CHINA'S GROWTH AND PRODUCTIVITY PERFORMANCE DEBATE REVISITED[*]

- Accounting for China's Sources of Growth with A New Data Set

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ABSTRACT

This study presents a series of careful investigations in both input and output data problems in Chinese official statistics, especially those often ignored or mishandled in the existing studies, including an enormous structural break in employment statistics, an implausibly high post-reform labor productivity growth in the so-called "non-material services", serious inconsistencies in output measures between industrial statistics and national accounts and between volume movements and changes in real values, as well as conceptual problems and flaws in the official measures of fixed asset investment and investment prices. Alternative adjustments for these problems are the basis for the construction of a new set of data for the aggregate economy and its five major sectors in 1949-2012. I find that the impact of external shocks is more pronounced using my alternative GDP estimates than with official estimates. Under the most reasonable scenarios, my results show that China's annul TFP growth is -0.5 and 1.1 percent per annum for the planning and reform period, respectively, much slower than 0.1 and 3.2 percent if using unadjusted official data. However, China's post-reform best TFP growth is found for 2001-07 at 4.1 percent per annum and poorest TFP performance is found for 2008-12 at -0.8 percent per annum. On average, and for most of the sub-periods examined, the results are very sensitive to how GDP estimates are adjusted, followed by what investment deflator is used. But it is less sensitive to how employment data are adjusted and what depreciation rate is adopted.

Keywords: Gross value added; the Gerschenkron effect, numbers employed and hours worked; physical capital stock; human capital stock; total factor productivity; economic development and reform in China

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1. INTRODUCTION

The quality of China's post-reform growth has been the subject of a heated debate in the literature. It draws a significant attention whenever the China model of reform and development is appraised or questioned. The center of the debate is whether China's growth over the reform period is significantly attributed to productivity growth or mainly driven by factor accumulation. Unfortunately, although more and more studies have participated in the debate in the past two decades, it has remained unsettled and inconclusive.

Based on the estimates of total factor productivity (TFP) for the aggregate Chinese economy in the literature, we may approximately categorize the existing studies into two opposite camps, optimistic versus pessimistic.[1] 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 study and 3.6 percent for 1978-2004 in the latter.[2] The "pessimists" may be represented by Young's study (2003) which only estimates China's TFP growth at 1.4 percent per year for the period 1978-1998. Since Young only covers the non-agricultural economy, one may argue that his estimate for the TFP growth should have been even slower if agriculture were included, that is, at best TFP contributed no more than 15 percent of the growth in that period.[3] There are, however, estimates standing in between which includes an estimate of 2.4 percent of annual TFP growth for the period 1978-1999 in Wang and Yao (2002) and 2.5 percent for 1982-2000 in Cao *et al.* (2009).

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[1] For the purpose of this study, we mainly cover the estimates using the aggregate data unless studies using regional and sectoral data that cover the whole economy, e.g. Cao *et al*. (2009) and Y. Wu (2003), except Young (2003) who only covers the non-agricultural economy.

[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 (2007) 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 growth 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.

There are also contradictory findings for more comparable but shorter periods. For example, for the reform period up to the mid-1990s (1978/79-1994/95), China's annual TFP growth rate is estimated at 3.8 and 3.9 percent in Borensztein and Ostry (1996) and Hu and Khan (1997), and even as high as 4.2 percent in Fan *et al*. (1999). These high TFP results can be compared with a much lower estimate at 1.1 percent by Woo (1998) and 1.4 percent (1982-1997) by Y. Wu (2003). Maddison's (1998a) earlier estimate of 2.2 percent stands in between.[4]

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) and 2.8 percent (1993-2005) by He and Kuijs (2007), 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).

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, p.53) 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 that "China stands out for the sheer magnitude of its gains in total factor productivity". By contrast, Young (2003) concluded that the productivity performance of China's nonagricultural sector during the reform period is respectable but not outstanding at all. This echoes Krugman (1994)'s earlier comment that if taking a longer view and benchmarking the measure on the early 1960s rather than 1978, China appears to be more like the East Asian economies, that is, "only modest growth in efficiency, with most growth driven by inputs" (pp.75-76).

It is difficult to settle the debate by any conjecture about the performance of the Chinese economy. For example, China's miraculous performance should be attributed to its structural changes that are in line with China's comparative advantage (Lin, Cai and Li, 1996), reflected by its rapid growth of export-oriented industries in the past two decades. However, empirical studies have shown that other East Asian economies

[4] In this literature review here I concentrate on the results using the aggregate data and adopting the index number approach. But there are some studies that opt for the regression approach, e.g. one by Chow and Li (2002) which gives at an estimate of 3 percent for 1978-98.

that pursued the same export-oriented development did not do well in terms of TFP (Young, 1992, 1994a, 1994b and 1995; Kim and Lau, 1994). Some argue that China's better performance post-reform is benefited from a strong authoritarian regime that can maintain stability and implement industrial policies with a sturdy institutional support or a powerful political structure thanks to Mao's central planning legacy (Oi, 1992; Popov, 2007). However, this reasoning is often taken as a negative factor for the inefficiency of the other East Asian countries.

Xu (2011), on the other hands, rejects such a simple interpretation of China's authoritarianism and attributes China's outstanding productivity performance (based on the findings of Perkins and Rawski, 2008) to what he calls a "regionally decentralized authoritarian (RDA) system", which is a combination of political centralization and economic decentralization (Qian *et al*., 2006 and 2007). Under the RDA, Chinese regions compete fiercely against each other for better performance rankings and regional officials' careers are linked to their performance in the "tournaments" (Li and Zhou, 2005). Besides, financial benefits also incentivize officials deeply involved in local business (Walder, 1995; Oi, 1992). Nevertheless, while it may not be a surprise why the RDA can promote a super fast output growth, it is by no means clear that through what mechanism it can find its way to drive a superb TFP growth.

Instead, there is ample evidence to show the RDA induces various government subsidies for the sake of growth. Typically, the central government suppresses the prices of energy and other primary inputs and the local authorities tend to externalize factor costs of the local selected industries, including the costs of land, energy, labor, capital and environment (Huang and Tao, 2010; Geng and N'Diaye, 2012). While it may not be difficult to understand that at the micro level underpaid costs can exaggerate profit, hence encouraging overinvestment and inefficient use of capital, it is hard to accept that such a negative externality may lead to a better TFP growth.

It is obvious that these conjectures can easily lead to different expectations to empirical results. Bringing in and relying on any of the theoretical arguments can only confuse rather than enlighten our understanding of the most likely problem underlying because there are likely several forces working in different directions. What we are facing is an empirical rather than a theoretical problem.[5] Since all the studies adopted the neoclassical framework and the majority follows the growth accounting approach, a rather simple logic can suggest that the core of the problem lies with data and measurement. Indeed as I have written elsewhere the Chinese official statistics suffer from many deficiencies ranging from inconsistencies in definition, classification and coverage, to the legacy of the material product system (MPS) in national accounting adopted in the earlier period of central planning from the Soviet Union, and from errors caused by inappropriate statistical approaches to data fabrications caused by institutional deficiencies.[6] Regrettably, despite more than two decades of significant scholarly efforts in accounting for China's sources of growth, researchers still have to get back to the data fundamentals and ask whether deficiencies in official statistics have caused significant biases and how to choose appropriate approaches to tackle them or how to justify the reasons for ignoring them.

2. Taking Data Problems More Seriously

While getting back to the data fundamentals does not sound exciting, it is the only way to settle the debate. Taking data problems more seriously does not mean that the data issue is the most important one in this area of research, but it is scientifically and logically an essential issue. Growth accounting is highly data-driven and its results are highly sensitive to what data are used and how variables are measured. Researchers in this field should have be reminded that there were dedicated economists from the 1950s to 1980s whose carefully studied data and measurement problems in the accounting for the sources of growth in the US economy settled intensive debates about the US productivity performance (see Jorgenson, 1990, for a comprehensive review of the contribution of the related studies).[7]

It is necessary to observe the important principles in dealing with data and measurement problems in such studies. First, a targeted data problem should be fully discussed not only with clear evidence but also with an understanding of the behaviors

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[5] The relevance of the neoclassical orthodoxy in the case of China and many other developing and transition economies is highly questionable for its strong institutional and behavioral assumptions (see Pack, 1993; Felipe, 1999), but it is a different issue here. After all, the debate is not about what theory or methodology is more appropriate in the case of China but which result is closer to the reality given the theory and methodology.

[6] See Wu (2000, 2002a, 2007 and 2011), Maddison and Wu (2008) and Wu and Yue (2012) for more discussions.

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

of agents involved in the data generating process. Second, any assumption that is adopted to solve a data problem should be compared with alternative scenarios and supported by sensitivity tests. Third, data work for any industry or sector of an economy should be considered for accounting identity and intersectoral coherence given by a set of control totals in a national accounts framework. Fourth, any adjustment that affects either level or growth rate in one time point must be justified for the flow or stock effect over a longer period. Last but not least, all kinds of data work must be made transparent and unconditionally available for other researchers to repeat the same exercise.

Data problems have indeed been treated as a fundamental issue in some growth accounting studies on China or studies that try to tackle major measurement problems encountered in accounting for China's productivity performance. Instead of taking official data for granted or simply filling data gaps by strong assumptions, those researchers have made significant efforts in identifying data problems in official statistics,[8] investigating their nature, and proposing alternative estimates with testable reasons and empirical supports. They have also tried to make their data and measurement work transparent. Examples of such efforts include studies by Maddison (1998a, 2007), Wu (2002a, 2007, 2008a, 2011), Maddison and Wu (2008) and Keidel (1992 and 2001) on output level and growth rate, Woo (1998), Ren (1997) and Young (2003) on deflators, Rawski and Mead (1998) on farm employment, Young (2003) on human capital, Wu (2002b) on employment, Chow (1993), Holz (2006b and 2006c), Wang and Szirmai (2012) and Wu (2008b) on investment flows and capital stock.

While it will take some time for researchers to decide if these efforts to fix the data problems can be acceptable, there are still unsolved data problems that are obstructing a proper productivity assessment of the Chinese economy. First, as discussed in Maddison and Wu (2008), there is an enormous break in the official aggregate employment data, available with three broad sectors, showing an implausible 17-percent jump in 1990 over 1989. This can be compared to a very plausible 1.5-percent increase in another employment series with much more detailed

[8] In most cases, "official statistics" in this study, especially the statistics of national accounts, refer to the results of reconstructed and subsequently revised GDP estimates since the reform and particularly since the transition in official statistical system from MPS (material product system) to SNA (system of national accounts) in 1987 marked by the 1987 SNA-MPS hybridized input-output table (DNEB and ONIOS, 1991); see SSB-Hitotsubashi (1997), DNEA (1997, 2004 and 2007) and revisions in *China Statistical Yearbooks* by NBS (various issues).

industry breakdowns, which is reported in the same statistical yearbook. As suggested by Yue (2005 and 2006), this problem might be caused by a clash between population census-based estimates and annual estimates through a long-established data reporting system. This requires a careful investigation of the cause of the break and a proper adjustment with sectoral foundation rather than simply smoothing it.

Second, the Chinese official statistics show that the labor productivity of the so-called "non-material services" (a MPS concept that refers to services that are not considered contributing to material production, including all non-market services under SNA) grew at an astonishing annual rate of 5.4 percent for the entire reform period and even at 7.1 percent per annum for 2001-07. Such a performance has never been observed in the human history in normal situation that shows labor productivity in services would grow only by about one or even less than one percent a year, because of the highly labor-intensive nature of most services, especially "non-material services" (van Ark, 1996). Based on this observation, Maddison proposed a "zero-labor-productivity-growth" hypothesis to gauge the real output of those services (Maddison, 1998a and 2007), but it has been debated (Maddison 2006 and Holz, 2006a).

The third problem is with the official estimates of the real industrial output. There was an unnoticed contradiction between the national accounts and the industrial accounts in the official estimates of value added since the late 1990s. The former covers the national economy whereas the latter only covers enterprises at/ above "the designated size" (Appendix A). When the size criterion of five million yuan of annual sales was introduced in 1998, the value added and employment of the "above-designated-size" enterprises accounted for about 60 percent of the industrial totals. However, by 2006 the value added by the "above-designated-size" enterprises was equal to the national industrial GDP and by 2008 it exceeded the national industrial GDP by 10 percent (see more details in Appendix A). This has raised serious questions not only about the quality of the official estimates of the industrial value added and employment data, but more importantly, about flaws inherited in the official statistical system.

In fact, before this new problem with the official industrial statistics had surfaced, I already found that official estimates exaggerated China's real industrial growth by using a commodity index approach (Wu, 1997 and 2002a),[9] which was adopted in Maddison (1998a and 2007) and Maddison and Wu (2008). In a more recent work (Wu, 2011), I show that the impact of external shocks on the industrial GDP growth is more pronounced using my revised commodity index than official estimates. It is now clear that there is a need to revisit the earlier work not only in the wake of the new problem but also to further address two problems in the commodity index approach, that is, the Gerschenkron effect, also known as substitution bias, caused by the single 1987 price weights and the bias of a fixed 1987 value added ratio (Wu and Yue, 2000; Maddison and Wu, 2008; Wu, 2002a and 2011). It is also necessary to investigate whether my commodity-index approach indeed tends to underestimate quality improvement (Holz, 2006a; Rawski, 2008).

This study attempts to improve Chinese data for the standard growth accounting from two dimensions. On the output side (the *numerator*), first, I test the sensitivity of Maddison's value added estimates for "non-material services" under his zero-labor-productivity hypothesis using alternative assumptions and incorporating the annual movements in the official estimates and my new estimates of the military personnel (part of the non-material service employment). Second, I substantially revise my earlier value added estimates for the industrial sector based on a commodity index approach by introducing more price weights and time-variant value added ratios, and examine the results for potential downward bias due to underestimation of quality change.

On the input side (the *denominator*), based on a careful examination using earlier census data, I first work on the measure of labor input. This includes an adjustment to the break in the official employment series at broad-sector level with alternative scenarios, a conversion of the natural employment numbers into to full-time equivalent (FTE) numbers employed based on new evidence on hours worked, and finally augmenting the numbers by an education-based human capital index. Second, I construct a net capital stock series after a careful examination of the available national asset surveys and problems with the initial stock and investment deflators and a choice of measures on capital consumption.

[9] Other studies that adopted alternative price indices (Jefferson *et al*., 1996; Ren, 1997; Woo, 1998; Young, 2003) and energy consumption approximation (Adams and Chen, 1996; Rawski, 2001) also support the upward bias hypothesis.

The rest of the paper is to be organized as follows. Section 3 explains why official estimates for the real output may be biased upwards. Section 4 first adjusts the serious break in the official employment statistics, then, makes a new estimation for the employment in "non-material service", and finally converts employment in natural numbers into full-time equivalent numbers based on hours worked. Section 5 provides new estimates for the value added of China's "non-material services". Section 6 constructs an education-based measure for China's human capital stock. Section 7 substantially revises my commodity-index based estimates for the value added of Chinese industry, focusing on a test of the Gerschenkron effect and the impact of external shocks using multiple price weights. Section 8 constructs alternative series of net capital stocks for the Chinese economy using different deflators and depreciation rates. Section 9 discusses the growth accounting results using this new data set. Section 10 summarizes the new data efforts and concludes the paper with implications of the new findings and the direction of future research.

3. The Upward-Bias Hypothesis

It has long been believed that because of theoretical, methodological and institutional problems the official estimates of China's GDP growth have been biased upwards. In this section, I first show that why the Marxist theory-based MPS tends to exaggerate growth compared with SNA. I then, using the industrial sector as an example, show why the "comparable price system" adopted together with MPS in growth indexing introduces more upward bias because of the improper "linking" segmented indices into one in the official practice. Finally, I discuss why institutional deficiencies also play a role in generating the upward-biased growth estimates.

Why does MPS tend to exaggerate the real growth?

Since China's statistical practice is still influenced by "many central planning legacies" (Xu, 2002a) and there are still "gaps" between the adopted SNA standards and Chinese practices (Xu, 2009), it is necessary to understand the key differences between the MPS and the SNA and their implications in measuring the real output level and growth rate in a more rigorous way. Before proceeding further, it should be noted that our approach is a value-added one, which constructs output from the production-side of the national accounts. Also, for the sake of simplicity, our discussions and mathematical expressions below are in the real terms, leaving the price problem of official statistics in measuring real value added to Section 7.

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

Perhaps contrary to the common perception, the MPS does not completely ignore the contribution by the "non-material services". In the calculation of the 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 the "material production", such as banking or financial services, scientific research, and legal and other business services. The rest of the "non-material services" including residential government services are ignored under the MPS.[10]

As shown by the formula below, the gross value of output of "non-material services" C_t^{ns} consists of two components: the gross value of the "non-material services" used (paid) by the material sectors, C_t^{ns1}, and the gross value of the rest of "non-material services" used by consumers that are excluded from the MPS, C_t^{ns2} :

$$C_t^{ns} = C_t^{ns1} + C_t^{ns2}. \tag{3.1}$$

Now, let the value of all material inputs be C_t^m, the value of depreciation of fixed capital be D_t^m , and net value added (excluding depreciation) from the material

[10] 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 about 60% of "non-material services" for consumers that were ignored under the MPS (NBS, 2001, Table 3-5).

production be V_t^m. We can define the gross material product or GMP for the total economy as:

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

Then, the standard measure of NMP can be derived by subtracting C_t^m and D_t^m from Eq. 3.2, which equals the sum of the net value added (V_t^m) and the payments to the "non-material services" (C_t^{ns1}), that is:

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

Apparently, neither the GMP nor the NMP is compatible with the SNA concept of gross value added or GVA (GDP), which includes net value added and depreciation of all economic activities, material or non-material (and market or non-market), as shown in Eq. 3.4 below:

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

The three components on the right hand side of Eq. 3.4 are: 1) the gross valued added by the material sectors under the MPS *plus* the missing "material services" for consumers, i.e. ($V_t^{*m} + D_t^{*m}$), 2) the gross value added by the "non-material services" paid by the material sectors under the MPS, i.e. ($V_t^{ns1} + D_t^{ns1}$), and 3) the gross value added by the rest of "non-material services" that is gone missing under the MPS, i.e. ($V_t^{ns2} + D_t^{ns2}$).

Clearly, the GMP has a serious double counting problem because it includes the intermediate inputs of all the material sectors (C_t^m). However, both the GMP and the 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, the NMP is not free of the double counting problem because it includes the *gross value of output* rather than the *gross value added* of the "non-material services" consumed by the material sectors (note that $C_t^{ns1}/(V_t^{ns1} + D_t^{ns1}) > 1$). Finally, the NMP ignores the value of capital consumption.

The differences between the MPS and the SNA imply that, firstly, the GMP (as well as the NMP but to a less extent) tends to exaggerate the real output 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, the GMP will have a higher growth rate than the GDP. Scholarly work has shown that this is indeed the case for a typical centrally planned economy (e.g. see the Soviet case by Maddison, 1998b). Wu and Yue (2000) and Wu (2011) have also shown that the Chinese economy has experienced a declining value added ratio over time (Table 6).

Secondly, if the excluded "non-material services" tends to grow at a much slower pace compared with the rest of the economy, especially manufacturing, which is a widely observed phenomenon in general (van Ark, 1996) and in the centrally planned economy in particular because its industrial policy tends to sacrifice services, the real growth of output is inevitably to be exaggerated (Maddison, 1998b).

Prior to 1992, China's statistical authorities followed the Soviet MPS which involved double counting and excluded a large part of service activities, therefore as above discussed it underestimated the level of the real output while overstating the growth rate of the real output (Keidel, 1992; Rawski, 1993; World Bank, 1994; Woo, 1998; Maddison, 1998a; Wu, 1997, 2000 and 2002a).

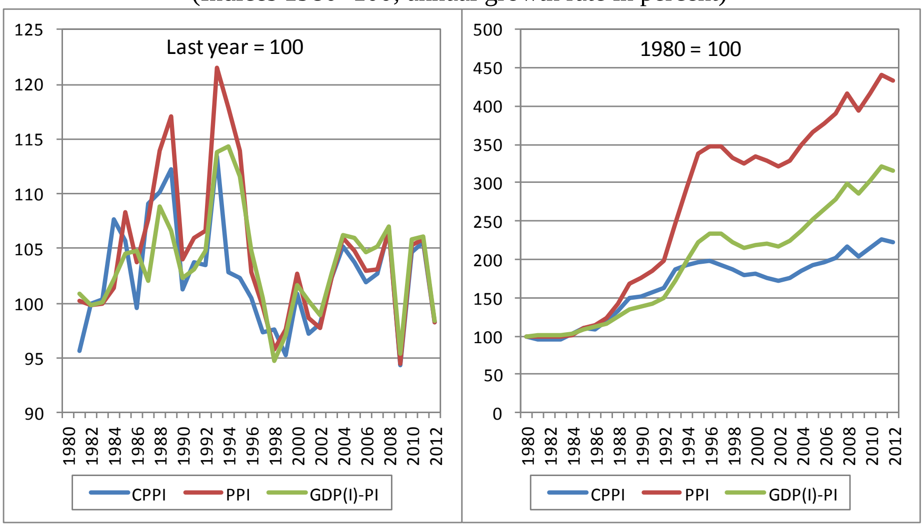
Why does the "comparable price system" exaggerate the real growth?

The official growth indexing relies on a "comparable price system", adopted together with the MPS in the early 1950s. As Maddison (2007) noted, it used segmented price weights with overlong intervals between adjacent benchmark years, hence inevitably underestimating price changes and exaggerating the real growth. The problem can be well explained by the Gerschenkron effect (Gerschenkron, 1951), i.e., a comparison of two situations in terms of output growth, weighted at the base-year prices, can be expected to be biased upwards because the price movements are inversely related to the quantity movements when the normal demand relationship is held, which is usually the case. By the same token, the growth estimates prior to the base year (in an index that is based on a year between the beginning and the ending points) can be expected to be downward biased. This effect is also known as the substitution bias, and the longer the time span, the stronger the bias.

There have been five sets of "constant prices", based on 1952, 1957, 1970, 1980 and 1990, respectively. The number of commodities in the sample set is presumably adjusted when constructing each set of the "constant prices" (Xu and Gu, 1997). The 1990 "constant prices" was used for the period 1990-2002. It is one of the two sets of the "constant prices" in the system that was used for more than a decade. The other is the 1957 "constant prices". It should also be noted that these "constant prices" are administrative prices except for the 1990 "constant prices" that also include market or semi-market prices as China just began a dual-track price reform. In the growth indexing, these "constant prices" are linked into one index, called "comparable price index" (hereafter CPPI for simplicity and distinguished from CPI).

In Wu (2011), I prove that linking the quantity index estimated by segmented "constant prices" weights as in the Chinese national accounts practice also introduces an upward bias and can be explained by the Gerschenkron effect (Appendix B). Since the CPPI had been used up to 2002 and it still serves as the basis in measuring price changes afterwards it is wrong or groundless to argue that the application of the "comparable price system" has little impact on the estimation of the real GDP growth in the post-reform period (Holz, 2006a).

FIGURE 1
COMPARISON OF CPPI, PPI AND GDP-IPI FOR CHINESE INDUSTRY
(Indices 1980=100; annual growth rate in percent)



Sources: The data for calculating the implicit industrial GDP deflator (GDP(I)-PI) are from *China Statistical Yearbook* (NBS, Tables 2-1 and 2-4, and earlier issues). The PPI data are directly from *China Statistical Yearbook* (NBS, 2012, Tables 9-11 and 9-12, and earlier issues).
Notes: CPPI is constructed using GVO data at current prices and at different "constant prices" available from *China Industrial Economy Statistical Yearbook* (DITS, various issues, up to 2003).

In Figure 1, I present three official price indices for the industrial sector as a whole (including all manufacturing, mining and utility industries) for the period 1980-2012. They are CPPI, producer price index or PPI and the implicit industrial GDP deflator or GDP(I)-PI. CPPI is derived from the GOV data for the period up to 2002 and updated to 2012 using sector-weighted PPI assuming that the post-2002 deflation follows the movement of PPI. It should also be noted that both CPPI and PPI refer to gross value of output, whereas the GDP(I)-PI refers to gross value added. From 1980 to 2012, PPI rose by 4.7 percent per year, GDP(I)-PI by 3.7 percent per year while CPPI by 2.5 percent per year. The annual fluctuations follow a similar pattern but to different degrees. CPPI appears to be the least volatile index while PPI is most volatile. This follows that given the nominal output, CPPI implies the most rapid real output growth, whereas PPI suggests the slowest real output growth.

