1965-71	-0.4	-0.4	-0.3	-0.3	-0.3	-0.2	-0.7	-0.7	-0.6	-0.7	-0.7	-0.6
1971-78	-1.5	-1.9	-1.9	-1.9	-2.0	-2.0	-2.2	-2.3	-2.3	-2.2	-2.3	-2.3
1952-78	-1.4	-1.5	-1.3	-0.9	-0.9	-0.7	-0.9	-0.9	-0.7	-0.9	-0.9	-0.7
1978-84	3.4	3.0	3.0	1.4	1.1	1.1	2.1	1.8	1.8	2.1	1.8	1.8
1984-91	2.2	2.6	2.6	0.0	-0.1	-0.1	-0.5	-0.7	-0.7	-0.5	-0.7	-0.7
1991-01	3.9	3.7	3.6	0.5	0.3	0.2	1.0	0.7	0.6	1.2	0.9	0.8
2001-08	2.6	2.7	2.6	2.1	2.1	2.0	2.1	2.1	2.0	2.2	2.2	2.1
1978-08	3.1	3.1	3.0	0.9	0.8	0.7	1.1	0.9	0.9	1.2	1.0	1.0
Alternative Deflator for Capital Stock												
1952-57	0.9	1.0	1.4	2.5	2.5	3.0	2.6	2.6	3.1	2.6	2.6	3.1
1957-65	-2.9	-2.9	-2.6	-2.0	-2.0	-1.7	-1.6	-1.6	-1.3	-1.6	-1.6	-1.3
1965-71	-0.3	-0.4	-0.3	-0.3	-0.3	-0.2	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
1971-78	-1.9	-2.3	-2.3	-2.3	-2.3	-2.4	-2.6	-2.6	-2.7	-2.6	-2.6	-2.7
1952-78	-1.2	-1.3	-1.1	-0.7	-0.7	-0.5	-0.7	-0.7	-0.5	-0.7	-0.7	-0.5
1978-84	3.0	2.5	2.5	1.0	0.7	0.7	1.6	1.3	1.3	1.6	1.3	1.3
1984-91	1.9	2.3	2.3	-0.4	-0.5	-0.5	-0.9	-1.0	-1.0	-0.9	-1.0	-1.0
1991-01	2.1	1.9	1.8	-1.3	-1.5	-1.6	-0.9	-1.0	-1.2	-0.7	-0.8	-1.0
2001-08	2.3	2.3	2.3	1.8	1.7	1.7	1.8	1.7	1.7	1.9	1.8	1.8
1978-08	2.3	2.2	2.2	0.1	-0.1	-0.1	0.3	0.1	0.0	0.3	0.2	0.1

Source: Author's calculation.

Notes: Adjusted employment data of "Scenario 3" (Table 1) are used in all models.

TABLE A9

COMPARISON OF TFP ESTIMATES WITH ALTERNATIVE EMPLOYMENT ESTIMATES USING INPUT-OUTPUT TABLE INCOME WEIGHTS

(Percent change per annum)

	Official GDP			Maddison-Wu GDP			GDP as Alternative I			GDP as Alternative II		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
NBS Expenditure Accounts Implicit Deflator for Capital Stock												
1952-57	0.3	0.3	0.3	1.4	1.4	1.9	1.4	1.5	2.0	1.4	1.5	2.0
1957-65	-3.3	-3.3	-3.3	-2.3	-2.4	-2.4	-1.9	-2.1	-2.0	-1.9	-2.1	-2.0
1965-71	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.7	-0.6	-0.7	-0.7	-0.6	-0.7
1971-78	-1.5	-1.5	-1.5	-1.6	-1.8	-1.9	-2.0	-2.1	-2.2	-2.0	-2.1	-2.2
1952-78	-1.4	-1.4	-1.4	-0.9	-0.9	-0.9	-0.9	-1.0	-0.9	-0.9	-1.0	-0.9
1978-84	3.4	3.4	3.4	1.5	1.6	1.4	2.0	1.7	2.1	2.0	1.7	2.1
1984-91	2.2	2.2	2.2	-0.4	-0.3	0.0	-0.6	-0.5	-0.5	-0.6	-0.5	-0.5
1991-01	3.9	3.9	3.9	0.6	0.5	0.5	1.0	0.9	1.0	1.2	1.1	1.2
2001-08	2.6	2.6	2.6	2.1	2.1	2.1	2.0	2.2	2.1	2.1	2.3	2.2
1978-08	3.1	3.1	3.1	0.9	0.9	0.9	1.1	1.1	1.1	1.2	1.1	1.2
Alternative Deflator for Capital Stock												
1952-57	0.9	0.9	0.9	2.0	2.0	2.5	2.0	2.1	2.6	2.0	2.1	2.6
1957-65	-2.9	-2.9	-2.9	-1.9	-2.0	-2.0	-1.5	-1.7	-1.6	-1.5	-1.7	-1.6
1965-71	-0.3	-0.3	-0.3	-0.4	-0.2	-0.3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
1971-78	-1.9	-1.9	-1.9	-1.9	-2.1	-2.3	-2.3	-2.4	-2.6	-2.3	-2.4	-2.6
1952-78	-1.2	-1.2	-1.2	-0.7	-0.8	-0.7	-0.8	-0.8	-0.7	-0.8	-0.8	-0.7
1978-84	3.0	3.0	3.0	1.0	1.1	1.0	1.6	1.2	1.6	1.6	1.2	1.6
1984-91	1.9	1.9	1.9	-0.8	-0.6	-0.4	-0.9	-0.8	-0.9	-0.9	-0.8	-0.9
1991-01	2.1	2.1	2.1	-1.2	-1.3	-1.3	-0.8	-0.9	-0.9	-0.6	-0.7	-0.7
2001-08	2.3	2.3	2.3	1.7	1.8	1.8	1.7	1.9	1.8	1.8	2.0	1.9
1978-08	2.3	2.3	2.3	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3

Source: Author's calculation.

Notes: Capital stock data are based on multiple depreciation rates (Table A7) in all models.