Following what has been discussed, PPI should be more reliable than CPPI and used in deflating gross value of output. However, since PPI can be used as an input price deflator for producer goods or at least as a close proxy, a faster increasing PPI, compared with GDP(I)-PI, may imply that the rise of input prices must be even higher than PPI. If this is the case, there must be a rising value added ratio (value added to gross output) due to efficiency improvement or subsidies. In fact, the value added ratio in Chinese industry has been declining rather than rising (see discussion below and Table 6). It is never clear which price index and what deflation procedures have been used in the official estimation of China's industrial GDP. This casts a big puzzle and motivates the effort of using volume movements to bypass official price measures.

Institutional Deficiencies

We now consider another problem that is also related to China's practice of the "comparable price system". In order to measure price changes and real growth, enterprises are given price manuals that provide product-specific "constant prices" for the base year of the current period. Enterprises are required to regularly report itemized output at both the "constant" and current prices. However, these manuals cannot cover all items produced and or sufficiently specify details. This is particularly problematic when there are new products appearing after the base year. Enterprises have no guidance on how to properly price them. Since it is very complicated to turn new products into something equivalent listed in the manual for the base year, enterprises tend to report new products at the current prices rather than converting them into the "constant prices" that do not exist. This creates leeway for both enterprises (state firms in particular) and local governments to exaggerate the number of new products and to overprice them in constant terms. A different but also similar problem that violates the rule of using the assigned "constant prices" involves small-sized, non-state enterprises established after the base year. These enterprises tend to report the same figures at both "constant prices" and current prices for convenience or just out of ignorance (Rawski, 1993; Woo, 1998). Local governments also tend to close their eyes to such practice because of their political incentives to show faster growth (Li and Zhou, 2005; Ma, 1997).

Mathematically, we can assume that the output (GVO) in any given "price manual period" consists of two parts, one using the assigned "constant prices" for the "price manual-listed products" and another using the current prices or some prices that are different from and higher than the "constant prices" for the "new products". So the *reported* growth rate of gross value of output $g_t^{GVO(R)}$ between two periods (0 and *t*) can be defined as

(3.5) $$g_t^{GVO(R)} = \frac{GVO_t^I + GVO_t^{II}}{GVO_0^I + GVO_0^{II}} = \omega_t^I \frac{GVO_t^I}{GVO_0^I} + \omega_t^{II} \frac{GVO_t^{II}}{GVO_0^{II}}$$

where $GVO_t^I = \sum p_c q_t$ and $GVO_0^I = \sum p_c q_0$, i.e. the first part (I) of the output is priced by the "constant prices" p_c, $p_c \neq p_0$; $GVO_t^{II} = \sum \tilde{p}_t q_t$ and $GVO_0^{II} = \sum \tilde{p}_t q_0$, that is, the second part (II) of the output is (inappropriately) priced by the current prices p_t or something that is close to the current prices $\tilde{p}_t$ as the "constant prices" interpreted by enterprises for the reasons discussed; and ω_t^I and ω_t^{II} are the respective weights for the two parts of the output.

If $p_t > p_0 > p_c$ and ω^{II} grows, the reported growth rate will be significantly biased upwards compared with the *actual* growth rate (g_t^{GVO}), that is,

(3.6) $$g_t^{GVO(R)} = \frac{GVO_t^I + GVO_t^{II}}{GVO_0^I + GVO_0^{II}} > g_t^{GVO} = \frac{\sum p_c q_t}{\sum p_c q_0} = \frac{GVO_t^I}{GVO_0^I}.$$

Beside this leeway at local and enterprise levels, there has been evidence showing that pressures upon statistical offices to provide "right numbers" that can show "expected" performance may also come from powerful authorities at the central level rather than local governments (Wu, 2007).[11]

Empirical evidence

This upward-bias hypothesis has been investigated and tested for the total economy by various empirical studies using different approaches ranging from physical output or commodity indicator (Maddison, 1998a and 2007; Maddison and Wu, 2008),[12] energy consumption (Adams and Chen, 1996; Rawski, 2001), food consumption (Garnaut and Ma, 1993), to foreign price approximation (Ren, 1997). Despite different results, all alternative measures appear to be strongly supportive to the hypothesis. For example, for the period 1978-97, compared with the official GDP growth rate of 9.8 percent per annum, it is estimated as 4.8 percent by the energy approach (Adams and Chen, 1996), 6.8 to 8.5 percent by alternative price indices (Ren, 1997; Wu, 2000), and 7.5 percent by volume movement (Maddison, 1998). For the period 1978-2005, the annual growth rate is estimated by Maddison and Wu (2008) at 7.9 percent per annum compared with the official estimated rate of 9.6 percent per annum.[13]

4. Reconstruction of Chinese Employment Series

China's official data on employment not only have conceptual problems (see Wu, 2002b) but also suffer from structural breaks. In particular, 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 F-3)! This new 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,

[11] Wu (2007) shows that the post-2004 census revision is made directly to the real output, which is equivalent to an implicit adjustment to underlying prices (census by nature does not observe price changes). After replicating the adjustment procedures using the standard interpolation approach, he shows that the reported NBS estimates are arbitrarily modified and deliberately left 1998 unadjusted—the year when China was heavily hit by the Asian financial crisis, as clearly shown by my commodity index (see below), but the government believed that the Chinese economy stood firmly or remained intact due to the right leadership and policy.

[12] Different from other studies, these studies work on sector or industry level. The commodity-index approach is used for industry and agriculture, whereas volume movement approach is used for "non-material services", leaving the official estimates of construction and "material" services unadjusted.

[13] Based on Table 1 of Maddison and Wu (2008), all figures are converted to 1990 Geary-Khamis PPP dollars.

fall short of the new estimate of total employment in 1990 by 80.1 million. The post-1990 data series is then built on this new level of total employment, hence sustaining a continuous gap with the underlying trend based on the pre-1990 data series. When this 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 by the statistical authority.

In this section I first adjust the 1990 break in the employment series by investigating the nature of the break and the fundamental forces that might affect the demand and supply of labor at the time of the break. I provide new estimates with three scenarios. I then make a new effort to re-estimate the missing military personnel and to add it back to China's "non-material service" employment for the period prior to 1990—a factor that played an important role in Maddison's value added estimates for "non-material service" (Maddison, 1998a and 2007). Finally, I convert the estimated natural numbers employed to full-time-equivalent numbers employed based on the new estimates of hours worked from two recent studies (Wu and Yue, 2012; Wu and Zhang, 2013).

An adjustment to the 1990 break

A quick look at the 1990 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. without any significant deviation from the trend. On the other hand, it was impossible for the demand for labor to have a faster-than-normal increase in the middle of a serious growth slowdown – by the official statistics (Table F-7) the growth of GDP dropped sharply from 10.5 percent in 1988 to 3.3 percent in 1989 and stayed at around a similar rate (3.2) in 1990, which was the slowest growth since the reform.

As discussed in Yue (2005), the gap is caused by inappropriately linking the results of the 1990 Population Census results to the annual estimates that are based on a regular employment registration and reporting system established in the early planning time. The population census discovered a large number employed who had been missed by the regular reporting system, yet the NBS did not integrate the results with the annual estimates at the 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 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 80.1 million of additional workforce recorded in the 1990 Census did not appear suddenly in 1990, which is a reasonable assumption, a logical inquiry should ask whether the gap had always existed in the economy but never covered by the labor statistical system or it began from a particular time when changes in employment policy allowed informal employment to emerge but not necessarily 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 to see if a similar discrepancy existed in earlier periods and examining changes in employment policy that created outside system employment.

China only conducted three population censuses before the 1990 Population Census in 1953, 1964 and 1982. Unfortunately, the available data from the 1953 and 1964 censuses do not contain any useful employment information. However, the 1982 Population Census reports China's total number of employment as 521.5 million, or 68.6 millions more than the annual estimate of 452.9 million for that year. Additional information from the 1987 one-percent population sample survey gives an estimate of 584.6 million or 56.7 million more than the annual estimate of 527.8 million (see Tables F3 for official statistics). It is clear now that the structural break started at least in 1982 rather than in 1990.

My next question is when this additional employment began to emerge. There has been ample studies suggesting that the government began to relax its employment regulation in the early 1970s to make room for the development of rural enterprises (then named as "commune and brigade factories") and to allow "outside of 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 within a year, hence they were insufficiently covered by the labor planning and reporting system. I thus feel justifiable to assume that the discrepancy began in the early 1970s, which was the time when China temporally settled down from the chaotic situation at the early stage of the Cultural Revolution and reemerged internationally (marked by normalizing relationship with the US and Japan).

In the following alternative adjustment scenarios, the two 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 (one percent of the population). I use the total numbers of employment for 1982 and 1987 (the census concept-based "one-percent sample survey" results are multiplied by 100) as the control totals for the two years and use the annual movements between the 1982, 1987 and 1990 benchmarks construct a series of control totals. Consequently, but not surprisingly, the break is pushed back to 1982 and results in 19.3 percent jump in 1982.[14] I then propose three scenarios for a proper adjustment to the 1982 employment data break, especially for considering the sectoral impact of the adjustment, which are explained below with the results, respectively.

Scenario 1: This scenario 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 1983 growth rates of 3.2 and 2.7 percent, respectively) instead of the official estimate of 19.3 percent (Table 1). This raises the level of employment a way back from 1981 to 1949, maintaining the original official growth rates for all other years. As a result, the total employment is raised by 69.3 million to 506.6 million in 1981 and by 28.7 million to 209.5 million in 1949. The additional employment is then allocated into the existing sectors based on the sectoral weights. But, this scenario does not consider any policy change effect and assumes that all the employment data prior to 1982 are underestimated to the same extent as suggested by the 1982 Census.

Scenario 2: This scenario assumes that the gap identified by the 1982 census only began in the early 1970s when the government began relaxing planning controls over employment. In the adjustment, as Scenario 1, the level of employment in 1981 is first raised to iron out the break. Then, incorporating the new trend between 1970 and 1982 and the annual deviations from the original trend over the same period, a new

[14] The adjustment is made for four sectors, namely, agriculture, industry, construction and services. 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 census total employment is 74 percent, which is higher than that from the regular statistical report system, 68 percent. This is unreasonable in that the census is expected to pick up more non-agricultural employment that is not covered by the reporting system. Taking 1990 and changes between 1980 and 1990 as references, I reduce the number of agricultural employment by 10 percent and reallocate the difference to other sectors by their weights. The results look more plausible with agricultural employment accounting for 66.3 percent, industry 18 percent, construction 2.2 percent, and services 13.5 percent.

series of employment is estimated for 1971-81 adding more numbers employed to each year of this period, which is, for example, 69.3 million for 1981 and 4.8 million for 1971. The additional numbers are allocated based on the existing sectoral structure also like Scenario 1.

Scenario 3: This scenario differs from Scenario 2 in the way of allocating the additional employment. It assumes that the additional employment is only engaged in labor-intensive, non-farming activities. In services, since these additional laborers are likely least-educated and largely part-time and multi-job workers, they are assumed to only work in "material services". The "non-material services" are excluded in this allocation because they are unlikely to engage in financial, governmental, and healthcare and education services. Results based on this scenario are reported in Table D-1.

TABLE 1
CHINESE EMPLOYMENT DATA ADJUSTED FOR THE 1989-90 STRUCTURAL BREAK: ALTERNATIVE ESTIMATES COMPARED WITH OFFICIAL STATISTICS
(Annual growth rate in percent)

	Working-age Population	NBS Original	NBS Revised	Scenario 1 Results	Scenario 2/3 Results
1969-70	3.0	3.6	3.6	3.6	3.6
1970-71	2.8	3.4	3.4	3.4	4.7
1971-72	2.5	0.7	0.7	0.7	2.0
1980-81	2.9	3.2	3.2	3.2	4.5
1981-82	*3.0*	*3.5*	*17.6*	*2.9*	*2.8*
1982-83	3.2	2.5	2.6	2.6	2.6
1988-89	2.0	1.8	3.4	3.4	3.4
1989-90	*1.8*	*15.7*	*3.3*	*3.3*	*3.3*
1990-91	1.5	1.1	1.1	1.1	1.1

Sources: Data for working-age population and official employment are from NBS (2010 and other issues). See the text for the distinction between the two NBS series and explanation for the three scenarios. Official statistics refer to end-year numbers whereas the adjusted data are mid-year estimates. For a proper comparison with the NBS estimates, the adjusted data do not include military personnel. The completely adjusted, including military personnel, and official employment estimates are reported in Tables D-1 and D-2, respectively.

Table 1 shows my alternative adjustments to the official employment statistics only for the benchmarks and the 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 labor supply. The "NBS revised estimates" show the effect of my 1982 Census-based adjustment that shifts the *break* backwards from 1989-90 to 1981-82. As discussed, the effects of the three scenarios can be shown from 1981-82 backwards. Note that Scenarios 2 and 3 are the same at the aggregate level. Their annual growth rates have been significantly raised in the period 1970-81 due to the adjustment.

The revised estimates in aggregation and by broad sector based on Scenario 2 and 3 (the same at this level of sectoral details) are reported in Table F-1, which can be compared with the original official estimates in Table F-3.

Military personnel as part of the "non-material service" employment

Maddison (1998a) followed a standard practice attempting to add military personnel back to China's "non-material service" employment in constructing the national labor accounts. More importantly, as Maddison argued, the exclusion of military personnel would significantly lower the service output estimation especially for the earlier post-war period when the military employment was sizeable and engaged in many economic activities.[15] However, due to very limited information he could gather Maddison simply assumed the size of the military personnel was a constant 3 million for the period 1952-1996 (Maddison, 1998a, pp. 168-9). In his later work, based on new information he assumed that the official employment statistics had included military personnel in services from 1993 onwards (Maddison 2007, p. 170).

The new effort in this study is based on more detailed information through more careful research and data gathering (documented in details in Appendix Table C). This new work begins with reconciling two employment series with one categorizing total employment in "material" and "non-material" and the other under primary, secondary and tertiary. The "material" and "non-material" categorization for employment is in line with the official output statistics under MPS. Although the practice stopped after 1993, the available data are enough for our investigation because our focus is on the pre-1990 period. This reconciliation ensures the compatibility of the two employment series, and hence maintaining consistency in the "non-material service" employment where military personnel belong to.

[15] 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 that they only engaged in "non-material (and non-market) services" may exaggerate the input and output of these services, but it will not affect the aggregate analysis.

My new evidence shows that, first, the official practice of excluding military personnel was ended in 1990 and, second, the size of military personnel prior to 1990 was not a constant 3 million over time as Maddison assumed. In fact, China's armed forces were numbered at about 5.5 million in 1949. After four rounds of demobilization between 1950 and 1956, the number was substantially reduced to 2.4 million by the end of 1958. It, however, rose again between the mid 1960s and the mid 1970s in response to the boarder tensions and conflicts with the Soviet Union and India, respectively. By the end of 1975, the Chinese military personnel picked at 6.8 million. There were two new rounds of demobilization were conducted in the post-Mao period initiated by Deng who aimed at maintaining smaller but more modernized armed forces at around 3 million from the end of the 1980s (Table C, Appendix C).

The new estimation has both level and rate effects in terms of employment and any employment-based income statistics. Clearly, in terms of the level of employment, the effect of adding the newly estimated military personnel to the existing "non-material service" employment is much greater for the earlier period than for the later period. After the adjustment, the military personnel accounted for 67 percent of the "non-material service" employment in 1949, 27 percent in 1975 and only 5 percent in 1989. This has consequently changed the movement of the "non-material service" employment. Compared with Maddison's estimate of annual growth for this sector at 6.3 percent for the period 1952-1962, my estimate is only 4.5 percent. This implies that any employment-based level estimation for that period, such as using labor compensation to estimate value added in "non-material services" or using benchmark labor productivity to gauge the real output growth of "non-material services" as Maddison did will be substantially raised but the related growth rate will be reduced accordingly.

Hours worked

There have been no systematic official estimates of hours worked. Published data focus on weekly average hours worked of the state industrial sector. They are based on occasional surveys and processed in a way that covers up useful information at detailed industry and ownership levels, apparently to disguise unfavorable results to the government. Wu and Yue (2012) make the first attempt that takes the institutional standard of weekly working hours as the baseline following the official working-day calendar and its changes over time and then they make anecdotal information-based assumptions to adjust non-baseline industries. They assume that the state sectors follow the baseline, which is plausible, whereas non-state industries, especially labor-intensive and export-oriented industries and retail trade as well as personal and domestic (household) services are assumed to work for much more hours per week.

TABLE 2
ESTIMATED HOURS WORKED PER PERSON EMPLOYED FOR THE BENCHMARK YEAR
(Number of hours)

	Total economy	Agriculture	Industry	Industry (Wu-Yue)	Construction	Services "material"	Services "non-material"
1957	2,459	2,469	2,338	2,387	2,469	2,448	2,448
1965	2,437	2,448	2,274	2,423	2,448	2,448	2,448
1971	2,492	2,519	2,263	2,489	2,510	2,502	2,468
1977	2,822	2,988	2,236	2,315	2,920	2,853	2,588
1984	2,923	3,243	2,144	2,193	3,134	3,063	2,689
1991	2,897	3,195	2,159	2,229	3,079	3,030	2,693
2001	2,819	2,990	2,180	2,244	3,049	3,042	2,731
2007	2,456	2,414	2,323	2,412	2,731	2,806	2,386
2012	2,255	2,020	2,449	--	2,491	2,624	2,132

Sources: Author's estimates for years before 1980. The estimates for later years based on Wu and Zhang (2013, work in progress) and Wu and Yue (2012).

This study follows Wu and Zhang (2013)'s preliminary work that makes use of most available data collected in household surveys and population censuses. The main sources are China Household Income Project (CHIP, 1988, 1995, 2002 and 2007), the 2005 1% Population Sample Survey and the 2010 population census. These benchmark years are used in the estimation based on which estimates for other time points are either interpolated or extrapolated using the constructed employment series as the "control totals" for the period 1980-2010. The estimation for 1980-2010 is made at sector level (37 sectors) and then grouped into 5 major sectors. For the period before 1980, the institutional working hours for industry, as constructed in Wu and Yue (2012), are used as the baseline to gauge working hours of other sectors. The results of average hours worked per week are presented in Table 2. They are used to convert the natural numbers employed into full-time equivalent (FTE) numbers employed, assuming 8 hours per day and 5.5 days per week for 50 weeks for the entire period in question (i.e. 2200 hours per year as one FTE employed person), to take into account the effect of changes in weekly hours worked, which makes the quantity measure compatible over time (Table F-2).

5. A Measure of Chinese Human Capital Stock

A standard measure of the contribution of human capital to growth requires data on labor composition by major human capital attributes (demographic, educational and industrial or occupational characteristics) and compensation data that exactly match the quantitative matrix as weights to construct a homogenous-quality labor input measure (Jorgenson, Gollop and Fraumeni, 1987). This not only requires qualified population census or sample survey data at such level of details, but also requires corresponding compensation data from labor market surveys reconciled with the national income accounts. By this standard the available Chinese data are limited and in poor quality (Young, 2003; Wu and Yue, 2012). Besides, labor compensation under central planning was suppressed and relative wages across different types of labor were distorted. Therefore, this study follows a group of researchers who measure the quantity and quality of schooling (e.g. Barro and Lee, 1997) to construct a measure of education attainment-based human capital stock for China because schooling data are relatively easier to obtain for the entire period covered in this research. Since such a measure can reflect the ability of learning at work, it is to some extent able to capture the changes of industry- or occupation-specific knowledge through on-job training and work experiences.

Construction of homogenous flows of schooling

There are two types of education data available in the annual Chinese statistics, i.e. numbers enrolled and numbers graduated per annum by the level of education. Because of limited information on annual drop-outs and repeat rates as well as the breakdown of the education system due to political reasons (the decade-long Cultural Revolution in 1966-1976 as an extreme case), which affect the average schooling cycle of each education level, I therefore prefer the use of the graduation data to the use of the enrollment data.

The method that I adopt to estimate education-based human capital stock is the perpetual inventory method (PIM) that is usually used to estimate physical capital stock (see Section 8). Here, the number of annual graduation is considered as the current year flow of human capital investment, which after a proper depreciation treatment, is added to an existing stock. In the estimation, different levels of schooling have to be made "homogenous". In the case of lacking employment data by human capital attributes and their market costs, a popular approach to the problem is to convert the number of annual graduates at different education levels into a primary schooling-equivalent (PSE) measure by somewhat arbitrarily assigned education level-specific "impact factor" (Maddison, 1998a).[16] However, it is more appropriate to consider the impact of education on "returns to education" in China in the literature (see reviews by Zhang *et al*, 2005 and Meng *et al*, 2012). Following the work by Zhang *et al* (2005) and Meng and Kidd (1997), incorporated with a real wage index to fill gaps and extend the series, I construct a series of marginal conversion parameters for each level of education. To derive a homogenous PSE flow, the number of graduates at each education level is first multiplied by the standard years of schooling at this level (see "notes" to Table 2), then multiplied by its specific marginal conversion parameter (i.e. an impact factor). Since this approach only takes into account the full attainment of each level of education rather than reported years of schooling or (approximate) level of attained education in household surveys, it can avoid problems of double counting and ambiguity in measuring actual attainment.

However, to construct the PSE flows, the Cultural Revolution (1966-76) effect has to be taken into account and adjusted.[17] In the absence of useful information, the adjustment is based on the number of "effective schooling" years in the cycle of each level over the period affected. Since the Cultural Revolution occurred in the summer of 1966 and the normal teaching period already ended, the quality of the graduates in that year should not be affected. The first year to see the impact was 1967. Therefore, I assume that the graduates in 1967 from all levels lost one year of "effective schooling", that is, three years instead of four years for tertiary graduates, two years instead of three years for junior and senior secondary graduates, respectively, five years instead of six years for primary graduates. The same approach is applied to the subsequent years until the last enrollment during the revolution graduated. Note that in the case that a fully cycle fell completely in the revolution period, I assume that the graduates gained at least one year of "effective schooling". Other adjustments that

[16] China's standard years of schooling are six for the primary level, three for the junior and senior secondary level, respectively, four for the tertiary level (including polytechnic institutions), three for vocational schools and six for special schools. Maddison (1998a, Table 3.8, p.63) follows his earlier work (Maddison, 1995) assigned an impact factor of 1 to primary education, 1.4 to secondary and 2 to tertiary in the case of China.

[17] I am indebted to Shi Li at the CASS Conference on China's Growth and Demographic Dividends in 2012 for very helpful comment and suggestion on this particular point.

also consider "effective schooling" are based on the impact of policy changes upon different types of education during the revolution, for example, a policy change in 1971-72 that resumed the primary and secondary schools and reemphasized the education of "natural" or secular knowledge in addition to the dominant revolutionary training.

The initial education-based human capital stock

To set up the initial education-based human capital stock, I first compare two assumptions for the average schooling of the working-age population in 1950, i.e. 1.7 years by Maddison (1998a) and 0.9 years by Wang and Yao (2002). Maddison used the enrollment data, which might exaggerate the actual annual increase in educated human capital. 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 may underestimate the average years of schooling in China where there was no Indian type of caste system that obstructed mass education.

Based on the size of China's working-age population in 1950, which was 298 million (Table 2), the implied initial level of China's primary school-equivalent human capital stock was 507 and 268 million years of schooling by Maddison's and Wang and Yao's assumption, respectively. If assuming that China's modern school education[18] in the first half of the twentieth century had grown at a rate that was 20 percent slower than that of the post-war 1950-57 (2.3 percent), which is plausible given frequent wars and destructive interruptions, the average schooling of China's working-age population in 1900 would be 0.91 and 0.49 years by these two assumptions, accordingly. Based on other studies (Liu and Yeh, 1965; Perkins, 1975; Rawski, 1989; Yuan, Fukao and Wu, 2010), it is possible that at the turn of the twentieth century, there were about 8 to 10 percent of the working-age population engaged in the urban or modern economies and possessed *all* the human capital stock based on the modern school education. This implies that on average each employed person could have finished from 9.1 to 11.4 years of the primary schooling-equivalent education (depending 10 or 8 percent of the working-age population engaged in the

[18] The beginning of the modern school system in China can be dated back to 1862 when the first government-run foreign language school, Tungwen (Tongwen) College, was set up in Beijing. It may be reasonable to assume that by the turn of the last century, modern schools had begun to take shape all over China in cities and country towns.

modern sector) if based on Maddison and 4.9 to 6.1 years if based on Wang and Yao. I feel that it is more reasonable to follow Maddison because it is plausible that on average each person engaged in the modern sector could have completed his/her junior secondary education or left education in the middle of the senior secondary level.

Based on this assessment, a PIM exercise is conducted with Maddison's initial level of human capital stock of 507 million primary schooling-equivalent years. Besides, I also assume that the education-based human capital stock depreciates by a constant rate of one percent per year (i.e. taking a geometric declining function), which means that about 20 percent of the school knowledge will become obsolete 25 years after the high school.

Estimated PSE flows and stocks

The results are summarized in Table 3 for different periods under central planning and in economic reform. The full results are reported in Appendix Table F-4 and Table F-5. The periodization in Table 3 is mainly based on the shifts of policy regime in the Chinese economy and external shocks to the economy, although the nature of the present study is measurement-oriented rather than policy analysis.[19] The first two columns show the annual flows of PSE investment (in period average) and new PSE stock by the end of each period (period-specific growth rates are given in brackets). They are followed by the net PSE stock per working-age person in the fourth column. To somewhat compensate for the missing information on the human capital gained through on-job training and work experiences, we can assume that all the school education-based human capital is used by the workforce rather than the working-age population.

The last column of Table 3 shows the net PSE stock per person employed using the employment series constructed under Scenario 2 (the same as Scenario 3 at the aggregate level). This is not unreasonable if we accept that an educated working-age

[19] The planning period includes the adoption of the Soviet-style central planning system with the full implementation of the first Five-Year Plan in 1952-57, the Maoist feverish Great Leap Forward and its aftermath in 1958-65, the early chaotic period of the Cultural Revolution in 1966-71 and the rest of the Cultural Revolution period including the fall of the Maoists in 1972-77; the following reform period includes the agricultural reform in 1978-84, the initial industrial reform with a double-track price system in 1985-91, the adoption of "socialist market economy" and reforms of state-owned enterprises in 1992-2001, the post-WTO development in 2002-07 and the global financial and economic crisis and its aftermath in 2008-12. The same periodization is used throughout this study.

person is more likely to be employed. It is also worth noting that using the numbers employed as the denominator, the effect of any type of withdrawal from the workforce is already taken into account and therefore I do not have to consider the age/cohort-specific participation rate of the working-age population. With the inclusion of the average PSE stock per person employed in the growth accounting analysis, we can conceptually treat the employment series in natural numbers as a homogenous quantity measure, hence separating the contributions by quantity and quality of the workforce.

TABLE 3
ESTIMATED YEARS OF PRIMARY SCHOOLING-EQUIVALENT (PSE) EDUCATION PER WORKING-AGE PERSON AND PER PERSON EMPLOYED
(End-of-period stock unless specified, figures in brackets are period growth rate in percent)

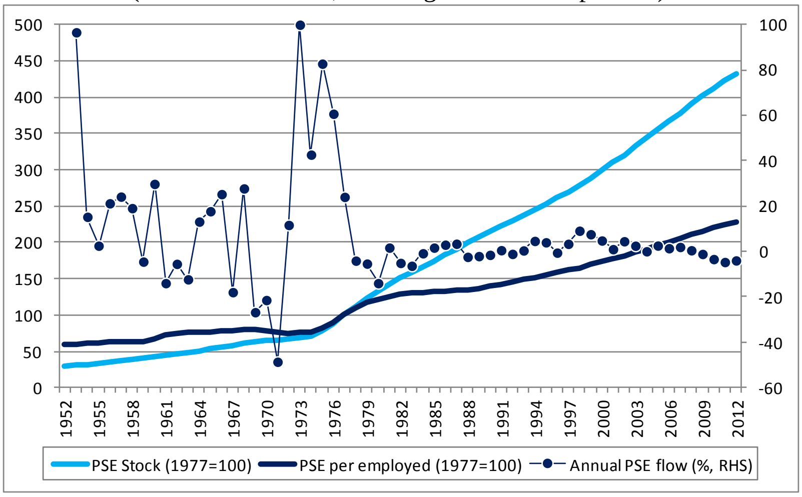
Period[1]	Annual flow[2] of PSE investment (ml. years)	Net PSE stock (ml. years)	Working-age population (16-64) (ml.)	Net PSE stock per working-age person (years)	Total numbers employed (ml.)	Net PSE stock per person employed (years)
Initial Stock in 1950		*507.0*				
1952-57	22.9	615.5	354.4	1.7	237.4	2.6
	(18.3)	(3.6)	(2.6)	(1.0)	(2.5)	(1.1)
1957-65	43.1	901.3	390.4	2.3	286.7	3.1
	(8.2)	(4.9)	(1.2)	(3.6)	(2.4)	(2.4)
1965-71	46.5	1,119.6	460.3	2.4	357.5	3.1
	(1.3)	(3.7)	(2.8)	(0.9)	(3.7)	(-0.1)
1971-77	109.4	1,701.8	531.7	3.2	416.4	4.1
	(15.3)	(7.2)	(2.4)	(4.7)	(2.6)	(4.5)
1977-84	183.8	2,832.4	645.3	4.4	528.1	5.4
	(7.7)	(7.5)	(2.8)	(4.6)	(3.5)	(4.0)
1984-91	168.2	3,782.4	762.5	5.0	651.2	5.8
	(-1.3)	(4.2)	(2.4)	(1.8)	(3.0)	(1.1)
1991-01	192.6	5,269.1	882.1	6.0	725.6	7.3
	(1.4)	(3.4)	(1.5)	(1.9)	(1.1)	(2.3)
2001-07	252.3	6,437.7	950.4	6.8	767.0	8.4
	(4.6)	(3.4)	(1.3)	(2.1)	(0.9)	(2.4)
2007-12	251.2	7,352.6	1,002.1	7.3	787.5	9.3
	(-0.1)	(2.7)	(1.1)	(1.6)	(0.5)	(2.2)

Sources: Author's estimates. Data on graduation and working-age population up to 2011 are from NBS sources (2012, Tables 3-3 and 20-9, and earlier volumes to fill gaps), and data on 2012 are from NBS (2013, pp.38-39 and 163).

Notes: 1) See text for the reasoning of periodization. 2) The annual flows are in period average and figures in brackets are period-specific growth rate in percent.

Table 3 shows a very rapid growth in both PSE flows and stocks from the 1950s to the mid 1960s. After reaching the highest speed through the 1970s to the mid 1980s, the growth slowed down. Noticeably, the period of deepening industrial reforms, especially in 1984-91, saw an unprecedented decline in PSE flows and a marked drop in the growth of per capita PSE stock measured in terms of working-age population and employment. This is very likely caused by a market-driven shift towards labor-intensive manufacturing that did not require a level of education higher than junior secondary, and the huge release of redundant workers from the inefficient state-run heavy industries which reduced incentives to compete for jobs in state enterprises through sufficiently long and high-quality school education.

FIGURE 2
INDEX OF CHINA'S TOTAL PSE FLOWS AND NET PSE STOCKS AND CHANGES OF AVERAGE PSE STOCK PER EMPLOYED PERSON
(Indices 1977=100; annual growth rate in percent)



Sources: Author's estimates. See Table 2 for details.

China's subsequent (since the 1990s) growth performance of per capita PSE stock stayed slightly below 2 percent per year in terms of working-age population and about 2.3 per year in terms of workforce and by 2012, it achieved 7.3 and 9.3 years of PSE stock, respectively. We can make a level comparison with the major East Asian economies at the similar stage of the development. Measured in Geary-Khamis PPP in 1990 prices (Maddison, 1998a, revised and updated by TCB, 2013), by 2012 China's per capita GDP level was $11,000, which was similar to the level of Japan in 1973 and the level of Taiwan in 1992 and South Korea in 1994. Compared with the per capita PSE stock measured on the basis of working-age population for China in 2012, i.e. 7.3 PSE years, Japan achieved 12.1 PSE years by 1973, Taiwan and South Korea reached to 13.8 and 13.6 PSE years by 1992, respectively (there is no comparable PSE estimate for South Korea in 1994 in Maddison, 1998a). In 1973, compared with China, Taiwan and South Korea began with a similar level of per capita PSE stock, 7.4 and

6.8, but experienced a much faster growth by 3.4 and 3.7 percent, respectively, about 1.5 percentage points faster than that of China, i.e. 2 to 2.3 percent since the 1990s.

Based on the comparison, China appears to be atypical in such a comparison not only because the Cultural Revolution take a heavy toll on the normal education process, but also the reform that radically shifted China towards more labor-intensive manufacturing from the Soviet-style heavy industrialization. These can be intuitively examined in Figure 2. While the comparison may suggest that there is substantial room for China to catch up, the absolute decline in the annual PSE flows since 2009 is not a good sign at this stage of development, which indicates the premature shrinking of the schooling-age population as an effect of China's forced one-child policy.

6. Measuring Gross Value-added by "Non-material Services"

Maddison's zero-labor-productivity growth hypothesis

Based on the labor-intensive nature of services, especially "non-material services", and the evidence of very slow labor productivity growth in services of the OECD countries, e.g. 0.32 percent per annum in 1973-79 (van Ark, 1996, pp. 109-115), Maddison argued that the Chinese official estimate of gross value added for this sector was implausible because it implied an abnormally high labor productivity growth in those services. He showed that for the period 1978-2003 the official estimate of GDP growth by "non-material services" was 11 percent per annum, and if using the official employment data, China's labor productivity growth in "non-material" services would be 4.3 percent per annum (Maddison, 2007, Table C.6), which appears to be too high to be true. It is likely to be caused by insufficient measure of price changes of the output of those services and/or exaggerated output in nominal terms. It may also be caused by considerably underestimated initial level of those services due to price distortions.

Based on the experiences of developed economies, Maddison proposed a "zero-labor-productivity-change" hypothesis and used in his estimation for China's GDP by "non-material services". This means that the GDP of those services would grow at the same rate of the employment of those services. He arrived at an annual GDP growth rate of 5.5 percent for 1978-2003, just a half of the official estimate of 11 percent. The impact of his adjustment on China's total GDP growth is about 0.9 percentage points.

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. Nevertheless, my further investigation in this study shows that Maddison's rebuttal to Holz (Maddison, 2006) is well justified at least for the pre-reform period. Using official estimates on both the value added and employment of "non-material services", the growth of labor productivity in 1953-81 is indeed zero. If using my new estimates on Chinese employment, and skipping the earlier recovery period and the shocks brought by the "socialization" (semi-nationalization of private enterprises) and of the Great Leap Forward (GLF) and its aftermath periods, there was also no labor productivity growth observed from the mid 1960s to the early 1980s.

Alternatives to the Maddison hypothesis

However, I believe that there is still room to further improve Maddison's estimates by taking into account the annual movements of labor productivity around the mean. After all, Maddison's hypothesis is purposed to set up a starting point. This adjustment is introduced to both the pre- and post-reform periods as the revised version Maddison's estimates following his "zero-labor-productivity" hypothesis.

For the reform period, which is redefined from 1982 when the official estimates of labor productivity started to rise as observed, I first assume that the labor productivity of "non-material services" rose by one percent per annum throughout the period 1982-2012 (Alternative I, Table 4). To test the sensitivity of the estimate, I further raise the annual labor productivity growth by another one percent from 1993 onwards (Alternative II, Table 4), a period that began with the government's formal adoption of the "socialist market economy" model and deepening reforms and restructuring of the state sector. Thus, it is reasonable to expect some gains in productivity due to efficiency improvement. In the next step of the estimation, the new trend that is constructed by the two alternative assumptions is further adjusted by annual deviations from period-specific mean based on official estimates.

My new assumptions are still arbitrary and strong because a significant shift in policy regime may have a once-off effect on efficiency but not necessarily mean a continuous increase in labor productivity over the following period, especially for "non-material services". In fact, economic history has suggested that a transition from manufacturing towards services, which is inevitable along with income growth, will lead to a decline rather than an increase in productivity in general.

In Table 4, compared with Maddison's original estimates of labor productivity growth in "non-material" services which are modified by my new employment estimates, the alternative assumptions-based estimates show greater volatility in general and faster labor productivity growth in the reform period in particular. The impact of the original and revised Maddison estimates on China's total GDP growth rate (by official estimates) is -0.24 and -0.39 percentage points for the planning period and -0.87 and -0.84 for the reform period, respectively. The impact of the two alternative estimates is -0.40 percentage points for the planning period and -0.75 and -0.68 for the reform period, respectively.

TABLE 4
GROWTH OF LABOR PRODUCTIVITY IN "NON-MATERIAL" SERVICES IN CHINA: ALTERNATIVE ESTIMATES COMPARED WITH OFFICIAL ESTIMATES
(Annual compound growth in percent, 1990 yuan)

Period	Official	Maddison Original[1]	Maddison Revised[2]	Alternative I[3]	Alternative II[3]
1953-57	-1.2	3.3	0.0	-5.0	-5.0
1957-65	1.4	-0.7	0.0	1.2	1.2
1965-71	0.5	-0.7	0.0	-0.6	-0.6
1971-77	-0.3	0.6	0.0	-1.3	-1.3
1952-77	*0.3*	*0.3*	*0.0*	*-0.9*	*-0.9*
1977-84	2.7	0.4	0.0	0.5	0.5
1984-91	6.1	0.5	0.0	-0.2	-0.2
1991-01	5.2	-1.0	0.0	1.9	1.3
2001-07	7.1		0.0	2.1	3.9
2007-12	5.4		0.0	-0.7	2.0
1978-09	*5.2*	*-0.2*	*0.0*	*0.9*	*1.4*

Sources: Author's estimates. In the calculation, the official and alternative value added data, at 1990 prices, are matched with the official and alternative estimates of employment. All official data are from *China Statistical Yearbook 2010* (NBS, 2012 and other issues). The original Maddison estimates are from Maddison (1998a and 2007).

Notes: 1) The original Maddison results cover the period 1952-2003 and modified by the new employment estimates. 2) The revised Maddison estimates are based on the new output and employment. 3) See text for assumptions used to obtain the alternatives estimates, I and II.

Maddison's level adjustment

Some scholars argue that Chinese statistics has traditionally underestimated value added due to price distortions that deliberately underpriced farm output and primary inputs to subsidize the development of heavy manufacturing (e.g. Keidel, 1992;

Maddison, 1998a). "Non-material services" were particularly underpriced because they were ideologically considered "unproductive" in the Marxist MPS framework. For this reason, in his estimation, Maddison raised the benchmark (1987) level of "non-material services" by one third in constant 1987 prices. He argued that this was more appropriate than arbitrarily and completely re-pricing Chinese output at sector level by foreign prices (Ren, 1997) or theory-based relative prices (considering underlying true factor costs) (Keidel, 1992). In fact, Maddison's adjustment mainly affects the period prior to the early 1990s. Together with the effect of employment movement in "non-material services", this adjustment also substantially raises the level of labor productivity before 1992. In the present work, I adopt his approach of level adjustment and apply it to the benchmark of 1990. The full results are reported in the last column of Table F-6, which can be compared with the (re-constructed or cleaned up) official GDP estimates in Table F-7.

7. An Alternative Production Index for Chinese Industry

My alternative approach to the real output of Chinese industry is commodity indicators-based. The commodity index approach to the problem follows earlier studies on the Soviet Union's industrial production performance (e.g. Gerschenkron, 1947; Bergson, 1961). It is purposed to bypass the problematic or unavailable official price measures to detect the underlying trend growth over different periods. The initial version of my estimates for the period 1952-1995 (Wu, 1997) relied on simple volume movements of major industrial commodities or commodity groups in implicit price weights as given by China's 1987 Input-Output Table (CIOT). In 2002, using a unique data set of the 1987 ex-factory price for over 2000 commodities I substantially improved this work by using explicit price weights (Wu, 2002a). Later, a straightforward update of this improved quantity index was fully adopted in Maddison (2007) and Maddison and Wu (2008). In Maddison and Wu (2008), we show that China's industrial GDP grow by 10.1 and 9.8 percent per annum during the planning and the reform period (up to 2003), which are 1.4 and 1.7 percentage points slower than official estimates, respectively.

Problems in commodity index-based estimates

A main critique to my commodity index approach comes from Holz (2006a) and Rawski (2008) who believe that the index has underestimated China's real industrial growth because it may miss or significantly underestimate the quality improvement of commodities over time.[20] In my latest work, I showed, though only preliminarily, that the deviation of my commodity index-based industrial GDP from the official measure did not suggest any reasonable trend of the expected quality improvement along with the reform (Wu, 2011), which is certainly provocative to the critique but also deserves further investigation that is attempted here. In fact, the criticism has unfortunately missed the main deficiencies of the commodity index approach that were already warned in Wu and Yue (2000) and Wu (2002a). In Maddison and Wu (2008), we recapped two potential problems inherited in this approach.

The first problem is the assumed fixed value added ratio (the ratio of gross value added over the gross value of output or GVA/GVO) as given in the 1987 Chinese input-output table. If the ratio has increased over time, the growth rate could have been underestimated, but if the ratio has declined, the growth could have been exaggerated. Based on the earlier official estimates for the net material product (NMP) of the MPS framework, Wu and Yue show that for the industrial sector as a whole the ratio had remained somewhat stable at 0.38 up to the early 1980s, but declined afterwards (Wu and Yue, 2000, p.92, Table 2). More detailed information from China's full input-output tables, available for every five years, suggests that the ratio indeed declined over time from 0.34 in the 1987 CIOT to 0.23 in the 2007 CIOT (Table 6 in this study). This implies that simply multiplying the physical output index with the GVA of the 1987 CIOT as in Wu (1997 and 2002a) and Maddison and Wu (2008) is inappropriate.

The second potential problem is related to the Gerschenkron effect or substitution bias because my long series is based on the 1987 price weights. That is, it is likely biased upwards for the post-1987 period, though it may not be significantly biased downwards for the pre-1987 period because of strict planning controls over prices maintained up to the mid 1980s. Wu and Yue (2000) made the first yet rather preliminary attempt to investigate whether there existed the Gerschenkron effect in the first version of my index in the 1987 price weights (Wu, 1997). They showed that if shifting from the 1987 to the 1992 price weights, China's industrial annual growth

[20] 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.

rate would be further lowered by about one percent for the period 1978-97 but raised by merely 0.1 percent for the period 1952-78.

In my recent work (Wu, 2011), both the time-variant value added ratio effect and the Gerschenkron effect are more carefully investigated by introducing two additional input-output table weights, 1992 and 1997. The results for the reform period are found indeed sensitive to changes of the weighting year and the value added ratio, while the results for the planning period are not, similar to the findings in Wu and Yue (2000). However, this work is still insufficient to address the two problems mainly for two reasons. First, the 1992 and 1997 prices are still influenced by the "comparable price system", that is, they are coincided with the "1990 segment" of CPPI which ended in 2003. Second, the period covered in Wu (2011) is only up to 2008 when China was impacted by the global financial and economic crisis, which is obviously an inappropriate ending point for a long series. Besides, there is a good reason to examine the performance of Chinese industry over the crisis and its aftermath periods using the commodity-index approach.

A further improvement with the commodity-index approach

The present study introduces 2002 and 2007 price weights based on the 2002 and 2007 CIOTs in order to capture changes in a more market-based pricing and more liberal post-WTO policy environment. As a substantial extension of Wu (2011), I now have five sets of price weights (1987, 1992, 1997, 2002 and 2007), exhausting all available full CIOTs, to test the Gerschenkron effect. These five CIOTs, adjusted and reclassified to 83 sectors, together with the NMP/GMP ratio in Wu and Yue (2000), allow me to construct a matching series of value added ratio at sector level to which the weighted commodities or commodity groups are aggregated.

The commodity data set finally contains 165 commodities or commodity groups and is substantially revised and updated to 2012. The very recent ending pointallows us to close examine the dynamics of the economy over the 2008 global financial and economic crisis and its aftermath. The methodology is presented as key steps in the construction of the commodity index and the index-based industrial value added and given in Appendix D, which can also be referred to Wu (2002a and 2011) for more details. The data used in this revision and update are also given in Appendix D. The new results are reported and discussed below under three topics: an examination of the Gerschenkron effect, the construction of a real output index for Chinese industry based on the commodity index, and a robustness check of the findings on external shocks in alternative price weights.

An examination of the Gerschenkron effect

Table 5 is designed for a better examination of the Gerschenkron effect. It presents annual GOV growth rate (as discussed, the effect cannot be examined by GVA) for Chinese industry as a whole in alternative base-year price weights. The table separates the results into two parts: one including two pre-1987 periods for which there is no any CIOT available as a proper base year; the other including five consecutive post-1987 periods, each based on a specific CIOT. This separation more or less coincides with the nation-wide first round industrial reform began in the mid-1980s. It should also be noted that the base year of each sub-period post 1987 represents at least one significant shift of the policy regime, sometimes coinciding with an external shock. Understanding the implications of policy changes and external shocks for price and structural changes is the key to the justification of which indices are more plausible than others and can be used to better gauge China's real industrial growth.

TABLE 5
EXAMINATION OF THE GERSCHENKRON EFFECT:
ANNUAL GVO GROWTH RATE OF CHINESE INDUSTRY IN ALTERNATIVE CIOT WEIGHTS
(Compound growth, percent per annum)

CIOT Weights in	Annual Growth before the First (1987) CIOT		Annual Growth between Benchmark CIOTs[2]				
Prices of[1]	1952-77	1977-87	1987-92	1992-97	1997-02	2002-07	2007-12
1987	8.8	9.2	8.4	11.1	10.3	26.2	13.3
1992	8.8	8.8	7.5	10.4	9.9	26.6	13.5
1997	8.5	8.5	6.9	8.9	8.6	24.0	12.7
2002	8.6	9.0	4.5	7.3	5.5	20.5	11.3
2007	8.1	9.6	2.2	5.2	3.1	17.2	10.0

Sources: Author's estimates.
Notes: 1) Refers to the period for which a specific current-price input-output table is available and used for inter-industry and intra-industry weighting. 2) The boxed annual growth rate indicates a specific period that uses weights in its first year prices corresponding to the first column. It is a reference rate for alternative CIOT-weights-measured growth rates for the same period, which is a way to examine the Gerschenkron effect.

Specifically, and necessary to be aware of, in 1987-88 the government decided to slowdown the pace of price and wage reforms in the wake of unprecedented price hike since the reform; in 1992 Deng called for bolder reforms that led to the official adoption of the "socialist market economy" in 1993; in 1997-98, taking stock of the earlier successful price reforms and a substantial improvement in the supply side of the economy, the government kicked off more radical ownership reforms; but meanwhile China was hit by the Asian financial crisis that started a five-year long deflation period; the year of 2002 marked the beginning of China's post-WTO period (China was granted WTO membership towards the end of 2011) in which China emerged as the "world factory"; and the last benchmark 2007 represented China's post-WTO performance in the eve of the global financial and economic crisis that resulted in an unprecedented fiscal spending to save the economy from a significant global recession.

The expected Gerschenkron effect is clearly evident for the post-1987 period as shown in Table 5. To help read the results, the boxed annual growth rate indicates a specific period whose base year is corresponding to the same base-year CIOT weights shown in the first column. This also helps the examination of estimates in alternative weights of the same sub-period (presented in columns). The estimated annual growth rate using more recent base-year price weights is slower than those using any earlier base-year price weights with the exception of the period 2002-07 and 2007-12 using the 1987 price weights. This is just as expected that the estimates using earlier base-year price weights are more biased upwards than those using later base-year price weights. However, for any of the sub-periods before a specific base-year, the estimates may contain some downward bias if consumers are rational (and the substitution bias is held for both before and after the base year). This is also true in our findings for the post-1987 period. Taking the period 1992-97 as an example, the estimated annual growth rate is 10.4 percent if using the 1992 price weights, but will be 8.9 and 7.3 percent if shifting to the 1997 and 2002 price weights, respectively.

It shows that for the period 1978-87 and the pre-reform periods, however, the results are not sensitive to changes of the base-year price weights. This is also expected for the planning period because of restrict price controls by the planning authorities. The reform-led as well as market-driven corrections to the previous price distortions were still limited in the early stage of the reform as represented by the period 1978-87. Thus, it is inappropriate to assess the behavior of agents based on later, less distorted price structures as well as industrial structures.

The same consideration of policy regime should also be made when assessing the post-1987 price weights. China's price reform began with a double-track arrangement that ensured a planned resource allocation and delivery while giving incentives to producers to respond to the market demand after meeting the planned targets. Although the "market margin" in pricing continuously increased, the price controls were not substantially relaxed until the late 1990s when the supply-side of the economy was significantly improved and there was no longer any severe shortage of consumer goods. This should be an important issue to be born in mind in considering which price weights-based estimates are closer to the truth.

Taking into account the presence of the Gerschenkron effect and the process of China's price reforms in the transition, I feel justified to construct a quantity index for each sector of Chinese industry that is mainly based on the 1997, 2002 and 2007 price weights.[21]

Construction of a multi-weights quantity index

Before proceeding further, we should first examine the changes in value added ratio based on the five full CIOTs as presented in Table 6. The decline in the ratio is obvious. I construct a time series of the ratio based on interpolations between the CIOT benchmarks including an extrapolation for 2007-12 using the changes in 2002-07, and Wu and Yue (2000)'s earlier estimates based on NMP/GMP data. This is to address one of the two main problems of my earlier work using the fixed input-output weights (Wu, 2002a; Maddison and Wu, 2008).

Taking into account the presence of the Gerschenkron effect in different price weights and changes in the value added ratio, a commodity index-based, multi-weights real output index for Chinese industry is constructed as follows. First, as we have discussed with the results in Table 5, it is appropriate to use the estimates in the 2007 price-weights for the period 2007-12. Second, for the period of 2002-07, a geometric mean is used to integrate the estimates obtained by the 2002 and 2007 price weights. This is to moderate, if not completely cancel off, the upward bias of the estimates with the 2002 price weights and the downward bias of the estimates with the 2007 price weights for the same period. Third, for the same reason, for the period

[21] It should be noted that this is a significant change from my earlier multi-weights estimates without data on the 2002 and 2007 CIOT and price weights in which I opted for using the 1992 and 1997 price weights in the quantity indexing (for a comparison see Wu, 2011).

1997-2002 a geometric mean is also used to integrate the estimates using the 1997 and 2002 price weights.

TABLE 6
RATIO OF GROSS VALUE ADDED TO GROSS VALUE OF OUTPUT IN CHINESE INDUSTRY
(GVO=1)

Sector	1980	1987	1992	1997	2002	2007
Energy	0.620	0.563	0.440	0.436	0.449	0.317
Primary inputs	0.363	0.326	0.280	0.295	0.285	0.222
Semi-Finished & Finished	0.300	0.281	0.244	0.265	0.248	0.197
Total industry	0.383	0.339	0.284	0.301	0.299	0.233

Sources: Calculated based gross value of output data from *China Input-Output Table* for 1987, 1992, 1997, 2002 and 2007 (DNEB and ONIOS, 1991; DNEA, 1996, 1999, 2005 and 2009).
Note: Figures for 1980 are based on the MPS accounts, estimated by Wu and Yue (2000, p. 97).

Finally, for the period prior to 1997, following the above discussion of the price reform, it is more appropriate to directly use the estimates in the 1997 price weights than those in the 1987 and 1992 price weights or any type of integration of these weights. These annual growth rates are used to derive a 1990-based real output index for Chinese industry. The results on period-wise growth rates are summarized in Table 7, whereas the full results in value added in 1990 prices are reported in Table F-6.

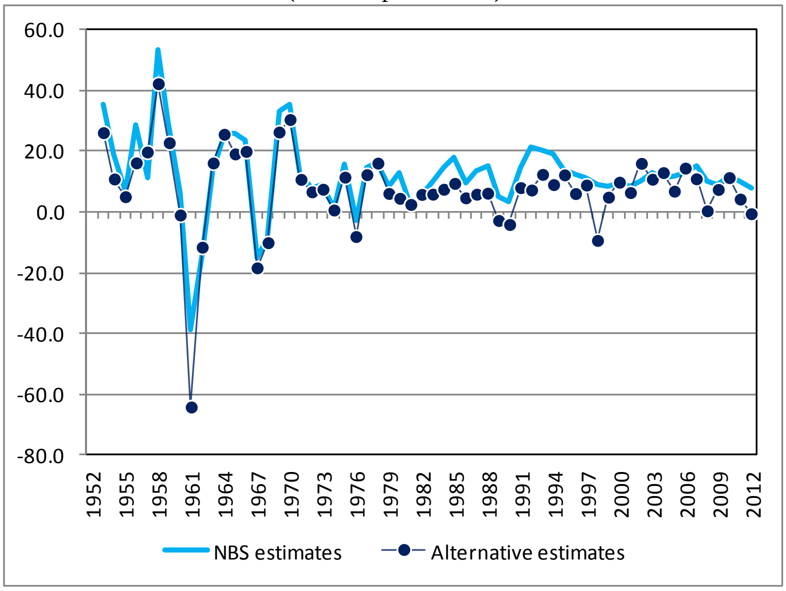
TABLE 7
ANNUAL GROWTH OF ESTIMATED GROSS VALUE ADDED FOR CHINESE INDUSTRY
(Compound growth, percent per annum)

	Planning	Reform	Phases of Reform Period				
Sector	1952-77	1977-12	1977-84	1984-91	1991-01	2001-07	2007-12
Energy	13.7	3.8	4.8	1.8	5.5	5.0	0.4
Primary inputs	8.4	6.6	6.7	4.6	6.0	12.2	3.8
Semi-Finished & Finished	8.6	9.4	9.0	5.3	9.4	17.2	7.1
Total industry	9.1	7.1	7.2	3.5	6.9	13.4	5.5
Total industry (NBS)	*11.3*	*11.5*	*9.9*	*11.2*	*13.3*	*12.3*	*9.8*

Sources: Author's estimates using multi-weights. The NBS estimates are from the national accounts data of *China Statistical Yearbooks*.

What should be drawn attention is, as shown in Table 7, the alternative growth estimates using the commodity-based indicators suggest a much more volatile performance than those of official estimates. Such comparisons can be particularly made for the periods that experienced external shocks, e.g. the period 1984-91 that saw continuous recessions from 1989 to 1990 in the wake of the Tiananmen crisis; the period 1991-2001 that experienced a recession in 1998 brought about by the Asian Financial Crisis, and the period 2007-12 that encountered a recession in 2008 caused by the global financial and economic crisis and a recession in 2012 partially due to the delayed recovery of the developed economies in general and the European Union debt crisis in particular, and partially due to accumulated structural problems within the Chinese economy caused by overlong input-driven, extensive growth.

FIGURE 3
ANNUAL GROWTH OF GROSS VALUE ADDED IN CHINESE INDUSTRY:
OFFICIAL VERSUS ALTERNATIVE ESTIMATES, 1952-2012
(Percent per annum)



Sources: Using data on Tables F-6 and F-7.

The impact of these shocks is more pronounced by the estimates using the commodity-based indicators than official estimates, which can be intuitively examined with the time series in Figure 3. Focusing on the reform period, the newly estimated growth rate for 1989 and 1990 is -2.7 and -4.0 percent, compared with the official estimates of 5.1 and 3.4 percent, respectively; the estimated growth rate for 1998 is -9.3 percent, compared with the official estimate of 8.9 percent; and my results for 2008 and 2012 are 0.5 and -0.5 percent, compared with the official estimates of 9.9 and 8.0 percent, respectively. These indeed suggest that whenever there is an external shock to the Chinese economy, no matter economic or political, domestic or foreign, the commodity index-based real output measure demonstrates a much worse performance than what the official statistics tells us. More importantly, the discrepancy has substantially increased since the reform.

What I would like to emphasize here is, however, not that this finding lends a strong support to the institutional argument of the upward-bias hypothesis, which introduces more or less systematic errors to the growth statistics when the general institutional conditions do not change. Instead, I would like to argue that it lends an important support to the political economy hypothesis of official statistics that state agencies, statistical or the like of other ministries, may impose *ad hoc* adjustments when the economy was badly hit by an external shock (Wu, 2010). If this is true, there must be a subsequent counter modification subsequently to "correct" the effect of the *ad hoc* adjustment to ensure that the impact of the latter will not screw up the published historical index. And this modification has to be done professionally. It is no wonder why there appear to be some smoothing procedures in official estimates, which seem to have moderated the volatilities picked up by the commodity indicators particularly since 1995. With a sound extension, the new findings have confirmed the conjecture by Maddison and Wu (2008) that official estimates tend to smooth out high volatility.

A robustness check of the findings on external shocks

Table 8 is designed to examine if the findings are robust by taking into account the degrees of price distortions inherited in the different weights. It is quite clear that, after going through the results using all five price weights, only the 1989-90 Tiananmen Crisis appears to be very sensitive when shifting from the earlier to the later price weights. The only difference of this shock from others is that it is a political one rather than an economic one directly linked to changes in demand and supply situations, although it is also external to the operation of the economy but not related to changes in the international economy.

Not only considering the process of the price reform as above discussed, but also taking into account the timing of the most recent shocks since the Asian Financial Crisis, it is justified to focus on the results using the later three price weights, i.e. 1997, 2002 and 2007, especially the last two price weights that are considered more market based or less distorted, hence more appropriate to address the current situation.

Table 8 shows that shifting between these three price weights indeed does not significantly change the results regarding for the three recessions, i.e. 1998, 2008 and 2012.[22] This not only justifies my approach to the construction of the final real output index, but also provides a strong support to my choice of the indices in different price weights for different periods (see Table 5 and the discussion).

TABLE 8
ESTIMATED EXTERNAL SHOCKS TO CHINESE INDUSTRY USING ALTERNATIVE CIOT PRICE WEIGHTS
(Percent change over the previous/pre-shock year)

CIOT Weights in Prices of	Energy	Primary inputs	Semi-finished & finished	Total Industry
		1989-90 Tiananmen Crisis[1]		
1987	-5.2	-3.1	-8.9	-2.0
1992	-5.1	-3.1	-11.5	-4.1
1997	-5.3	-3.7	-13.4	-6.8
2002	-6.0	-12.6	-15.1	-10.2
2007	-7.0	-18.9	-14.8	-13.7
		1998 Asian Financial Crisis[2]		
1987	1.5	-3.3	-14.9	-7.5
1992	1.1	-4.1	-14.2	-7.8
1997	1.6	-5.6	-13.8	-8.0
2002	1.3	-11.7	-16.3	-10.8
2007	1.2	-13.6	-18.3	-10.6
		2008 Global Financial & Economic Crisis		
1987	-1.2	0.2	-0.3	-0.3
1992	-1.4	0.4	-0.8	-0.3
1997	-1.2	0.4	-0.4	-0.8
2002	-1.5	1.2	1.7	0.2
2007	-1.5	0.5	2.7	0.5
		2012 GFC Aftermath & EU Debt Crisis		
1987	-1.0	0.2	-2.1	-1.5
1992	-0.7	0.3	-0.6	0.4
1997	-1.4	0.0	-0.5	-0.2
2002	-1.5	-0.4	-0.9	-0.3
2007	-1.4	0.0	-1.3	-0.5

Sources: Author's estimates.
Notes: 1) The figures are shown as percent change in 1990 over 1988 as the commodity indicators pick up two consecutive declines in 1989 and 1990. 2) AFC began in 1997 but China was mainly hit in 1998. This part refers to percent changes in 1998 over 1997.

A reply to the quality problem critique

[22] Table 8 is not designed to directly work out the final results used in Figure 3. To arrive at the final estimates, one needs to refer to the earlier discussion. Basically, the estimated growth rate for 1989 and 1990 is based on the 1997 prices weights, for 1998 based on the geometric mean of the growth rates estimated by the 1997 and 2002 price weights, and for 2008 and 2012 is based on the 2007 price weights.

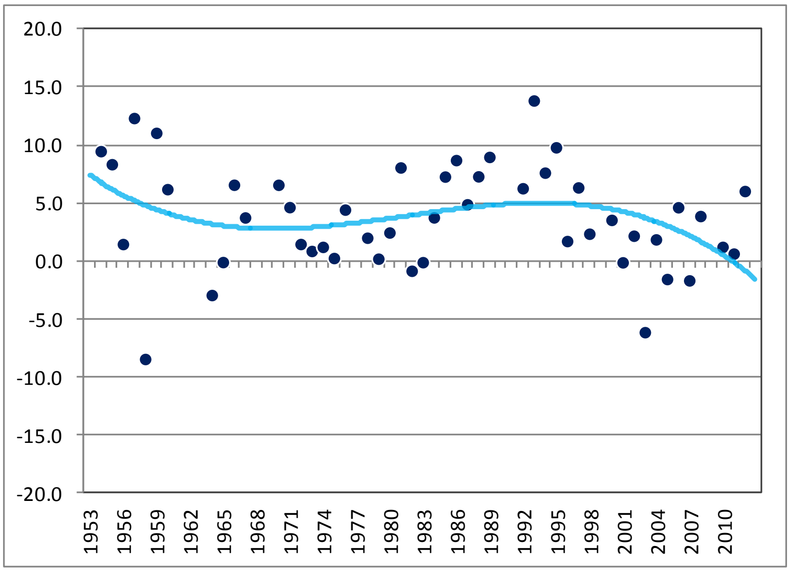
One of the criticisms to my commodity index-based real output index for Chinese industry is that it underestimates the effect of quality change. This is to say that the quality change is implicitly counted as a price effect in the exercise and hence being removed in the construction of the quantity index (Holz, 2006a; Rawski, 2008).

Surely, it is not easy to maintain product homogeneity in this kind of exercise. However, there are many products used that are homogenous in nature, e.g. coal, iron ore, salt, basic metals and basic chemicals. More heterogeneous products such like pressed steel products are measured by types with information on price and quantity rather than in aggregate tonnage, similarly for many producer goods from chemical fertilizers, refined oil products to semi-conductors.[23] Despite these efforts, some underestimation of the quality change may still exist. The question is, however, how serious the quality problem is in the constructed quantity index.

FIGURE 4

DOES WHAT IS MISSED SUGGEST A REASONABLE TREND OF QUALITY CHANGE?

(Percentage-point difference by subtracting alternative estimates from NBS estimates)



Sources: Figure 3.

Notes: Shocks identified in Figure 3 are excluded in order to obtain more reliable estimates for a "quality trend".

[23] Instead of constructing simple quantity index by the units of all (mixed) semi-conductors produced as reported by DIS, I worked on six major types of semi-conductors with their ex-factory prices and quantities and went through two levels of aggregation to obtain an average price for the single CIES item "semi-conductor" for each benchmark year, i.e. 6.13 yuan for 1987, 2.61 yuan for 1992, 1.88 yuan for 1997, 1.33 for 2002 and 1.01 for 2007, respectively. Semi-conductor may be an atypical case as it has experienced tremendous quality increase and significant price decline. Yet, my procedures show that quality change in this case is not completely uncounted.

Fortunately, the way in which we apply different price weights to the exactly same set of commodity data for the same period provides us an advantage for examining the quality problem in the commodity index-based real output index. The official index can be used as a "benchmark". We can assume that the percentage-point differences by subtracting the alternative estimates from official estimates contain mainly the missing quality, thus the change of the so-derived differences over time can be taken as an indicator of the trend of quality change in Chinese industry. Note that to obtain a reliable measure, the external shocks identified in Figure 3 have to be removed from the calculation.

The results are presented in Figure 4. It is reasonable to expect that the missing quality should be steadily rising over time especially since the economic reform. To facilitate the examination I also add a polynomial trend to filter out the noises. If the critique were correct and the gap indeed mainly contains the missing quality change, China's industrial development appears to be first undergoing a continuous quality deterioration for about 20 years till the early 1970s, which is implausible even if the inefficiency of the central planning period is considered, then followed by a slow quality improvement till the early 1990s before China adopted the "socialist market economy" system, and a further rapid decline along with deepening industrial reforms and China's participation in WTO till the present time, which does not look plausible at all.

Impact of the alternative estimates

It is useful to examine the impact of my alternative GDP estimates for Chinese industry upon the officially estimated total GDP growth. This is presented in Table 9. It shows the effect of my estimates-implied growth on the official GDP growth for the total economy, holding the official GDP estimates for the rest of economy unchanged.

It shows that the impact of my adjustment is 0.45 percentage points on the growth of the planning period but -1.77 percentage points on the growth of the reform period, other things being equal. Again, at the aggregate level, my results have substantially adjusted downwards the growth performance of the period when there was an external shock (the time of 1989/90 in the period 1984-91 and 1998 in 1991-2001). For the period 2001-07 that saw a continuous strong growth, my adjustment has little impact on the total growth rate based official estimates.

TABLE 9

IMPACT OF THE ALTERNATIVE ESTIMATES OF CHINA'S INDUSTRIAL VALUE-ADDED ON THE OFFICIALLY ESTIMATED GDP GROWTH

(Annual compound growth rate in percent)

	Growth of Industrial Gross Value Added		Total GDP Growth		
	Official Estimates	Alternative Estimates	Official Estimates	After industry Adjusted*	Difference in percentage points
1952-57	19.85	16.97	6.68	7.74	1.07
1957-65	8.98	6.42	2.45	2.78	0.34
1965-71	11.76	10.42	5.31	6.02	0.72
1971-77	7.23	5.29	3.97	3.81	-0.17
1952-77	*11.31*	*9.14*	*4.33*	*4.78*	*0.45*
1977-84	9.87	7.23	9.17	8.14	-1.03
1984-91	11.19	4.05	8.59	5.93	-2.66
1991-01	13.30	7.26	10.36	7.78	-2.57
2001-07	12.25	13.00	11.28	11.27	-0.01
2007-12	9.75	4.75	9.32	7.32	-2.00
1977-12	*11.49*	*7.20*	*9.77*	*8.00*	*-1.77*

Sources: Calculated based on data from Tables F-6 and F-7.

8. AN ESTIMATION OF CHINA'S AGGREGATE CAPITAL STOCK

Understanding Official Statistics on Investment

Since there have been official estimates of China's aggregate capital stock, researchers have to construct it by themselves using available official statistics from different sources, investment statistics and expenditure accounts statistics. However, one has to be very careful to avoid conceptual pitfalls in investment related official statistics. Historically, there have been four different investment series in two separated official statistical sources. They are "total investment in fixed assets (TIFA)" and "newly increased fixed assets (NIFA)" in official investment statistics and "accumulated value of national income (AVNI)" and "gross fixed capital formation (GFCF)" in official national accounts statistics.

AVNI is a MPS concept that began in the early 1950s but discontinued and replaced by GFCF in 1993 when China began to shift to SNA. However, studies before GFCF statistics became available could only use the AVNI statistics (e.g. Chow, 1993; He, 1992). Conceptually, AVNI is a net measure of investment in the "material sectors" of the economy and net of the depreciation value of fixed assets. But, on the other hand, it is an incomplete and "dirty" indicator because it not only excludes investment in all "non-material activities" but also mixes up fixed asset investment, circulation funds and inventory. Therefore, it has no any theoretical underpinning if simply adding up the annual AVNI flows to construct a capital stock series for the economy. Under the Chinese SNA, the Department of National Economic Accounts (DNEA) of NBS has adjusted the historical AVNI series to construct a series of GFCF (DNEA, 1997). The GFCF series has since been revised for twice (DNEA, 2004 and 2007).

TIFA also has a long history dated back to the beginning of the 1950s. It was designed to measure investment projects above certain size in value terms at current prices, available with breakdowns in investment types which are the only information for gauging asset types,[24] ownership types, by sector/industry and by source of funding. The data collection for TIFA is conducted through the investment monitoring authorities at different levels of administration and published by DFAIS (Department of Fixed Asset Investment Statistics) of NBS.

Due to insufficient coverage and conceptual problems, TIFA should not be directly used as the investment variable in the perpetual inventory method equation as done in many existing studies (Ho and Jorgenson, 2001; Hu and Khan, 1997; Huang *et al*., 2002; Li *et al.*, 1992; Ren and Sun, 2007; Young, 2003). Firstly, TIFA excludes all fixed asset investment projects that is smaller than half million yuan and all intangible assets. More problematically, it includes the transaction of *existing* assets typically land that rocketed in the last decade,[25] creating serious doubling counting problem. However, the coverage problem including land transaction-related double counting has largely been tackled in the construction of the national accounts. In this sense, GFCF is more qualified as an investment indicator than TIFA.[26]

[24] TIFA consists of three categories that distinguish fixed asset investment by nature, namely, "construction and installation", "purchase of equipment", and "other expenses" that are largely consumables to facilitate the above two activities (DFAIS, 1997, pp.444-445).

[25] In China, land belongs to the state or semi-state organizations ("collectives") as in the case of farm land. There is no ownership transfer-based land transaction, but only the trade of "land use rights". However, the government (both central and local) controls the primary release of the land use rights according to land size, location and market situation (unit price and timing). There have been increasing criticisms on the land-related government revenue and land-financed local public spending that has been considered largely responsible for China's property bubbles ricking the financial system (Zhu, 2011).

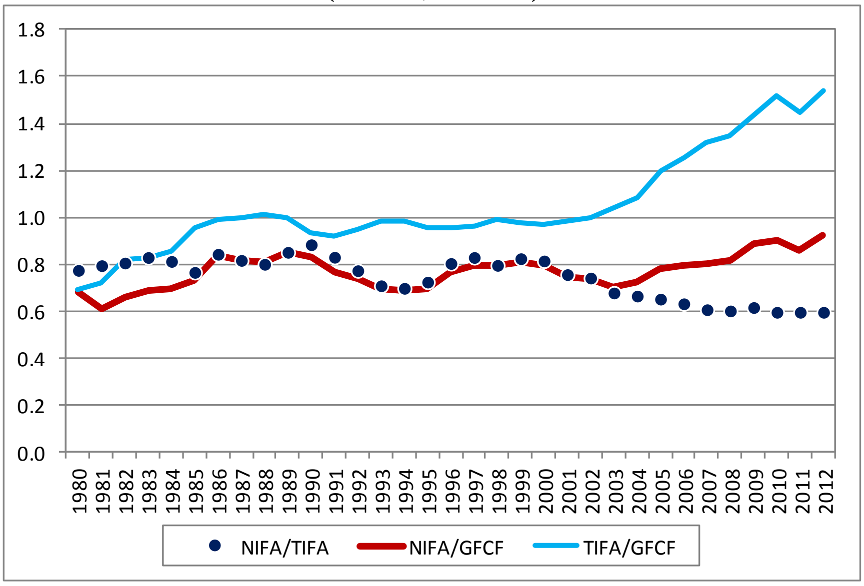
[26] As observed at localities, TIFA statistics are manipulated by local officials in order to meet growth target: some non-investment spending are reported as fixed asset investment; some previously completed projects are repeatedly reported to exaggerate growth performance; and some planned future projects are reported as actual investment.

Besides, TIFA has a serious conceptual problem because it blurs the line between fixed capital formation and inventory. It is by official definition a measure of the *workload* in the 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 and recorded in TIFA may not eventually 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 productive assets and some may never meet the standards, hence be completely wasted, which is a typical phenomenon observed in all centrally planned economies.

The nature of the problem shows a significant conceptual and practical difference between China's national accounts and SNA. The SNA principle governing the time of recording and valuating fixed capital formation 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 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 as *investment* in fixed assets in TIFA. 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.

By concept NIFA is designed to measure the completed fixed assets projects in value terms that are transferred to investors or users in the current period. As shown in the conceptualization for NIFA in Wu (2008), it is the current year completed and recorded result of TIFA initiated in the *current* and in *all the previous years*. NIFA appears to be a better indicator than TIFA but it is by no means flawless. Firstly, since NIFA is originated in TIFA, it has been affected by the same coverage and double counting problems as in TIFA. There is not a system that checks and removes the double-counted land value when a project is completed. Secondly, as required by the statistical authority, "to timely show the achievement in fixed asset investment, completed projects should be generally counted as *currently in operation* even if they are not yet quality-verified and passed" (DFAIS, 1997, p.448). Thus, even if NIFA does not exaggerate the actual fixed capital formation it will still have a different growth pattern from that of the true capital stock in the economy. Lastly, NIFA has inherited a complicated price problem from TIFA. It is never clear whether the valuation in NIFA is at current prices or the prices recorded in TIFA in the years of investment. However, since the *workload* approach is used in the valuation of TIFA, one may reasonably believe that the completed projects recorded in NIFA are also valued in multiple historical prices.

FIGURE 5
COULD THE RELATIONSHIP BETWEEN TIFA, NIFA AND GFCF BE GAUGED?
(TIFA=1; GFCF=1)



Sources: Author's reconstruction based on data from NBS (2012, Tables 2-17, 5-2 and 5-20, and other issues) and DNEA (2004 and 2007).

Based on all these considerations, studies that relied on the official so-called "transfer rate"[27] (DFAIS, 1997, p.174), which is measured as NIFA divided by TIFA, to estimate the "real" GFCF have inevitably included serious flaws (Wang and Fan, 2000; Holz, 2006b; Wang and Szirmai, 2012). Although NIFA and TIFA can be connected in theory, they are conceptually incompatible (Wu, 2008b). There is no regularity that makes NIFA predictable by TIFA because the average time used for a given amount of investment in fixed assets not only depends on the size and type of investment but also depends on the behavior of investors that is affected by ownership form, governing policy and institutional environment.

An Adjustment to GFCF

Based on the above discussion, GFCF is relatively more appropriate for the investment variable required in our estimation of net capital stock for the Chinese

[27] The official English translation of this ratio is recently changed to "Rate of fixed assets projects completed and put in use" (see for example NBS, 2009, p.206).

economy. GFCF is now available as part of the national expenditure accounts starting in 1952 together with inventory, private and government consumption and net export (DNEA, 2007). However, it is still not clear how NBS constructs GFCF from TIFA and NIFA. One cannot simply presume that the official GFCF series is problem free.

In the present work, I do not directly use the official GFCF, here denoted as GFCF(A) in Table 10. Instead, I first remove the investment in residential housing (as an unproductive asset) to obtain a new series of GFCF(B), and then construct a new series of GFCF(C) by applying the share of the official GFCF in the gross domestic expenditure accounts to my alternative GDP estimates (Table F-6). This is to ensure a conceptual consistency with my GDP adjustment. As Table 10 shows, in nominal terms, the movements of GFCF are closer to those of NIFA rather than TIFA. The housing adjustment has a downward effect of 0.2 percentage points for the planning period and 0.7 percentage points for the reform period. I leave the discussion of changes of investment prices in different measures and the further adjustment to derive the series of GFCF(C) after the sub-section on deflator.

TABLE 10

OFFICIAL AND ALTERNATIVE ESTIMATES OF ANNUAL INVESTMENT GROWTH, AND THE SHARE INVESTMENT IN CHINA'S GDP

(Annual compound growth in percent in nominal or 1990 prices, unless specified)

			GFCF in Nominal Prices		Price Change of GFCF		GFCF(B) in 1990 Prices		GFCF(C)[5] in 1990 Prices	
	TIFA[1]	NIFA[1]	GFCF(A)[2]	GFCF(B)[2]	Official IPI[3]	Alternative IPI[4]	Official IPI	Alternative IPI	Alternative IPI	Share[6] (GDP=1)
1952-57	28.3	13.1	18.3	17.7	-2.1	-2.3	20.3	20.5	19.9	0.09
1957-65	4.6	5.9	8.2	8.2	1.6	1.6	6.5	6.4	7.3	0.16
1965-71	11.5	10.9	9.5	9.0	-1.1	-1.1	10.1	10.2	9.9	0.17
1971-77	4.7	4.5	7.1	7.1	0.8	-2.3	6.3	9.7	9.1	0.23
1952-77	*10.7*	*7.9*	*10.2*	*10.0*	*0.0*	*-0.8*	*9.9*	*10.8*	*10.8*	*0.16*
1977-84	16.7	13.4	13.0	12.1	2.7	3.1	9.2	8.8	7.4	0.25
1984-91	17.3	17.6	16.0	16.8	8.0	7.5	8.2	8.7	5.2	0.27
1991-01	20.9	19.7	20.1	19.3	5.9	2.3	12.7	16.7	13.3	0.41
2001-07	24.3	19.8	18.4	15.0	2.7	2.0	11.9	12.7	11.4	0.52
2007-12	22.2	21.8	18.5	19.5	3.4	3.2	15.6	15.8	12.9	0.62
1977-12	*20.1*	*18.3*	*17.3*	*16.6*	*4.8*	*3.5*	*11.3*	*12.7*	*10.1*	*0.40*

Sources: Author's estimates. For the basic data, see Figure 5.

Notes: 1) TIFA and NIFA are as defined in text. 2) GFCF(A) includes residential housing and GFCF(B) removes residential housing. 3) The official investment price index (IPI) is the expenditure accounts implicit deflator. 4) The alternative IPI is constructed based on PPI of investment goods industries, see text for details. 5) GFCF(C) is alternative GDP-adjusted GFCF(B). 6) The share of GFCF is estimated as GFCF(C)/alternative GDP in 1990 prices.

The Initial Capital Stock

Despite many efforts have been made in estimating China's aggregate capital stock,[28] the estimation of its initial (post-war) stock has been left ambiguous. Existing studies have made or adopted very different estimates for the initial capital stock (usually referring to 1952) ranging greatly from less than 50 to over 250 billion yuan in 1952 prices which imply a capital-output ratio (K/Y) ranging from below 0.45 to a level as high as over 2 if based on the official GDP for 1952. Some may argue that the initial stock in the early 1950s does not really matter if mainly interested in the reform period and in growth accounting (Young, 2003, p.1253). But it is however important if we are interested in examining changes in capital-labor ratio, capital-output ratio and the trend of return on capital in the Chinese economy in the long run.

Few of the studies have discussed how their estimates are made. Maddison (1998a, pp.64-65) relied on a hypothetical capital-output ratio of 0.9 for 1952 that was empirically justified by the lower bound of the international standard and pre-war estimates by Yeh (1968 and 1979). I will use this as a reasonable starting point in the following discussion. My research on the initial capital stock follows two lines: one is theoretical which assumes a steady state situation for China in the early 1950s using an approach as explained in King and Levine (1994), and the other one is empirical which uses the data of China's first asset census in 1951 (SETC, 2000, Vol. 1).

The estimation of the initial capital stock follows the steady-state method as in King and Levine (1994). Let us assume that physical capital and the real output grow at the same rate φ^*, that is,

(8.1) $$\varphi_t^* = \frac{dK_t}{K_t} = \frac{dY_t}{Y_t}$$

where K_t is the capital stock and Y_t is real GDP at time *t*. Since $dK_t = I_t - \delta K_t$ then $\frac{dK_t}{K_t} = \frac{I_t}{K_t} - \delta$ where I_t is gross investment and δ is the depreciation rate of physical

[28] For studies in English see, e.g. Chow (1993), Chow and Li (2002), Field (1980), Holz (2006b), Hu and Khan (1997), Maddison (1998a), Wang and Szirmai (2012), Wang and Yao (2002), and Young (2003). For studies in Chinese see e.g. Bai *et al* (2007), He (1992), He *et al* (2003), Ren and Liu (1997), Tang (1999), Wang and Fan (2000), and Zhang and Zhang (2003).

capital. Letting *i* be the investment rate, i.e. $i_t = \frac{I_t}{Y_t}$, thus $\varphi_t^* = \frac{dK_t}{K_t} = \frac{i_t Y_t}{K_t} - \delta$, then the steady-state capital-output ratio is derived as follows:

(8.2) $$\kappa_t^* = \frac{i_t^*}{\delta + \varphi_t^*} \text{ that is, } K_t^* = \frac{I_t}{\delta + \varphi_t^*}.$$

To estimate physical capital stock at time *t* by the standard perpetual inventory method (PIM), the following equation is applied:

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

Then, based on (8.3) we can generate a function of initial capital stock and investment flows as follows:

(8.4) $$K_t = \sum_{i=0}^{t-1}(1-\delta)^i I_{t-i} + (1-\delta)^t K_0$$

where $K_0 = \kappa_t^* Y_0$

To solve for K_0 of Equation 8.4, we need data on investment flows, an average GDP growth rate and a depreciation rate for the initial period. The national accounts GFCF in 1952 can be used for I_0, official and my alternative measures of the average GDP growth for the period 1952-56 are used for $\bar{g}$, 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 official GFCF, GDP and the expenditure accounts implicit GFCF deflators, plus the 2-percent depreciation rate as revealed by the 1951 asset census, I obtain an initial capital stock of 166.7 billion in 1990 yuan for the midpoint time of 1952-57 (e.g. 1955) based on which the average GDP growth rate is calculated. However, if using my alternative estimates of GFCF, GDP and GFCF deflator, and choosing a 5-percent depreciation rate, the results would be 208.3 billion 1990 yuan. And if I use Maddison's assumption of a K/Y ratio of 0.9, I can obtain an estimate of 286.5 billion 1990 yuan for 1952 using my new estimate of GDP.

I evaluate the above estimates by examining seldom used information from the aforementioned 1951 national asset census that verified and evaluated China's stock of fixed assets, only available for publication in 2000 as a collection of archived 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 128.4 billion in 1952 yuan. Taking off the accumulated depreciation value of 39.2 billion, the net stock would be 89.2 billion 1952 yuan, equivalent to 169.6 billion 1990 yuan (based on 1990/1952 investment price ratio 1.901 by the NBS deflator).

However, one should not take this asset census data for granted. Two political economy factors have to be taken into account when evaluating this census results. On the one hand, the private owners of fixed assets had strong incentives to hide some assets in a state-run survey because of a high fear of confiscation or nationalization. On the other hand, the authorities also tended to undervalue private assets in order to reduce the purchase cost of the assets should the sate decide to buy rather than to confiscate them.

There is clear evidence in the census data that the fixed asset in the agricultural sector, dominated by private farmers, is implausibly low, only 0.04 percent of the total net stock. Land is certainly not included. But that is not our problem, at least for the current work as land is also not included. However, we can show that this census result is absolutely implausible only using the information from state-owned farms. In 1952, the land area of state-owned farms, inherited from the old government after the 1949 revolution, accounted for 3.5 percent of the national arable areas. Since state farms were operated with more machinery, draught animals and productive structures than private and household farms, it is reasonable to assume that the fixed assets owned by the state farms may account for at least 10 percent of the total assets in agriculture. Chow (1993) also conjectures that the initial agricultural capital stock should account for 30 percent of the national total excluding land.

I then make an estimation based on the following (still conservative) assumptions: 10 percent of the fixed assets in industry and services were underestimated and after an adjustment for the 10 percent underestimation the value of non-agricultural fixed assets should be accounted for 70 percent of the national total. The residual estimate from this calculation refers to the fixed assets in agriculture. The so-estimated total value of fixed assets is 140.1 billion 1952 yuan for 1951, of which agriculture accounted for 30 percent, industry 8 percent and service 62 percent. After a depreciation and an adjustment to the price change between 1952 and 1990, it would be 287.2 billion 1990 yuan. Next, based on the real growth of fixed asset investment between 1951 and 1952, 14.3 percent (CASS and CA, 1998, pp.1138-42), the comparable value for 1952 is estimated at 328.3 billion 1990 yuan, which is not too far away from the estimate of 286.5 billion 1990 yuan based on Maddison's assumption. This result (328.3 billion 1990 yuan) is used as the initial capital stock for 1952 in my PIM exercise.[29]

Depreciation Rate

Based on Equation 8.4 two sets of net capital stock series are constructed, each using the same alternative depreciation rates proposed in this study based on my earlier work on an industry-level estimation of capital stock (Wu, 2008b).

Following Hulten and Wykoff (1981), I assume that industry-specific depreciation rate, $\delta_i = R_i / T_i$, where T stands for the service life of an industry and function-specific asset which is based on official accounting regulations (State Council, 1985; Ministry of Finance, 1992), and R is the asset's declining balance rate based on the empirical findings in Hulten and Wykoff (1981). The estimated depreciation rates for 39 two-digit level industries are on average ranged from 7 to 8.5 percent for equipment and 2.5 to 3.5 percent for structures over three available time points, i.e. 1963, 1985 and 1993 (Wu, 2008b). Considering the likelihood of a market-induced faster depreciation process following the reform, as well as the underlying faster economic depreciation before the reform, it is reasonable to increase these estimates to 10 percent for equipment and 4 percent for structures in industry. This is a basis for us to gauge an average general depreciation rate for the economy as a whole. In Chinese industry, as evidenced in Wu (2008b) equipment accounts for 70 percent of the fixed assets and structures for 30 percent. This is reversed when focusing on the asset structure of the national economy based on investment, that is, approximately 35 percent for equipment and 65 percent for structures excluding housing, based on official investment statistics. Therefore, an average depreciation rate for the whole economy is about 6 percent (6.1%=10%*0.35+4%*0.65).

Therefore, the present study sets a depreciation rate of 6 percent (δ=0.06) as the baseline with 5 and 7 percent as the lower and upper bound, respectively. These are

[29] Based on the same achieve data (CASS and CA, 1998) on the growth of fixed asset investment over 1949-53, I also obtain an estimate of 256.6 billion for 1949, 267.3 billion for 1950 in 1990 yuan.

alternative depreciation rates for the entire period in question assuming that the depreciation process in the Chinese economy follows a geometric function.[30]

An Alternative Investment Deflator

I construct an alternative investment deflator to the official GFCF deflator that is implicitly given by the expenditure accounts for two reasons. First, the implicit GFCF-IPI may have overstated the price changes in the period 1995-2004 in which China experienced an unprecedented long deflation in investment goods, much longer than that experienced by the general economy in 1998-2002. Second, the implicit GFCF-IPI is highly likely to be influenced by the rapidly rising prices of land transactions along with China's property boom in the 2000s. As Figure 6 shows, since the mid-1990s, the implicit GFCF-IPI has mainly followed the PPI (producer price index) of building materials rather than the PPI of equipment industries. However, the PPI of building materials well reflects the effect of the long deflation in the Chinese economy but the GFCF-IPI does not. This justifies the use of a PPI weighting both the PPI of building materials and the PPI of equipment industries.

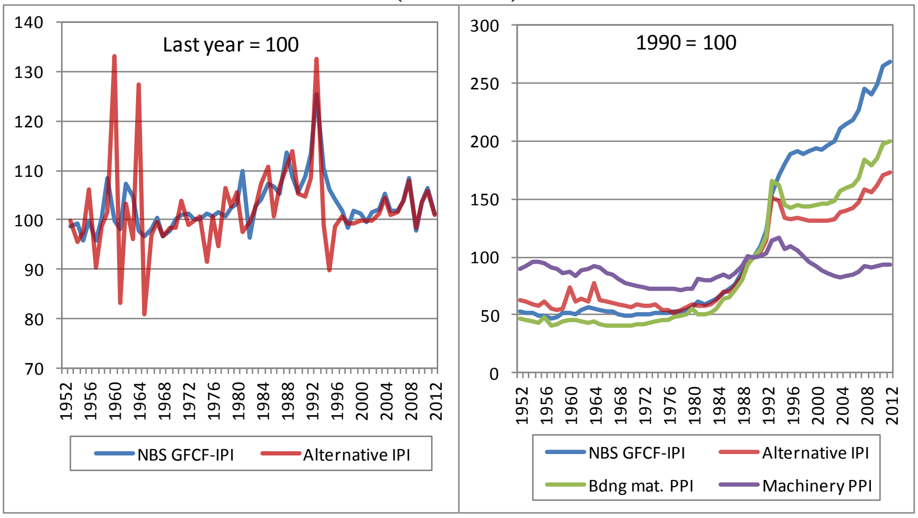
In the construction of the alternative IPI, I first construct two weighted PPIs: one PPI is based on the PPIs of construction materials industries, namely, non-metallic materials and basic and fabricated metals, and the other PPI is based on the PPIs of machinery and equipment industries including ordinary and special purpose machinery, transportation equipment, electrical and electronic equipment and office equipment (Figure 6). I then further weight the two so-constructed PPIs into one IPI, the alternative IPI as depicted in Figure 6.

Table 10 already includes a comparison of the implicit GFCF IPI with my alternative IPI. For the planning period, the GFCF IPI shows that there was no change in investment prices but my deflator suggests a decline by 0.8 percent in investment prices. For the reform period, however, the alternative IPI also implies a slower change of investment prices than the official IPI does, i.e. 3.5 compared with 4.8

[30] Besides, taking into account an increasing market influences on firms' depreciation decision that may have speeded up the depreciation process over time, we can also introduce a multiple-δ depreciation process by assuming 5 percent for the pre-reform period, 6 percent for the early reform period 1978-91, then 7 percent for the period from 1992 onwards up to 2008, and further 8 percent in the wake of the global financial and economic crisis, allowing a "smooth transition" over five years around the benchmarks to avoid breaks. This alternative treatment may be justifiable for reflecting changes of producers' behavior in response to the shifts of policy regimes that promote market competition, but it does not satisfy the theory of economic depreciation.

percent per annum. Consequently, using the alternative IPI will raise the growth of GFCF from 9.9 to 10.8 percent per annum for the planning period and from 11.3 to 12.7 percent for the reform period. It should be noted that other things being equal, this will raise rather than lower the growth of TFP.

FIGURE 6
WHICH INVESTMENT DEFLATOR IS MORE REASONABLE?
(1990=100)



Sources: NBS (2012, Tables 2-17, 9-11, 9-12 and other issues), DNEA (2004 and 2007) and EC (2002).

TABLE 11
ESTIMATED ANNUAL GROWTH OF NET CAPITAL STOCK BY OFFICIAL AND ALTERNATIVE DEFLATORS AND BY DIFFERENT DEPRECIATION RATES
(Annual percentage change)

	Net Capital Stock by GFCF(B) and Official Investment Deflator			Net Capital Stock by GFCF(C) and Alternative Investment Deflator		
	δ=0.05	δ=0.06	δ=0.07	δ=0.05	δ=0.06	δ=0.07
1952-57	4.03	3.21	2.39	5.54	4.74	3.95
1957-65	6.34	5.91	5.50	7.44	7.04	6.65
1965-71	5.87	5.75	5.66	6.87	6.77	6.70
1971-77	7.74	7.77	7.82	8.94	8.99	9.06
1952-77	*6.09*	*5.77*	*5.46*	*7.28*	*6.97*	*6.69*
1977-84	7.23	7.22	7.22	7.92	7.88	7.85
1984-91	9.19	9.27	9.35	7.69	7.65	7.61
1991-01	11.21	11.31	11.41	10.82	10.95	11.08
2001-07	11.19	11.22	11.25	10.92	10.95	10.98
2007-12	13.06	13.16	13.25	11.53	11.57	11.61
1977-12	*10.25*	*10.32*	*10.38*	*9.72*	*9.75*	*9.79*

Source: Calculated based on data in Table F-8.

Table 11 shows the growth rate of net capital stocks estimated by different IPIs and at different depreciation rates, which demonstrates different dynamics in different periods from that of GFCF in Table 10. Examining our baseline estimates with δ=0.06, compared with the official deflator-based results my alternative deflator-based results provide a faster growth of net capital stock for the planning period but a slower growth for the reform period.

TABLE 12
INVESTMENT-CAPITAL RATIO, CAPITAL-OUTPUT RATIO AND "RETURNS ON CAPITAL"
(Annual average)

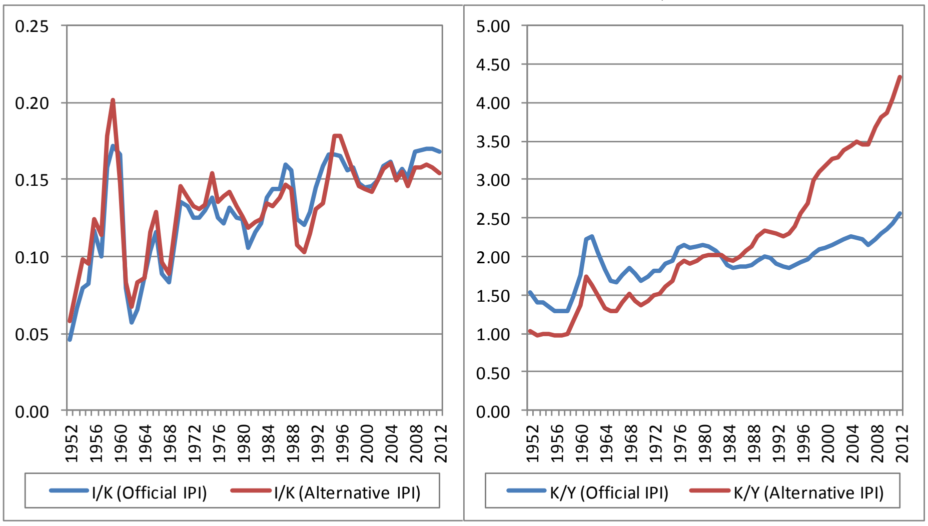
			MPK ("Returns on Capital")		
	I/K	K/Y	Y/K*.6	Y/K*.4	Y/K*φ
1952-57	0.10	0.99	0.61	0.40	0.42
1957-65	0.12	1.38	0.45	0.30	0.34
1965-71	0.12	1.40	0.43	0.29	0.36
1971-77	0.14	1.69	0.36	0.24	0.32
1952-77	*0.12*	*1.37*	*0.46*	*0.31*	*0.36*
1977-84	0.13	1.98	0.30	0.20	0.28
1984-91	0.13	2.15	0.28	0.19	0.25
1991-01	0.15	2.71	0.23	0.15	0.19
2001-07	0.15	3.42	0.18	0.12	0.16
2007-12	0.16	3.95	0.15	0.10	0.15
1977-12	*0.14*	*2.75*	*0.23*	*0.16*	*0.21*

Sources: Tables F-6, F-7 and F-8.
Notes: *Y* refers to my alternative GDP estimates; *I* is GFCF(C) using the alternative deflator; *K* refers to net stock based on δ=.06; the capital share of the national income is given as 0.6 following Chow (1993), 0.4 following Young (2003) and my time-variant estimates (φ) based on the Chinese input-output tables.

Table 12 presents the annual average of investment-capital ratio (I/K) and capital-output ratio (K/Y) for both the planning and reform periods. These measures are based on all my alternatively constructed variables: GDP, GFCF(C) and investment deflator. While the change of I/K is insignificant over periods, the change of K/Y is indeed substantial from about 1 in 1952-57 to nearly 4 in 2007-12. Based the World Bank data for 2010, using the same approach, we can show that countries at much higher level of development did not reach this level, e.g. 3.6 for Japan, 3 for South Korea and Germany, and 2.5 for US. It seems that China is undergoing a *premature transition* from labor-intensive to capital-intensive development. This is, however, not only a sign showing China's high reliance on investment-driven growth but more an indicator to inefficient investment. The dynamics of I/K and K/Y and a comparison between estimates using the different investment deflators are shown in Figure 7.

This can be further supported by a measure of "returns on capital" as marginal product of capital (i.e. Y/K adjusted by the capital share in the national income). As correctly put by Chow (2006), one of important assessments of the estimated capital stock is the rate of return to capital implied by the capital stock. Table 12 also provides three sets of estimates for all sub-periods based on different "capital income shares in national GDP", i.e. a fixed 60 percent following Chow (1993) and also Chow and Li (2002), and a fixed 40 percent following Young (2003) and my time-variant measure based income shares from China's input-output tables and their extensions.

FIGURE 7
INVESTMENT-CAPITAL STOCK (I/K) RATIO AND CAPITAL-OUTPUT (K/Y) RATIO BY OFFICIAL AND ALTERNATIVE INVESTMENT DEFLATORS, 1952-2012



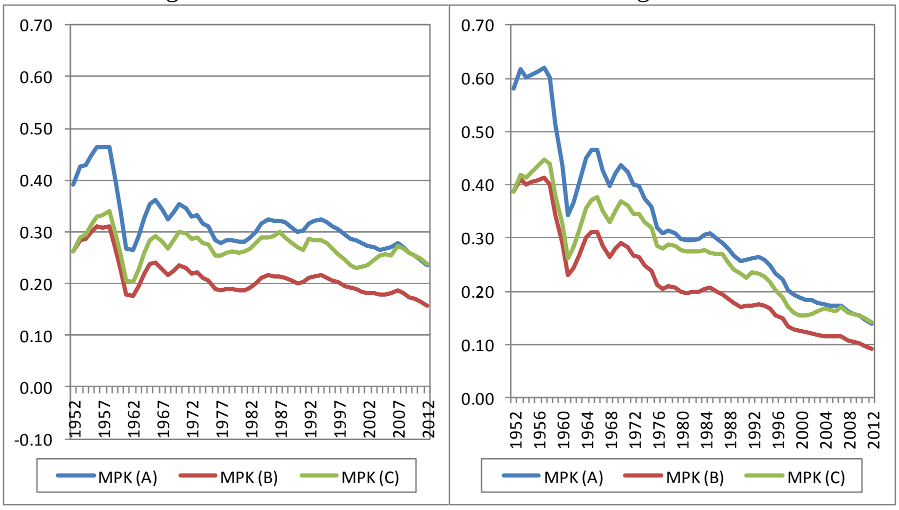
Source: Table 12.

As cited in Chow (2006), for 1954 Chow's estimated capital stock implies a rate of return to capital of 0.22 (different from what I have estimated based on Chow's 60-percent income share for capital, which is 0.61, an average rate of 1953-55), whereas Holz (2006b)'s work implies the rate as 0.99. Based on a market economy assumption for the Chinese economy in the early 1950s, Chow considers that Holz's result is implausible. Although there are conceptual problems in Holz's work, assuming that the economy in the early 1950s was still a typical market one could also be questionable based on clear evidence that the state already owned and controlled the majority of the modern sector of the economy and initiated a radical "corporatization/socialization" in the farm and service sectors by 1954/55. However, for that stage of development a somewhat higher rate of return to capital may be reasonable though it may not be as high as what Holz's results imply. For a comparison, the rate implied by my estimated capital stock is 0.42 and by Wang and Szirmai's work is 0.67, both substantially lower than that of Holz.[31]

FIGURE 8

"RETURNS ON CAPITAL" (MPK) OF THE CHINESE ECONOMY, 1952-2012

A. Using NBS GFCF-IPI B. Using Alternative IPI



Source: Table 12.

Note: MPK(A), MPK(B) and MPK(C) are based on 60 percent, 40 percent and time-variant input-output table capital share in national income.

For the most recent period 2007-12, based on the input-output table income share, China's MPK is only 0.15. Although it is still somewhat higher than the developed countries (the US is .12, Japan is .08 and Germany and South Korea is .10 for 2010), which should not be a big surprise, it is obviously too low if comparing with countries like Brazil (2.7) and India (2.6). The dynamics of alternative estimates of MPK and a comparison between estimates using the different deflators are presented in Figure 8.

Although the economic history shows that income growth in general is accompanied by diminishing returns to capital, in some economies this process can be slowed down or even turned around for some time by productivity advancement. There are interesting observations in Figure 8 which can be used to assess if my alternative estimates are reasonable. Let us use the results based on the time-variant input-output table capital share in national income as our baseline estimates. The central planning period is full of shocks and recoveries due to political reasons. The

[31] All of these estimates conform to the "diminishing return to capital" theorem, though their implied diminishing rates vary substantially. Using 1998 as an example, in line with Chow's timeframe, the estimated rate of return to capital is ranged from 0.122 by Holz (2006b), 0.158 by Chow (2006), 0.169 by Wu (2011) and 0.279 by Wang and Szirmai (2012). Compared to the corresponding rates in 1954, this suggests that the decline of the rate of return to capital between 1954 and 1998 is 2%, 0.7%, 2% and 4.7% per annum, respectively.

high and quickly rising MPK in the early 1950s was apparently due to the post-war recovery that used the idle productive capacity developed in the pre-war industrialization drive and during the wartime which may not be fully measured. Without this abnormal rise, China's MPK level in the 1950s might be around 0.35 on average, similar to other developing countries at this stage of development. China's MPK collapsed to below the 1949 level was caused by the failure of the Great Leap Forward (GLF). The subsequent recovery (1962-65) could only make up half of the losses. The MPK experienced another shock in the early chaotic period of the Cultural Revolution (1966-67). After a short recovery, it underwent a long decline path for most of the 1970s by -4.2 percent per annum.

Clearly, as expected, the reform period slowed down the MPK decline to about 1.9 percent a year in the past three decades, though still faster than 0.5 to 1.5 percent by international standard for an economy at this stage of development. Notably, China's MPK almost stopped declining or even temporarily turned around in some "good periods" including the first 7 years of the initial reform and the period following China's WTO entry till the global financial crisis in 2008. This shows that China gained from reform measures that enabled China's to benefit from its comparative advantage and to harvest its demographic dividends.

However, there were also some "bad periods", in which MPK declined rapidly, almost equivalent to the trend decline under central planning, i.e. in the period around "Tiananmen", the Asian financial crisis, and the period since the global economic crisis (-3.7 per year in 2008-12). This observation suggests that the institutional innovation in each reform drive was not sustainable. When the economy suffered a shock, the government's growth-motivated investment effort scarified efficiency and made the situation worse.

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:

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

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. Also, $L = N \cdot H$, with N standing for numbers employed and H for human capital. With total (logarithmic) differentiation and then a little mathematical rearrangement, we could get the Solow residual:

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

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

In the existing studies, the income shares are in most cases arbitrarily set by some unclear international norms. Typically, it is a fixed $\alpha = 0.6$ as in Young's work (2003) and a fixed $\alpha = 0.4$ as in Chow study (1993).[32] These different fixed income shares for labor are used in my growth accounting exercise to compare with my baseline income share for labor obtained from the benchmark input-output tables and their extensions based on the time series of national accounts and labor compensation.[33] This input-output table/national accounts approach shows a clear decline of α from about 0.59 in 1952 to 0.45 in 1978 and further to 0.41 in 2007 (when the last input-output table is available). I assume that that α further declines to 0.39 for 2012. Thus, by nature it is a time-variant income share for labor.

[32] A new estimate by Chow and Li (2002) gives an even higher capital share as 0.63 suggesting that the labor share is only 0.37.

[33] There is still 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).

In Table 13, I report three sets of estimates based on the three different assumptions of labor share in the national income (α = 0.6, α = 0.4 and α = time-variant income share for labor); each set contains results using the official data and my adjusted data, respectively, but all taking my baseline depreciation rate (δ = 0.06). This is to show the *overall* impact of my adjustment on the sources of growth. Let us first take a look at the results based on the time-variant income share for labor. Compared with the estimates using the official data, the results using the adjusted data reduce the annual GDP growth by 26.5 percent (2.6 percentage points) for the reform period but no change for the central planning period. For the annual growth of physical capital stock, compared with the estimates using the national accounts implicit investment deflator, the estimates using my alternative investment deflator show an increase by 22.2 percent (0.6 percentage points) for the planning period, whereas a reduction by 5.5 percent (0.3 percentage points) for the reform period. For the annual growth of the quantity of labor, the impact of using my adjusted data is 33 percent (0.1 percentage points) for the planning period and -33 percent (-0.1 percentage points) for the reform period. Since there is no official data for human capital, it is no need for a comparison.

The impact of using the adjusted data varies over different periods, however. For example, for the period 2001-07, the best period following WTO, using my adjusted data only reduces the growth of physical capital stock by 3 percent (-0.2 percentage points) and reduces the GDP growth by 8.8 percent (1 percentage point), which are insignificant, and there is no impact in terms of the growth of the quantity of labor. But, for the period 2007-12, the one experiencing the global financial crisis and its aftermath, however, using my adjusted data reduces the growth of physical capital stock by 11.7 percent (0.9 percentage points) and reduces the GDP growth by 30.1 percent (2.8 percentage points), but it raises the growth of the quantity of labor by 150 percent (3 percentage points, i.e. from -2 to +1 percent) (Table 13).

Consequently, we have different estimates for TFP. If accepting the input-output table income shares, when shifting from the official data to my adjusted data the estimated TFP growth rate will be substantially reduced from 3.2 to 1.1 percent per annum (boxed) for the reform period, completely attributed to the adjustment to the official estimates of GDP growth, and reduced from 0.1 to -0.5 percent per annum (boxed) for the planning period, caused by the upward adjustment of the physical capital input. Furthermore, the estimated TFP is very sensitive to the choice of the income share of labor which can be examined by comparing different panels of Table 13 assigned by different income shares of labor. In the case of using the official data, the estimated TFP growth rate will be raised from 3.2 to 4.4 percent per annum when the income share of labor is assigned to 60 percent as Young's hypothesis (2003), but it will be lowered to 2.7 percent if assigned to 40 percent, i.e. Chow's hypothesis (1993). In the case of using my adjusted data, the estimated TFP growth rate will be raised from 1.1 to 2.2 percent if taking Young's hypothesis but will be lowered to 0.7 percent if accepting Chow's hypothesis.

Besides, the effects of the alternative GDP and employment estimates on the estimated TFP growth rate can also be examined with Table E-1 and Table E-2 in Appendix E. Boxed results in these tables correspond with the boxed results in Table 13 for easy following. To summarize what reported in Table E-1, if holding the depreciation rate and investment deflator, changes in the alternative GDP estimates will have some effect on the estimated TFP growth but not all the time, and if holding the estimates for GDP and investment deflator, changes in the alternative depreciation rates will have trivial effect on the estimated TFP growth. However, other things being equal, a change from the official to my alternative investment deflator will lower the TFP growth by about 0.8 to 1 percentage points. And to summarize Table E-2, if holding the estimates of GDP and investment deflator, in most periods there is no change in the estimated TFP growth whichever the scenario is used in the structural break adjustment in the official employment series.

Obviously, none of these TFP values is unfamiliar in the existing literature as reviewed in Section 1. This confirms that the estimated TFP growth for the Chinese economy is very sensitive to how data are adjusted. It is reasonable to take the results based on the official data as the upper bound and the results using the adjusted data as the lower bound. If the data problems are indeed problematic as so far discussed, the baseline results of the lower bound TFP estimates should be closer to the truth. Figure 9 depicts my preferred lower-bound results in Table 13 for an easier examination of the sources of growth (boxed under "adjusted estimates"). The periodization is purposed for understanding the effect of policy regime shifts and external shocks as already explained in Footnote 19.

TABLE 13

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

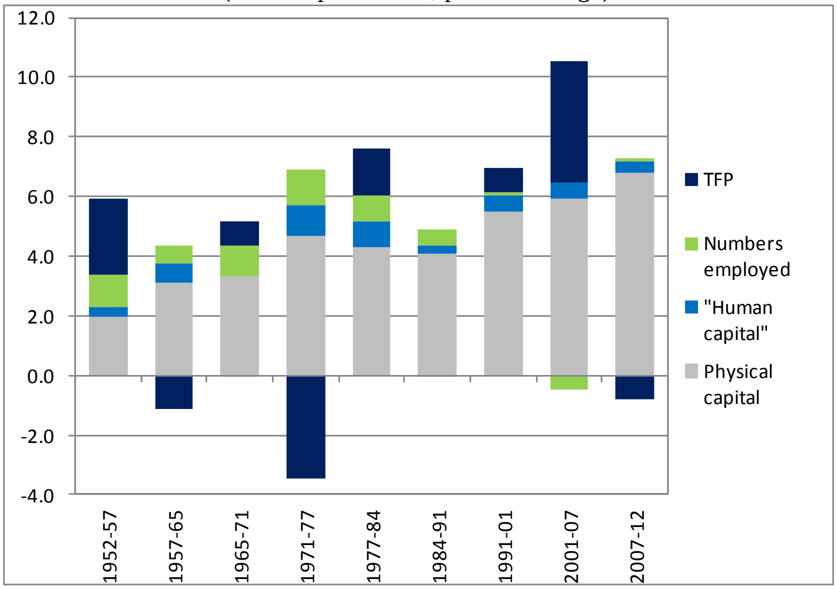
(Percent change per annum)

	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 labor income share based on input-output tables										
1952-57	6.7	1.2	0.3	1.3	3.7	6.0	1.1	0.3	2.0	2.5
1957-65	2.4	0.6	0.7	2.6	-1.4	3.2	0.6	0.7	3.1	-1.1
1965-71	5.3	1.0	0.0	2.8	1.4	5.2	1.0	0.0	3.3	0.8
1971-77	4.0	0.9	1.0	4.0	-2.0	3.4	1.2	1.0	4.7	-3.4
1952-77	*4.3*	*0.9*	*0.5*	*2.7*	*0.1*	*4.3*	*1.0*	*0.5*	*3.3*	*-0.5*
1977-84	9.2	0.8	0.9	3.9	3.3	7.8	0.9	0.9	4.3	1.6
1984-91	8.6	1.0	0.3	4.9	2.2	4.9	0.5	0.3	4.1	-0.1
1991-01	10.4	0.2	0.5	5.7	3.7	7.0	0.1	0.5	5.5	0.8
2001-07	11.3	-0.5	0.5	6.1	4.8	10.3	-0.5	0.5	5.9	4.1
2007-12	9.3	-0.2	0.4	7.7	1.3	6.5	0.1	0.4	6.8	-0.8
1978-12	*9.8*	*0.3*	*0.5*	*5.5*	*3.2*	*7.2*	*0.2*	*0.5*	*5.2*	*1.1*
Fixed labor income share as 60 percent (Young, 2003)										
1952-57	6.7	1.2	0.3	1.3	3.7	6.0	1.1	0.3	1.9	2.6
1957-65	2.4	0.7	0.7	2.3	-1.3	3.2	0.7	0.7	2.8	-0.9
1965-71	5.3	1.2	0.0	2.3	1.8	5.2	1.2	0.0	2.7	1.3
1971-77	4.0	1.2	1.3	3.0	-1.6	3.4	1.6	1.3	3.5	-3.0
1952-77	*4.3*	*1.0*	*0.6*	*2.3*	*0.4*	*4.3*	*1.1*	*0.6*	*2.7*	*-0.2*
1977-84	9.2	1.1	1.2	2.8	3.8	7.8	1.2	1.2	3.1	2.2
1984-91	8.6	1.3	0.3	3.6	3.1	4.9	0.7	0.3	3.0	0.8
1991-01	10.4	0.2	0.7	4.4	4.8	7.0	0.2	0.7	4.2	1.8
2001-07	11.3	-0.6	0.7	4.3	6.5	10.3	-0.6	0.7	4.2	5.7
2007-12	9.3	-0.3	0.6	5.1	3.6	6.5	0.1	0.6	4.5	1.2
1978-12	*9.8*	*0.4*	*0.7*	*4.0*	*4.4*	*7.2*	*0.3*	*0.7*	*3.8*	*2.2*
Fixed labor income share as 40 percent (Chow, 1993)										
1952-57	6.7	0.8	0.2	1.9	3.6	6.0	0.8	0.2	2.8	2.1
1957-65	2.4	0.4	0.5	3.5	-1.9	3.2	0.5	0.5	4.2	-1.8
1965-71	5.3	0.8	0.0	3.4	1.0	5.2	0.8	0.0	4.0	0.4
1971-77	4.0	0.8	0.9	4.6	-2.2	3.4	1.0	0.9	5.3	-3.7
1952-77	*4.3*	*0.7*	*0.4*	*3.4*	*-0.2*	*4.3*	*0.7*	*0.4*	*4.1*	*-1.0*
1977-84	9.2	0.7	0.8	4.3	3.1	7.8	0.8	0.8	4.7	1.4
1984-91	8.6	0.8	0.2	5.5	1.9	4.9	0.5	0.2	4.5	-0.4
1991-01	10.4	0.1	0.4	6.6	2.9	7.0	0.1	0.4	6.4	0.0
2001-07	11.3	-0.4	0.5	6.6	4.3	10.3	-0.4	0.5	6.4	3.6
2007-12	9.3	-0.2	0.4	7.7	1.2	6.5	0.1	0.4	6.8	-0.8
1978-12	*9.8*	*0.3*	*0.5*	*6.1*	*2.7*	*7.2*	*0.2*	*0.5*	*5.7*	*0.7*

Source: Author's estimates. *Notes*: 1) The official data include unadjusted GDP, unadjusted employment and estimated capital stock using the 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 using the alternative deflator. 3) Multiple depreciation rates are used in the estimation of capital stock in both cases. 4) The results in the framed areas are corresponding to the framed areas in Tables E-1 and E-2.

It is clear from 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 change and external shocks are the best candidates for the explanation of the changes of TFP growth over different periods.

FIGURE 9
SOURCES OF GROWTH IN THE CHINESE ECONOMY
(Percent per annum; period average)



Source: Table 13.

First, the puzzling high TFP growth in 1952-57 when the Chinese economy was shocked by a revolution and a radical shift from the market to the Soviet-style central planning system may be explained by the underestimation of capital stock existed before the new regime despite my adjustment based on the 1951 national fixed asset census (Section 8 on the initial capital stock). However, we would not rule out that there must be some efficiency gains attributed to China's first long awaited peaceful period after various wars since the late 1930s. Since the late 1950s the planning period was in general a grave yard for productivity. Apart from a recovery gain in TFP in 1965-71 after the great failure of the Great Leap Forward and its aftermath, the most of the 1970s (up to 1978) when the reform began saw a huge loss in TFP that wiped out half of the gain by inputs. The early reform period 1978-84 did enjoy a TFP increase but it did not sustain. One-off incentive gains due to institutional change could be the main reason.

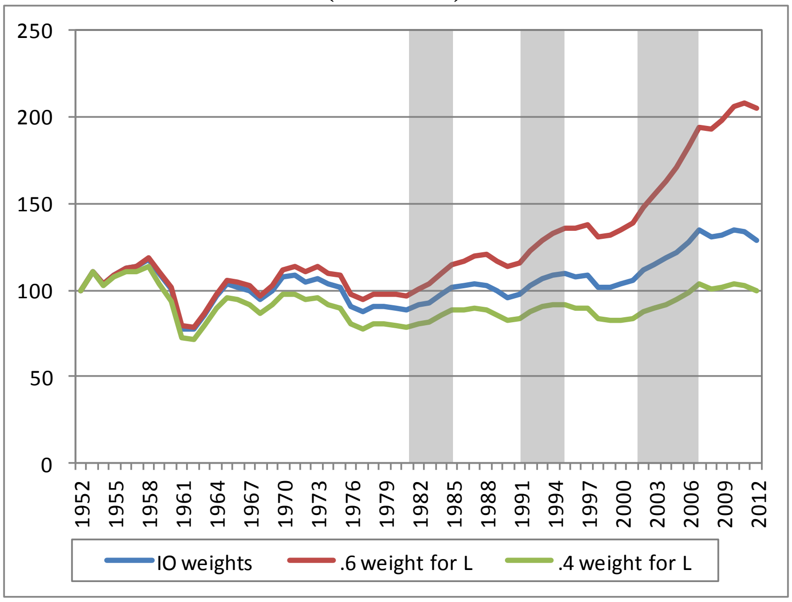
On the other hand, perhaps contrary to what many may have believed, the earlier industrial reforms between the mid 1980s and the end of 1990s were not TFP growth-promoting. The industrial reform began in 1985 which operated on the backbone of the central planning system brought about a political shock in 1989-90 and reflected by a zero TFP growth in 1984-91. However, in the following period 1992-2001, the fastest ever physical investment only achieved a slightly improved TFP performance, which contributed to the growth by about 10 percent a year.

The only period that saw a significant TFP growth was the one following China's WTO entry, i.e. 2001-07, before the economy was impacted by the global financial and economic crisis. In this period China benefited from its comparative advantage in labor intensive manufacturing through a substantially enlarged world market. China suddenly found itself in a very competitive position because there had built up a huge production capacity in the past decade that was significantly underutilized (evidenced by China's persistent deflation from 1998 to 2002). However, China's WTO entry is productivity promoting not only because it allowed China to benefit more from its comparative advantage but also speeded up China's learning by doing process through a deeper and wider international market exposure as well as further institutional reforms prompted by such an exposure.

All the observations are based on period-specific average growth rate. Figure 9 changes our angle of examination by the initial period-based TFP indices. The alternative TFP indices for China are constructed by annual estimates using my adjusted data with the different income shares for labor as well as my alternative investment deflator and the baseline depreciation rate. Although the patterns of these estimates are similar, there is no even-level effect because of changes of other variables and because our baseline assumption for labor income share is time-variant. Apparently, each time when there is an upswing in TFP growth in general (shaded years), the results based on the 60-percent income share for labor show an even faster growth in particular. This leaves a large gap at the end of the period in 2012 to the extent that is difficult to explain, especially when the actual labor share in the national accounts declined over time and down to a level of below 40 percent. But the estimates using the 40-percent income share for labor appear to be too low. Thus, we focus on the results using the time-variant income share for labor.

As observed in Figure 10, after a very high volatile process in the TFP performance under central planning, China only managed to regain its initial TFP level by the mid 1980s (the results with IO weights, Figure 10). But the subsequent movement was still volatile in which two external shocks, the Tiananmen political crisis in 1989-90 and the Asian financial crisis, forced it back to the initial level twice. An unprecedented long rise of TFP began with China's WTO entry and continued till the shock of the Lehman Brothers, as examined with the annual growth rate of TFP in Figure 9 and Table 13. Despite the government's huge rescue package and various inflationary subsidization measures, there has been no sign so far that China's TFP performance will soon get back to its trend that was built up in the period 2001-07.

FIGURE 10
ALTERNATIVE ESTIMATES OF TFP LEVEL FOR THE CHINESE ECONOMY
(1952 = 100)



Source: Author's calculation. See notes to Table 13, and Appendix Tables E-1 and E-2.
Note: Shaded periods refer to the results using IO-weights to highlight a continuous TFP growth.

10. CONCLUDING REMARKS

This study is heavily data driven because, as argued, this is the only way to settle the debate on China's productivity performance in the literature that adopt the same neoclassical framework and use the same or similar estimation methodology. It reviews and revisits the major data problems concerned in the literature and propose alternative adjustments in a transparent way that anyone can access the data and repeat any of the exercise. I summarize the main data and measurement works in this study and their implications as follows.

First, based on a careful investigation in the earlier population census and policy regime change in employment, I adjust the serious structural break in the official employment series in 1990, improve Maddison's estimation of military personnel as part of service employment, and then further convert the total numbers employed to a full-time-equivalent (FTE) measure based on newly estimated series of hours worked, first of its kind, using data from various censuses and surveys. This work not only reasonably smoothes the break but also makes the numbers employed conceptually compatible over time. Obviously and understandably, these adjustments mainly have level effects on measures such as K/L or Y/L ratios, rather than any significant growth effect on these ratios over a period. However, it is unreasonable to ignore it in a serious assessment of China's growth performance.

Second, I construct a measure of human capital stock possessed by China's workforce using official statistics on education (on primary schooling equivalent or PSE basis) and empirical research results on returns to education in China to augment the numbers of FTE employment. This is an attempt to make the numbers employed more "homogenous". It is not a standard way to measure cost-weighted labor input, but a better alternative than the direct use of natural numbers. Besides, my effort to take into account the impact of the Cultural Revolution on education makes a better measure for the change of the education-based human capital stock and its influence on the output growth. The growth accounting results show that the "human capital" growth accounts for 35 and 69 percent of the income-weighted "labor input" in pre- and post-reform period, respectively, which will certainly distort the estimated TFP if ignoring it.

Third, in gauging the real output growth of the so-called "non-material services" (including non-market services), based on my new findings that support Maddison's "zero labor productivity growth" hypothesis for the pre-1982 period, I introduce annual deviations to the zero-growth trend to improve Maddison's earlier estimates; and for the post-1982 period, instead of only following Maddison I also propose two alternative assumptions that allow these services to growth from 1 to 2 percent per year based on the well observed historical experience to see how significant the Maddison hypothesis is challenged. With the fastest growth scenario, which allows 1-percent annual growth for the earlier reform period up to 1992 and 2-percent annual growth afterwards, other things being equal, the official estimate of China's aggregate GDP growth will be reduced by 0.4 percentage points from 4.3 to 3.9 percent for the planning period and reduced by 0.7 percentage points from 9.8 to 9.1 percent for the reform period (based on my growth accounting results in Table 13).

Fourth, in this study I have further and significantly improved my commodity indicator-based production index for Chinese industry. I introduce two important price weights for 2002 and 2007, in addition to three weights (1987, 1992 and 1997) used in my earlier studies, all conforming to China's full input-output tables, to test for the substitution bias (the Gerschenkron effect) and, more importantly, to examine the impact of external shocks when the price weights are changed. The results are robust and lend a strong support to the approach and a construction of a better production index. The gross output based results are further adjusted by time-variant value added ratios from the input-output tables. I also investigate if the difference between my alternative and official estimates contains a component that convincingly captures quality changes missed in the commodity index. No clear evidence is found to support the missing quality critique. This adjustment however has produced the biggest downward impact on the official estimate of China's aggregate GDP growth among all adjustments, which is -1.8 percentage points, from 9.8 to 8 percent, for the reform period, *ceteris paribus*.

Last but not least, I provide a completely new set of estimates of net capital stock for the Chinese economy after careful investigations of the initial capital using the achieve data, the prices of fixed capital investment using PPI of capital goods manufacturers, and alternative depreciation rates supported by my industry-level estimates (Wu, 2008b). The constructed investment flows are further adjusted for housing and for my alternative output estimates to maintain consistency with the production accounts. In the final growth accounting exercise that uses all adjusted variables as well as the input-output table income shares (Table 13), this new capital stock measure, used to approximate the flow of capital service in the absence of information on asset types, reduces the physical capital contribution to the GDP growth by 0.9 percentage points for the fastest post-WTO growing period 2001-07. However, for the entire reform period up to 2012, the physical capital contribution is reduced only by 0.3 percentage points from 5.5 to 5.2 percent.

The overall impact of my adjustments on China's growth performance is downward but still reasonable in an international perspective, especially in a comparison with its East Asian neighbors. Based on the latest version of The

Conference Board Total Economy Database (TED) (TCB, 2013), originated from Maddison's world economy database with revisions and updates by TED, I define the same development stage for China, Japan, South Korea and Taiwan, in terms of per capita PPP in 1990 GK$. The first stage is from per capita PPP$4,000 to $8,000 and the second stage is from per capita PPP$8,000 to $12,000, matching China in 1992-2004 and 2005-14 (with 2013-14 projected based on the average growth of 2010-12), respectively. The same or similar two stages for Japan is 1950-60 and 1961-68, for South Korea is 1954-72 and 1973-86, and for Taiwan is 1957-70 and 1971-83. Over these two stages of development, China's total GDP grew by 7.4 and 7.5 percent per annum, compared with Japan's 8.5 and 9.7, South Korea's 6.8 and 8.2 and Taiwan's 8.5 and 8.6, accordingly. China does not appear to be a leader in this league.

However, we must not ignore the shocks that China has experienced over the same time. Economies at this stage of development, especially those opt for export-oriented development, are vulnerable to external shocks. China was badly hit by both the Asian financial crisis in 1998 and the global financial and economic crisis in 2008 and its long-lasting negative impact. In contrast, Japan already achieve the level of PPP$16,000 before the oil shock, and South Korea and Taiwan achieved this level before the Asian financial crisis. Without the shocks, China's annual growth would be 7.9 and 8.2 percent (assuming the years of shocks would grow at an average rate of the adjacent years). To me, it is easier to accept that the pace of China's growth is similar to or even slightly slower, instead of faster, than the East Asian economies not only because of heavy government interventions in resource allocation that is deemed inefficient, but also because of China's strong central planning legacy with huge wasteful investment and significant damages caused by radical political movements and significant policy mistakes for economic development.

All the adjustments have an impact on the estimated TFP growth. Obviously, the results do not appear to be in favor of the optimistic camp. Under the most reasonable scenarios, my estimates show that China's annul TFP growth is -0.5 percent for the planning period and 1.1 percent for the post-reform period, much slower than the results using unadjusted official data, i.e. 0.1 and 3.2 percent, respectively. In other words, the contribution of TFP growth to the GDP growth is 32 percent if using the unadjusted official data, but only 15 percent if using the alternative data. However, my warning is that one should not quickly jump to a conclusion without closely looking at the performance of individual periods reflecting important policy regime shifts and external shocks. With my adjusted data, the post-WTO period emerged as the best ever period with 40 percent of annual GDP growth contributed by TFP, whereas it turned into a negative 12 percent following the fall of Lehman Brothers in 2008.

Data tell the truth but they may also hide the truth. To make them truth-revealing one has to carefully investigate the problems and identify likely causes which disguise the truth. The following adjustments require sufficient knowledge not only about the economy but more importantly the institutions through which the data are generated and produced by state agencies. However, any data adjustment should be made transparent and its results accessible for repeating the same estimation.

We have confined the present study to the well known neoclassical growth accounting framework adopted in most of the existing studies, explicitly or implicitly. As stated at the beginning of the paper, the purpose of this study is to discover how and to what extent data problems may affect the estimated TFP growth, rather than exploring a new theoretical framework to explain China's TFP performance. For this purpose, I have maintained the same approach and the same theoretical framework. Nevertheless, it is perfectly reasonable to argue that the neoclassical framework used in this study is questionable (Felipe, 1999). Taking data problems more seriously is by no means to say that theoretical and methodological problems are unimportant. Rather, those problems cannot be properly evaluated before major data problems are resolved. After all, the current Chinese economy is too important to be misread. However, a better reading of China relies on a solid reconstruction of historical data series with a theoretically sound approach.

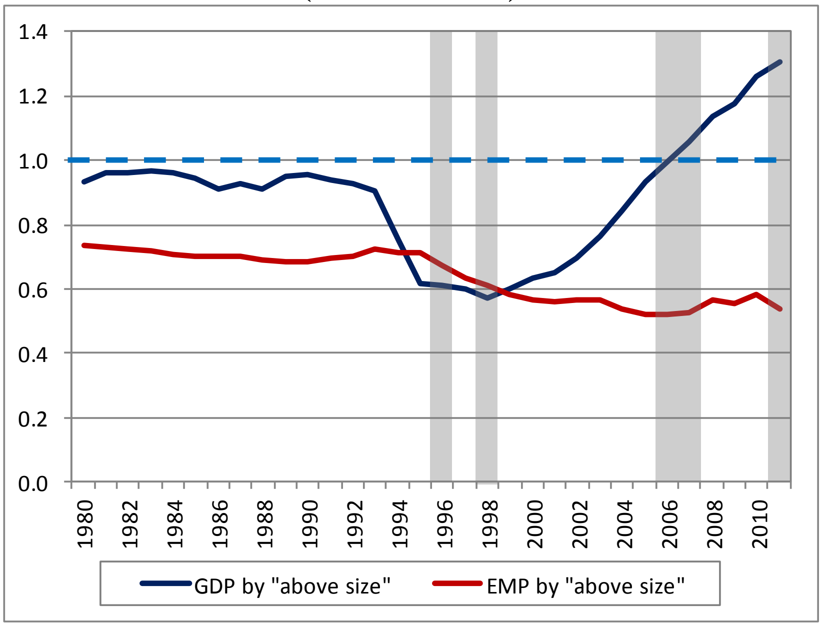
Appendix A
Inconsistency between National Accounts and Industrial Statistics in Value Added and Its Implications for Employment Statistics

China's detailed industry statistics are only available for enterprises at and above the "designated size" (hereafter "above-size enterprises") through a regular (monthly, quarterly and annually) statistical reporting system. The smaller, "below size" enterprises are monitored by regularly conducted sample surveys. There is also workforce "outside the system", which is only picked up by population censuses or annual 1% population surveys. The "outside the system" workers are recorded by a somewhat looser definition, such as "performing at least one hour wage-earning job in the week of the survey" as used in national population census. They can be full-time employees or self-employed persons in the formal sectors, or seasonal, temporal workers with by-employment (multi-jobs) mainly engaged in the informal sectors. Thus, on average, they are not equivalent to the workers "within the system" (i.e. at/above and below the "designated size").

This criterion was introduced to the official regular statistical reporting system in 1996 in parallel to the existing criterion of "at township or above administrative level" enterprises that began in the early 1980s replacing a standard solely based on ownership types. The new criterion defines an "above size" enterprise with a total annual sale of 5 million yuan. However, all SOEs no matter their size of sales were included. In 1998, the administrative level criterion was abandoned. That is, no matter at what administrative level, an enterprise was included as long as its total sales were 5 million yuan or more. In 2006, the value of total sales was changed to the value of the sales of major business. In 2007, the "below-size" SOEs were excluded from the system if they could not meet the size criterion. In 2011, the value of the sales of major business was raised to 20 million yuan.

The data collected through this reporting system are the basis for official statistical indicators on industrial activities at national level. There is, however, no information on how consistency has been maintained despite these criterion changes that define which enterprises should be included in the system and more importantly how the enterprises and industrial activities below the "size" and "outside the system" are estimated as a coherent part of the national output and employment accounts. In the mid 2000s, a serious inconsistency emerged in the GDP estimates and has since worsened. That is, the sum of the value added by the "above size" enterprises, reported in detailed *China Industrial Economy Statistics Yearbook*, first approached to the level of the national industrial GDP as given by the national accounts while the employment share of these above-size enterprises declined, and then exceeded the industrial GDP after 2006. This can be clearly examined in Figure A.

FIGURE A
VALUE-ADDED AND EMPLOYMENT BY INDUSTRIAL ENTERPRISES AT/ABOVE THE "DESIGNATED SIZE" COMPARED WITH THE NATIONAL TOTALS
(National Total = 1)



Sources: Reconstructed by the author based on national accounts data from various volumes of *China Statistical Yearbook* and industrial employment and value added data from various volumes of *China Industrial Economy Statistical Yearbook* and *China Labor Statistical Yearbook*.

Notes: The shaded periods indicate changes in the criterion of the statistical reporting system behind the observed increasing inconsistency.

Figure A presents both the GDP and employment shares of the above-size enterprises in the national totals (=1) with the periods marked to indicate the change of the key criterion. I have reconstructed the data for the period before the early 1990s to backwards extend the official series following the "relationship" between different series using the "above size" and administrative level and ownership type standards. It appears that despite some relative changes between the two shares, they maintained a fairly stable relationship before the early 1990s, that is, over 90 percent of the industrial GDP was produced by the "above size" enterprises that employed about 70 percent of the national industrial workforce. By 1998 when the "size" criterion was completely established and the administrative level criterion was abandoned, the two shares temporarily converged at around 60 percent of the national total. However, this was also the point at which a strong divergence of the two shares began. By 2006, the sum of the value added of the "above size" enterprises became equal to the national industrial GDP. It implies that 24 million workers employed by the "below size" enterprises and 43 million workers engaged in "outside the system" industrial activities produced nothing or simply disappeared. Such a contradiction continued and the data were published as usual without noticed until 2008 when the "above size" produced 113 percent of the national industrial GDP with 56 percent of the national industrial workforce. The only "revision" by the statistical authority was to stop publishing the value added by the "above size" enterprises while keeping all other indicators unchanged.

At an internal joint workshop between The Conference Board China Center and NBS in May 2010, when questioned the NBS statisticians acknowledged three factors that might be able to explain the discrepancy: 1) an increasing inconsistency in the number of enterprises covered by the 500 million-criterion—the number of enterprises rose from 160,000 in 1998 to 420,000 in 2008; 2) an increasing double counting problem caused by the so-called "headquarter effect" that repeatedly reported the same output value in the locations of factories and the location of the headquarter of a company; and 3) data falsification. However, NBS did not pay enough attention to the much worse inconsistency in its employment statistics that the GDP inconsistency might imply.

At the news release for the change in 2011 that raised the criterion of the value of sales of the major businesses from 5 million to 20 million yuan, just like what happened in 1998 when the "above size" system was finally introduced, NBS mainly emphasized that the change of the "above size" criterion would not introduce any significant inconsistency in the existing series of the value of output, completely ignoring its important implications for employment (NBS Information Net, March 8, 2011). In my view, lack of a coherent system that properly links output statistics with employment statistics is the primary cause of the problem. It is largely an institutional problem within the statistical authority as a legacy of the central planning system that tends to manage statistical work administratively that ignores the natural connections between output and all inputs, especially labor in this case.

APPENDIX B
CPPI AND THE GERSCHENKRON EFFECT

In Wu (2011), I show that linking the quantity index estimated by segmented "constant prices" weights as in the Chinese national accounts practice also introduces an upward bias which can be explained by the Gerschenkron effect.

This can be easily shown with simple mathematics. Let us assume that we need to calculate the real growth between the first year of Period 1 and the first year of Period 3. Note that the period here refers to the "constant price" period in the "comparable price system". Three sets of the "constant prices" are involved in the example below. The first year of each period is the base year of the prevailing "constant prices" for that period. Following the discussion of the Gerschenkron effect in the text, we know that

$$\text{(B.1)} \qquad \frac{\sum p_c^1 q^2}{\sum p_c^1 q^1} > \frac{\sum p_c^2 q^2}{\sum p_c^2 q^1}$$

and also

$$\text{(B.2)} \qquad \frac{\sum p_c^2 q^3}{\sum p_c^2 q^2} > \frac{\sum p_c^3 q^3}{\sum p_c^3 q^2}$$

where subscript c stands for the constant prices and the superscripts denote the periods with the different sets of the "constant prices", i.e. 1, 2 and 3 in this case. We can ignore the time as in this example it always refers to the first year of a period, i.e. $p_c = p_0$, because the first year is the base year of the prevailing "constant prices". Each side of the above two inequations represents a real growth index over the two periods using a specific set of the "constant prices". Let us now first rearrange (3.5) and then multiply it by the left-hand side of the inequation (3.6):

$$\text{(B.3)} \qquad \frac{\sum p_c^1 q^2}{\sum p_c^2 q^2} \cdot \frac{\sum p_c^2 q^3}{\sum p_c^2 q^2} > \frac{\sum p_c^1 q^1}{\sum p_c^2 q^1} \cdot \frac{\sum p_c^2 q^3}{\sum p_c^2 q^2}$$

which can be further rearranged as

$$\text{(B.4)} \qquad \frac{\sum p_c^1 q^2}{\sum p_c^2 q^2} \cdot \frac{\sum p_c^2 q^3}{\sum p_c^1 q^1} > \frac{\sum p_c^2 q^2}{\sum p_c^2 q^1} \cdot \frac{\sum p_c^2 q^3}{\sum p_c^2 q^2}$$

Therefore, we can prove that

(B.5) $$\frac{\sum p_c^1 q^2}{\sum p_c^1 q^1} \cdot \frac{\sum p_c^2 q^3}{\sum p_c^2 q^2} > \frac{\sum p_c^2 q^3}{\sum p_c^2 q^1}$$

It is clear that the estimated growth rate of Period 3 over Period 1 using two segmented "constant price" weights as shown on the left hand of the inequality ($p^1$and p^2) is biased upwards compared with that using one set of the "constant price" weights as shown on the right hand side of the inequality (p^2). Therefore, an index with a more recent, price weights is less biased than one with multiple sets of price weights.

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 throughout 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.[34] Therefore the effect of the adjustment for the military personnel is implicit. Following the new

[34] 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).

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 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 C

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.

References for Appendix C

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APPENDIX D
METHODOLOGY AND DATA FOR SECTION 7

My methodology for constructing a real output index for Chinese industry begins with a Laspeyres index approach to bypass the complicated CPPI problem. The exercise involves four major steps. The first step is to aggregate available commodities or commodity groups from *China Industrial Economy Statistical Yearbook*, hence termed as CIES items (see the data section below), into (larger) groups that can be matched with the basic (3-digit) industries in a specific year's Chinese input-output table. Each basic CIOT industry may contain several commodity groups. Benchmark-year price data are first used in intra-group weighting and then in aggregating the groups to produce indices that match the basic CIOT industries.

The second step is to use the gross value of output of the basic (3-digit) CIOT industries to weight and aggregate these commodity groups to match the major (2-digit) CIOT industries (or branches), called CIES item-*identified* quantity index for each industry.

The third step is to construct a complete GVO index for each of the major CIOT industries by assuming the *unidentified* part of the output value in an industry to move together with the CIES item-*identified* part of the output value. This is a strong assumption, but justifiable as we discussed in the data section. The above three steps are discussed in details in Wu (2002a).

The last step is to estimate gross value added at the major CIOT industry level (Wu, 2011). A time series of the GVA/GVO ratio (μ) by industry has to be constructed first based on all available Chinese input-output tables and information on the NMP/GMP ratio[35] from China's historical national accounts (Wu and Yue, 2000). The ratio is then applied to the estimated GVO at the same industry level to obtain GVA by industry.

A simple mathematical expression for this method is helpful. Let q_{hij} be the quantity of the h^{th} commodity (h = 1, 2, ..., l) of the i^{th} commodity group (i = 1, 2, ..., m) in the j^{th} industry (j = 1, 2, ..., n) and φ_{hij} be the weight for this commodity. The quantity index for the jth industry based on CIES items, $X_{j,t(T)}^{\text{GVO,CIES}}$, is defined as:

(B.1)
$$X_{j,t(T)}^{\text{GVO,CIES}} = \frac{\sum_{i=1}^{m}\sum_{h=1}^{l}\varphi_{hij,T}\,q_{hij,t}}{\sum_{i=1}^{m}\sum_{h=1}^{l}\varphi_{hij,T}\,q_{hij,T}}$$

where T denotes the base year (which is a specific CIOT base year in this study).

Equation (3.1) is in line with the approach of the Laspeyres index, i.e. a fixed base-year-weight index. As clearly shown in this equation, to compute an industry-specific GVO index, quantities of commodities within each industry have to be aggregated by proper weights. The procedure is "*intra*-industry aggregation". The prices used to obtain the weights should be the producer prices or ideally the unit values derived directly from the quantity and gross value of output of a commodity at factory gate. In the present exercise, prices and quantities are available from separate sources for most products, leaving a few to rely on the volume movement approach (Wu, 2002a).

Next, to derive the CIOT industry-level GVO index that incorporates the CIES-unidentified component, I assume the trend of the unidentified component to move with the identified component, therefore,

(B.2)
$$GVO_{j,t(T)} = X_{j,t(T)}^{GVO,CIES} \cdot GVO_{j(T)}^{CIOT}$$

[35] A ratio of new material product (NMP) to gross material product (GMP), which is a concept that is used in MPS to account for national income net of all inputs.

Lastly, I use the constructed CIOT industry level value added ratio (μ) to obtain GVA by industry. Since $\mu_{j,t} = GVA_{j,t} / GVO_{j,t}$, it follows that

(B.3) $$GVA_{j,t(T)} = GVO_{j,t(T)} \mu_{j,t} .$$

It is therefore obvious that changes of the value added ratio will make the GVA index of an industry deviate from the GVO index of that industry.

Data

Three types of data are required for this kind of exercise, namely, the output of industrial products in physical terms, producer prices that match the available products for the five base years, and the base-year GVO weights and GVA ratio by industry in the national accounts framework, as given in the Chinese input-output tables, which correspond with the products.

Our first task is to set up the CIOT-based national accounts framework. It involves the reclassification of all five available CIOTs to ensure consistency over the benchmark years. The reclassification has to satisfy the 1987 CIOT that has the least details on classification. Finally, 83 CIOT sectors become the standard classification system for all CIOTs in handling commodity grouping. Following the methodological steps, the weighted commodities (discussed below) are further grouped to match these 83 sectors to produce sector-level quantity indices. Then, the GOV weights of 83 sectors are used to regroup these sectors in constant price value into 25 (2-digit level) sectors for the final results (regrouped into 17 broad sectors in all final reports).

The value added ratios by industry for the base years are derived from GVO and GVA data of the reconstructed CIOTs. For the years between the benchmark CIOTs, the ratios are interpolated. For the pre-1987 period when there was no input-output statistics available, the ratios are estimated based on NMP/GMP ratios (Wu and Yue, 2000), and for the post-2007 period, the ratios are extrapolated based on the changes between 2002 and 2007.

The commodity or commodity group data for this study can be obtained from various volumes of *China Industrial Economy Statistical Yearbook* (CIES) published by the NBS Department of Industrial Statistics (DIS) (previously the Department of Industry and Transportation Statistics or DITS). The number of commodities or commodity groups changed over time, so did the number of commodities covered because of new commodities added in while some old series dropped or stopped. Additional information is used to bring in new products and to repair any broken commodity series (Wu, 2002a). In the present exercise, some commodities are revised based on recently available monthly series from CEIC Database.[36] These revised commodities are confirmed as compatible to CIES items and in most cases share the same sources of the latter. Finally, 165 out of 250 CIES commodity or commodity groups are used.

In the exercise, the CIES items are aggregated to match the CIOT industries. The direct coverage ratio based on the weighted commodities is 62%, 60% and 47% for the 1987, 1992 and 1997 benchmarks, respectively, and 43% for both the 2002 and 2007 benchmarks. Despite the coverage ratio has declined, the representativeness of the major commodities can still be considered fairly high in terms of the size and the increasing complicity of the industrial economy.

The price data that I have used to aggregate these CIES items up to the required basic industry level are ex-factory prices for the base years, i.e. 1987, 1992, 1997, 2002 and 2007. For the first three benchmarks data are available from the *Post-War Chinese Industrial Price Database*, compiled by the Institute of Economic Research of Hitotsubashi University in collaboration with Chinese statistical authority based on unpublished price surveys (IER, 1999). This database covers the ex-factory prices of around 2000 industrial products without matching quantities. To obtain prices that match the commodity groups in the selected CIES items, in most cases I estimate their output weights of the industry branch that they belong to using information from annual almanacs of state industry associations (mostly former ministries of individual industries) (Wu, 2002a).

Data on commodity prices for 2002 and 2007 are estimated using 3-digit level PPIs for 1998-2005 that covers 185 industries (IER, 2008) and 2-digit level PPIs for 1998-2007 (NBS, 2011). Basically, price movements at this level of industry details are assumed to be the same as price changes of matching commodities or commodity groups.

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[36] Interested researchers need to subscribe the use of the China data from the CEIC Company Ltd. All the basic data are sourced from government agencies of over 130 countries and processed by CEIC. The CEIC China data are checked and official sources are confirmed. See www.ceicdata.com for details.

APPENDIX E
SUPPLEMENTARY TFP RESULTS TO TABLE 13

TABLE E-1
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=0.5	δ=0.6	δ=0.7	δ=0.5	δ=0.6	δ=0.7	δ=0.5	δ=0.6	δ=0.7	δ=0.5	δ=0.6	δ=0.7
Official Expenditure Accounts Implicit Investment Deflator												
1952-57	3.3	3.7	4.0	1.5	1.9	2.2	1.6	1.9	2.2	1.6	1.9	2.2
1957-65	-1.6	-1.4	-1.2	-2.0	-1.9	-1.7	-1.7	-1.6	-1.4	-1.7	-1.6	-1.4
1965-71	1.3	1.4	1.4	1.0	1.0	1.1	0.8	0.8	0.9	0.8	0.8	0.9
1971-77	-2.0	-2.0	-2.0	-2.8	-2.8	-2.8	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
1952-77	*0.0*	*0.1*	*0.2*	*-0.8*	*-0.7*	*-0.5*	*-0.8*	*-0.7*	*-0.5*	*-0.8*	*-0.7*	*-0.5*
1977-84	3.3	3.3	3.3	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1
1984-91	2.3	2.2	2.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991-01	3.8	3.7	3.7	1.9	1.9	1.9	2.3	2.3	2.3	2.2	2.1	2.1
2001-07	4.8	4.8	4.8	4.6	4.5	4.5	4.8	4.7	4.7	5.1	5.1	5.0
2007-12	1.3	1.3	1.2	-0.4	-0.4	-0.5	-0.6	-0.7	-0.7	-0.2	-0.2	-0.3
1978-12	*3.2*	*3.2*	*3.1*	*1.7*	*1.7*	*1.7*	*1.8*	*1.8*	*1.8*	*1.9*	*1.9*	*1.9*
Alternative Investment Deflator												
1952-57	3.9	4.2	4.6	2.2	2.5	2.8	2.2	2.5	2.8	2.2	2.5	2.8
1957-65	-1.1	-1.0	-0.8	-1.6	-1.4	-1.3	-1.3	-1.1	-1.0	-1.3	-1.1	-1.0
1965-71	1.4	1.4	1.4	1.0	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8
1971-77	-2.4	-2.4	-2.5	-3.2	-3.2	-3.2	-3.4	-3.4	-3.5	-3.4	-3.4	-3.5
1952-77	*0.1*	*0.3*	*0.4*	*-0.6*	*-0.5*	*-0.4*	*-0.6*	*-0.5*	*-0.4*	*-0.6*	*-0.5*	*-0.4*
1977-84	2.8	2.8	2.8	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6
1984-91	2.0	2.0	1.9	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.1	-0.1	0.0
1991-01	2.3	2.2	2.2	0.6	0.6	0.5	1.0	0.9	0.9	0.8	0.8	0.7
2001-07	3.9	3.9	3.9	3.6	3.5	3.5	3.8	3.8	3.7	4.1	4.1	4.1
2007-12	0.8	0.8	0.8	-0.9	-1.0	-1.0	-1.2	-1.2	-1.2	-0.8	-0.8	-0.8
1978-12	*2.4*	*2.4*	*2.3*	*0.9*	*0.9*	*0.9*	*1.0*	*1.0*	*1.0*	*1.1*	*1.1*	*1.1*

Source: Author's estimates. See Table 13.
Notes: Adjusted employment data of "Scenario 3" (Table 1) are used in all models.

TABLE E-2

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

(Percent change per annum)

	Official	Maddison-Wu GDP			GDP as Alternative I			GDP as Alternative II		
	GDP	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
					Official Expenditure Accounts Implicit Investment Deflator					
1952-57	3.7	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
1957-65	-1.4	-1.8	-1.9	-1.9	-1.5	-1.6	-1.6	-1.5	-1.6	-1.6
1965-71	1.4	0.9	1.1	1.0	0.7	0.8	0.8	0.7	0.8	0.8
1971-77	-2.0	-2.8	-2.6	-2.8	-3.0	-2.8	-3.0	-3.0	-2.8	-3.0
1952-77	*0.1*	*-0.6*	*-0.6*	*-0.7*	*-0.7*	*-0.6*	*-0.7*	*-0.7*	*-0.6*	*-0.7*
1977-84	3.3	1.9	2.0	2.0	2.0	2.2	2.1	2.0	2.2	2.1
1984-91	2.2	-0.1	-0.1	0.2	-0.1	-0.1	0.2	-0.1	-0.1	0.2
1991-01	3.7	2.0	2.0	1.9	2.3	2.3	2.3	2.1	2.1	2.1
2001-07	4.8	4.5	4.5	4.5	4.7	4.7	4.7	5.1	5.1	5.1
2007-12	1.3	-0.4	-0.4	-0.4	-0.7	-0.7	-0.7	-0.2	-0.2	-0.2
1978-12	*3.2*	*1.6*	*1.7*	*1.7*	*1.7*	*1.8*	*1.8*	*1.8*	*1.8*	*1.9*
					Alternative Investment Deflator					
1952-57	4.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
1957-65	-1.0	-1.4	-1.4	-1.4	-1.0	-1.1	-1.1	-1.0	-1.1	-1.1
1965-71	1.4	0.9	1.0	1.0	0.7	0.8	0.8	0.7	0.8	0.8
1971-77	-2.4	-3.2	-3.0	-3.2	-3.5	-3.3	-3.4	-3.5	-3.3	-3.4
1952-77	*0.3*	*-0.5*	*-0.5*	*-0.5*	*-0.5*	*-0.5*	*-0.5*	*-0.5*	*-0.5*	*-0.5*
1977-84	2.8	1.4	1.5	1.5	1.5	1.6	1.6	1.5	1.6	1.6
1984-91	2.0	-0.4	-0.4	0.0	-0.3	-0.3	-0.1	-0.3	-0.3	-0.1
1991-01	2.2	0.6	0.6	0.6	0.9	0.9	0.9	0.7	0.7	0.8
2001-07	3.9	3.5	3.5	3.5	3.8	3.8	3.8	4.1	4.1	4.1
2007-12	0.8	-1.0	-1.0	-1.0	-1.2	-1.2	-1.2	-0.7	-0.7	-0.8
1978-12	*2.4*	*0.8*	*0.9*	*0.9*	*1.0*	*1.0*	*1.0*	*1.0*	*1.1*	*1.1*

Source: Author's estimates. See Table 13.

Notes: Stock estimates based on δ=.06 (see Table F-8) are used in all models.

TABLE F-1
ALTERNATIVE ESTIMATES OF CHINESE EMPLOYMENT, 1949-2012
(Mid-year estimates in thousands)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1949	182,413	161,454	5,818	1,250	13,892	9,084
1950	190,647	166,485	7,213	1,599	15,351	9,303
1951	201,402	171,673	8,942	2,045	18,742	11,135
1952	209,909	173,530	11,323	2,563	22,494	12,392
1953	215,165	175,320	13,099	3,131	23,615	12,036
1954	220,443	179,490	14,373	3,612	22,968	11,991
1955	224,788	183,715	14,506	4,469	22,098	11,646
1956	230,480	185,680	13,874	8,031	22,895	12,292
1957	237,358	189,265	13,877	9,173	25,043	13,447
1958	254,593	173,995	29,081	17,009	34,508	20,401
1959	266,265	158,805	36,482	25,908	45,070	29,670
1960	262,821	166,435	29,298	18,272	48,816	33,637
1961	260,239	183,815	26,012	8,828	41,584	27,384
1962	260,765	205,115	19,644	4,931	31,075	18,444
1963	266,439	216,210	16,686	3,799	29,744	17,538
1964	276,050	223,835	16,637	4,468	31,110	18,744
1965	286,742	230,985	17,616	5,339	32,802	20,194
1966	297,452	238,465	19,011	6,029	33,947	21,069
1967	308,329	247,310	20,030	6,275	34,714	21,450
1968	319,040	256,140	20,620	6,400	35,880	22,003
1969	331,262	265,900	22,287	6,578	36,497	22,326
1970	344,018	274,640	25,869	6,871	36,638	22,371
1971	358,581	281,040	32,209	7,074	38,258	22,731
1972	370,761	283,400	39,602	7,064	40,696	23,385
1973	381,242	285,700	45,919	7,133	42,490	23,868
1974	394,449	290,375	52,007	7,329	44,738	24,444
1975	407,958	293,370	59,219	7,750	47,618	25,027
1976	420,914	294,495	67,807	8,301	50,311	25,383
1977	432,582	293,915	75,095	9,089	54,482	27,106
1978	445,504	288,285	86,746	9,340	61,134	31,203
1979	460,542	284,750	99,160	9,433	67,199	34,474
1980	479,117	288,775	107,931	10,251	72,161	36,090
1981	500,900	294,495	117,466	10,933	78,006	38,119
1982	519,149	303,180	122,445	11,829	81,695	39,252
1983	533,197	310,050	124,579	13,313	85,256	40,663
1984	546,716	310,095	126,684	16,283	93,653	45,372
1985	560,242	309,990	127,668	20,603	101,981	49,345
1986	572,087	311,925	129,841	23,989	106,332	50,997
1987	582,424	314,585	131,732	26,143	109,965	53,441
1988	598,148	319,555	135,171	27,791	115,631	56,273
1989	619,076	327,365	141,914	28,128	121,669	58,515
1990	637,075	338,549	143,501	27,729	127,295	57,685
1991	651,200	347,175	141,851	27,847	134,327	64,237
1992	658,215	349,206	141,634	28,818	138,557	71,912
1993	664,800	345,798	140,787	31,708	146,506	78,575
1994	671,315	339,337	139,894	34,365	157,719	86,440
1995	677,600	332,374	138,932	35,646	170,648	93,734
1996	685,075	326,860	138,885	37,411	181,919	100,071
1997	693,850	326,475	139,237	39,324	188,814	104,182
1998	702,285	331,001	136,801	41,908	192,576	108,424
1999	710,155	338,301	131,944	44,289	195,621	111,638
2000	717,395	345,388	126,843	45,547	199,617	115,690
2001	725,550	351,502	123,300	46,795	203,953	121,001
2002	733,825	357,591	119,271	47,248	209,716	125,452
2003	740,860	359,838	118,925	45,101	216,996	130,245
2004	748,160	354,037	126,439	41,845	225,840	137,302
2005	755,125	341,883	135,690	42,210	235,342	146,719
2006	761,125	327,599	144,512	45,484	243,531	155,020
2007	766,950	314,281	154,183	49,084	249,402	160,451
2008	772,350	304,065	161,319	51,887	255,078	164,997
2009	777,375	294,742	163,106	55,833	263,694	171,505
2010	781,377	284,509	165,152	61,010	270,706	177,237
2011	784,427	272,623	169,610	64,169	278,025	183,427
2012	787,513	261,835	174,520	66,267	284,890	189,426

Sources & Notes: See Section 4, Scenario 2/3.

TABLE F-2

FULL-TIME-EQUIVALENT MEASURE OF CHINESE EMPLOYMENT, 1949-2012

(Mid-year estimates in thousands)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1949	194,064	170,201	7,088	1,317	15,458	10,108
1950	201,728	175,365	7,597	1,684	17,081	10,352
1951	212,737	180,341	9,393	2,148	20,854	12,390
1952	219,289	179,866	11,737	2,657	25,029	13,789
1953	224,110	181,071	13,529	3,233	26,277	13,392
1954	228,950	185,378	14,114	3,902	25,557	13,343
1955	244,142	200,303	14,378	4,872	24,588	12,959
1956	257,008	208,367	14,154	9,012	25,476	13,677
1957	265,299	212,390	14,750	10,294	27,865	14,963
1958	295,726	203,439	34,002	19,888	38,397	22,700
1959	321,708	194,962	44,789	31,807	50,151	33,015
1960	281,791	176,909	31,142	19,422	54,319	37,429
1961	277,496	195,382	26,459	9,383	46,271	30,471
1962	277,891	218,023	20,050	5,241	34,578	20,523
1963	295,000	240,583	17,093	4,227	33,097	19,515
1964	305,768	249,067	17,112	4,972	34,616	20,857
1965	317,669	257,023	18,206	5,941	36,500	22,471
1966	329,529	265,347	19,700	6,708	37,774	23,444
1967	341,597	275,189	20,799	6,983	38,627	23,868
1968	353,477	285,014	21,417	7,122	39,925	24,484
1969	366,945	295,874	23,141	7,319	40,611	24,842
1970	380,847	305,599	26,833	7,646	40,768	24,893
1971	406,112	321,753	33,132	8,073	43,154	25,495
1972	429,277	333,826	40,624	8,266	46,562	26,439
1973	451,222	346,255	47,080	8,560	49,327	27,201
1974	477,115	362,085	53,284	9,019	52,725	28,080
1975	503,733	376,386	60,544	9,781	57,021	28,980
1976	529,806	388,742	69,068	10,744	61,252	29,627
1977	554,972	399,182	76,335	12,064	67,390	31,891
1978	579,908	402,844	87,676	12,713	76,674	37,005
1979	607,452	409,397	99,345	13,168	85,542	41,210
1980	638,954	427,175	103,673	14,674	93,432	43,487
1981	665,358	435,637	112,780	15,650	101,291	46,065
1982	689,392	448,484	117,673	16,933	106,302	47,541
1983	708,789	457,822	120,543	19,012	111,411	49,496
1984	726,452	457,134	123,451	23,198	122,668	55,449
1985	744,858	456,294	125,334	29,284	133,946	60,456
1986	761,247	458,508	128,249	34,019	140,470	63,048
1987	775,380	461,819	130,938	36,990	145,634	66,400
1988	794,190	469,210	133,731	39,239	152,010	69,244
1989	817,611	479,889	139,479	39,578	158,665	71,232
1990	838,553	494,425	140,271	38,793	165,064	69,631
1991	857,525	504,200	139,189	38,973	175,163	78,633
1992	865,276	504,223	139,359	40,304	181,390	89,296
1993	872,587	496,246	139,002	44,273	193,066	98,986
1994	879,132	483,670	138,511	47,858	209,093	110,269
1995	884,341	469,915	137,937	49,459	227,030	120,391
1996	892,162	460,861	137,519	52,049	241,734	128,400
1997	902,745	459,578	137,589	54,888	250,690	133,527
1998	914,467	465,652	134,713	58,700	255,401	138,849
1999	927,474	476,010	129,642	62,268	259,554	142,424
2000	939,573	486,394	124,389	64,290	264,500	146,901
2001	929,629	477,678	122,199	64,849	264,903	150,220
2002	919,908	468,943	119,461	64,285	267,218	152,275
2003	907,328	455,372	120,381	60,248	271,327	154,569
2004	893,462	432,349	129,346	54,880	276,886	159,314
2005	880,092	402,894	140,285	54,351	282,562	166,446
2006	867,407	372,547	150,993	57,501	286,367	171,945
2007	856,084	344,892	162,809	60,923	287,461	174,002
2008	845,698	322,002	172,154	63,231	288,312	174,944
2009	836,179	301,204	175,909	66,801	292,265	177,792
2010	826,398	280,569	180,009	71,666	294,154	179,640
2011	816,396	259,437	186,831	74,006	296,122	181,771
2012	807,158	240,450	194,282	75,035	297,392	183,532

Sources & Notes: See Section 4, "Hours worked".

TABLE F-3
OFFICIAL ESTIMATES OF CHINESE EMPLOYMENT, 1952-2012
(End-year estimates in thousands)

	Total	Agriculture	Industry & Construction	Services
1952	216,293	179,494	15,869	20,930
1953	222,168	183,291	17,713	21,164
1954	226,334	187,464	18,852	20,018
1955	242,400	202,707	19,408	20,285
1956	256,519	208,097	26,101	22,321
1957	265,770	216,682	23,273	25,815
1958	308,734	181,113	82,734	44,887
1959	316,149	199,756	66,319	50,073
1960	277,453	180,868	43,708	52,877
1961	272,515	209,897	29,382	33,237
1962	275,991	226,149	21,189	28,653
1963	294,964	244,422	21,211	29,331
1964	307,178	253,713	22,843	30,622
1965	317,554	260,334	25,330	31,891
1966	330,139	270,359	27,421	32,358
1967	341,370	280,018	28,104	33,248
1968	353,576	290,010	28,971	34,595
1969	367,962	301,738	31,974	34,250
1970	381,037	309,461	37,049	34,528
1971	403,426	325,107	41,851	36,468
1972	415,653	333,155	44,798	37,700
1973	435,189	349,734	47,111	38,344
1974	454,343	364,336	49,477	40,530
1975	474,644	377,913	54,102	42,630
1976	493,517	388,656	58,840	46,021
1977	511,737	398,483	61,229	52,025
1978	529,588	395,697	72,561	61,331
1979	552,314	411,669	74,744	65,902
1980	582,789	430,792	76,519	75,478
1981	600,977	440,481	79,416	81,080
1982	622,646	456,487	83,026	83,133
1983	637,615	459,978	87,196	90,440
1984	658,514	455,048	97,637	105,829
1985	679,965	458,222	107,502	114,242
1986	702,294	459,427	117,452	125,416
1987	722,494	464,807	123,803	133,885
1988	741,591	473,519	128,083	139,988
1989	753,348	487,035	125,273	141,040
1990	879,618	568,311	143,982	167,324
1991	884,730	567,820	146,196	170,714
1992	888,570	558,779	150,346	179,446
1993	897,899	540,732	157,995	199,173
1994	903,740	522,073	162,774	218,893
1995	904,366	502,327	166,910	235,129
1996	908,406	490,945	173,164	244,296
1997	917,367	490,444	177,277	249,646
1998	931,921	494,873	178,450	258,597
1999	951,182	503,283	177,964	269,935
2000	971,461	507,570	176,780	287,111
2001	941,596	474,450	178,801	288,346
2002	915,186	443,629	174,278	297,278
2003	886,558	408,207	177,762	300,588
2004	857,043	366,477	186,941	303,625
2005	825,354	329,073	200,560	295,721
2006	829,736	311,721	213,366	304,648
2007	834,944	298,420	229,330	307,193
2008	838,801	288,386	235,119	315,296
2009	841,115	276,521	242,040	322,553
2010	838,628	263,751	251,275	323,601
2011	795,088	251,130	253,306	290,652
2012	799,783	243,377	261,529	294,877

Sources: Basic data are from various issues of *China Statistical Yearbook* and *China Labor Employment Yearbook*, and cleaned up consistency in their own logic.

TABLE F-4

CHINA'S SCHOOL GRADUATES BY LEVEL OF EDUCATION, 1949-2012

(Thousands)

	Total Number of Graduates	Of which: *Primary*	*Junior Secondary*	*Senior Secondary*	*Tertiary*	*Other Types*
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	0.1
1955	4,254	3,229	870	99	55	0.5
1956	5,054	4,051	785	154	63	0.5
1957	6,335	4,980	1,112	187	56	0.2
1958	7,448	6,063	1,116	197	72	0.4
1959	7,354	5,473	1,491	299	70	21
1960	9,335	7,340	1,422	288	136	149
1961	8,391	5,808	1,892	379	151	161
1962	7,837	5,590	1,584	441	177	45
1963	6,948	4,768	1,523	433	199	25
1964	7,682	5,674	1,386	367	204	51
1965	9,098	6,676	1,738	360	186	138
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	3,494	30	3
1974	30,041	15,210	10,606	4,179	43	3
1975	35,063	19,994	10,477	4,470	119	3
1976	42,279	24,895	12,060	5,172	149	3
1977	47,380	25,739	15,586	5,858	194	3
1978	46,800	22,879	16,926	6,827	165	3
1979	44,811	20,879	16,579	7,265	85	3
1980	36,573	20,533	9,648	6,162	147	83
1981	37,398	20,757	11,542	4,861	140	98
1982	34,708	20,689	10,321	3,106	457	135
1983	32,315	19,807	9,603	2,351	335	219
1984	31,917	19,950	9,504	1,898	287	278
1985	32,681	19,999	9,983	1,966	316	417
1986	33,948	20,161	10,570	2,240	393	584
1987	35,357	20,430	11,173	2,468	532	754
1988	34,749	19,303	11,572	2,506	553	815
1989	33,790	18,571	11,343	2,432	576	868
1990	33,564	18,631	11,091	2,330	614	898
1991	33,616	18,967	10,855	2,229	614	951
1992	33,588	18,724	11,023	2,261	604	976
1993	33,682	18,415	11,342	2,317	571	1,037
1994	34,342	18,996	11,526	2,093	637	1,090
1995	35,969	19,615	12,274	2,016	805	1,259
1996	36,439	19,341	12,790	2,049	839	1,420
1997	38,600	19,601	14,424	2,217	829	1,529
1998	41,987	21,174	15,802	2,518	830	1,663
1999	44,228	23,137	15,898	2,629	848	1,716
2000	46,034	24,192	16,071	3,015	950	1,806
2001	47,191	23,969	17,070	3,405	1,036	1,711
2002	48,991	23,519	18,799	3,838	1,337	1,499
2003	50,493	22,679	19,956	4,581	1,877	1,400
2004	51,388	21,352	20,704	5,469	2,391	1,472
2005	52,687	20,195	21,065	6,616	3,068	1,743
2006	52,795	19,285	20,624	7,271	3,775	1,840
2007	52,659	18,702	19,568	7,883	4,478	2,028
2008	52,978	18,650	18,629	8,361	5,119	2,219
2009	51,926	18,052	17,947	8,237	5,311	2,379
2010	50,959	17,396	17,486	7,944	5,754	2,379
2011	50,176	16,628	17,355	7,877	6,082	2,234
2012	49,421	16,416	16,867	7,656	6,247	2,235

Source: See Section 5 and Table 2.

TABLE F-5
ESTIMATES OF PSE-BASED "HUMAN CAPITAL STOCK" IN CHINA, 1949-2012
(In million years, million persons and PSE years)

	Years of Schooling (level mixed) (ml. years)	PSE Flows (ml. years)	Net PSE Stock (ml. years)	Working-Age Population (ml. years)	Net PSE Stock Per Working-age Person	Numbers Employed (ml. years)	Net PSE Stock Per Employed Person
1949	4.8	5.0	506.9	282.3	1.80	182.4	2.78
1950	5.7	5.8	507.7	286.3	1.77	190.6	2.66
1951	7.9	8.1	510.7	298.2	1.71	201.4	2.54
1952	9.7	9.9	515.5	312.5	1.65	209.9	2.46
1953	19.2	19.4	529.8	323.1	1.64	215.2	2.46
1954	22.1	22.4	546.9	331.2	1.65	220.4	2.48
1955	22.5	23.0	564.4	338.9	1.67	224.8	2.51
1956	27.4	27.9	586.7	346.3	1.69	230.5	2.55
1957	34.0	34.7	615.5	354.4	1.74	237.4	2.59
1958	40.6	41.3	650.7	363.3	1.79	254.6	2.56
1959	38.6	39.5	683.7	371.4	1.84	266.3	2.57
1960	50.2	51.3	728.1	376.4	1.93	262.8	2.77
1961	42.7	44.2	765.0	376.3	2.03	260.2	2.94
1962	40.5	41.8	799.1	374.1	2.14	260.8	3.06
1963	35.4	36.7	827.8	375.9	2.20	266.4	3.11
1964	40.3	41.5	861.0	382.4	2.25	276.0	3.12
1965	47.5	48.9	901.3	390.4	2.31	286.7	3.14
1966	60.3	61.3	953.6	399.4	2.39	297.5	3.21
1967	49.6	50.3	994.4	410.4	2.42	308.3	3.22
1968	63.4	64.3	1,048.7	422.2	2.48	319.0	3.29
1969	46.8	47.2	1,085.4	434.3	2.50	331.3	3.28
1970	36.6	37.1	1,111.6	447.1	2.49	344.0	3.23
1971	18.4	19.1	1,119.6	460.3	2.43	357.5	3.13
1972	20.4	21.3	1,129.7	473.2	2.39	367.5	3.07
1973	41.8	44.0	1,162.4	485.4	2.39	375.7	3.09
1974	60.5	62.8	1,213.6	496.8	2.44	386.4	3.14
1975	110.1	114.8	1,316.3	507.3	2.59	397.3	3.31
1976	176.5	184.6	1,487.7	518.4	2.87	407.5	3.65
1977	219.2	229.1	1,701.8	531.7	3.20	416.4	4.09
1978	208.9	219.9	1,904.7	546.1	3.49	426.3	4.47
1979	197.1	208.2	2,093.9	560.4	3.74	438.1	4.78
1980	171.3	179.3	2,252.2	574.9	3.92	453.0	4.97
1981	174.5	182.4	2,412.1	590.1	4.09	470.8	5.12
1982	166.7	173.3	2,561.3	606.9	4.22	490.1	5.23
1983	156.7	162.5	2,698.2	625.6	4.31	508.4	5.31
1984	155.9	161.2	2,832.4	645.3	4.39	528.1	5.36
1985	158.4	164.1	2,968.2	665.4	4.46	551.0	5.39
1986	162.7	169.0	3,107.5	684.7	4.54	572.1	5.43
1987	167.9	174.9	3,251.3	702.5	4.63	592.3	5.49
1988	162.7	170.8	3,389.6	719.2	4.71	613.8	5.52
1989	157.7	167.4	3,523.1	734.7	4.80	632.8	5.57
1990	157.2	165.0	3,652.9	749.2	4.88	642.7	5.68
1991	158.4	166.0	3,782.4	762.5	4.96	651.2	5.81
1992	157.6	164.3	3,908.9	774.3	5.05	658.2	5.94
1993	156.9	165.2	4,035.0	784.9	5.14	664.8	6.07
1994	160.7	172.9	4,167.6	795.0	5.24	671.3	6.21
1995	167.6	180.0	4,305.9	804.5	5.35	677.6	6.35
1996	168.3	179.2	4,442.0	813.7	5.46	685.1	6.48
1997	175.5	185.3	4,582.8	823.3	5.57	693.9	6.60
1998	190.4	202.3	4,739.3	833.7	5.68	702.3	6.75
1999	203.1	217.8	4,909.7	843.2	5.82	710.2	6.91
2000	211.8	228.4	5,089.1	858.9	5.93	717.4	7.09
2001	214.7	230.9	5,269.1	882.1	5.97	725.6	7.26
2002	219.0	241.4	5,457.8	897.3	6.08	733.8	7.44
2003	221.5	247.6	5,650.8	903.6	6.25	740.9	7.63
2004	220.8	248.0	5,842.3	911.1	6.41	748.2	7.81
2005	221.8	254.6	6,038.5	923.9	6.54	755.1	8.00
2006	220.2	258.4	6,236.4	939.1	6.64	761.1	8.19
2007	218.7	263.6	6,437.7	950.4	6.77	767.0	8.39
2008	220.2	265.2	6,638.5	958.5	6.93	772.4	8.60
2009	215.4	262.4	6,834.6	966.7	7.07	777.4	8.79
2010	211.0	253.8	7,020.0	979.0	7.17	781.4	8.98
2011	206.6	242.1	7,191.9	994.1	7.23	784.4	9.17
2012	203.9	232.6	7,352.6	1,002.1	7.34	787.5	9.34

Source: See Section 5 and Table 2.

TABLE F-6
ALTERNATIVE ESTIMATES OF CHINESE GDP BY SECTOR, 1949-2012
(In million 1990 yuan)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1949	240,055	86,868	17,567	2,323	66,649	55,669
1950	284,914	115,763	22,763	3,095	71,646	57,014
1951	362,245	154,444	28,150	4,130	87,761	68,239
1952	416,564	176,512	38,831	4,720	98,251	75,940
1953	478,203	179,615	50,471	6,438	120,840	90,811
1954	443,710	182,499	56,308	6,220	99,342	68,154
1955	487,577	196,806	59,269	7,079	112,211	80,871
1956	526,072	205,832	69,737	11,919	119,292	84,254
1957	544,628	212,062	85,034	11,168	118,182	82,737
1958	606,773	213,289	129,862	16,752	123,435	82,378
1959	625,952	179,788	163,272	17,707	132,592	85,411
1960	603,158	150,587	161,782	17,955	136,417	89,670
1961	497,941	153,151	85,172	6,212	126,703	94,283
1962	502,550	160,338	75,907	7,691	129,307	100,254
1963	574,418	178,739	89,273	9,683	148,361	118,040
1964	655,477	202,189	115,410	12,162	162,858	129,402
1965	724,833	222,343	139,859	13,451	174,590	137,229
1966	718,908	238,817	170,884	14,715	147,246	103,832
1967	752,493	243,706	142,277	13,980	176,265	134,212
1968	743,517	240,362	128,702	11,337	181,558	142,362
1969	808,737	242,752	167,615	15,249	191,561	144,325
1970	894,781	261,889	227,489	19,885	192,759	139,785
1971	950,572	267,207	253,490	22,291	203,792	149,098
1972	959,121	265,318	271,116	21,822	200,432	140,758
1973	1,028,587	289,654	292,437	22,564	211,965	147,577
1974	1,053,927	302,109	294,580	23,963	216,637	152,943
1975	1,116,444	309,060	330,666	27,270	224,724	158,066
1976	1,085,520	304,124	305,232	28,443	223,860	159,076
1977	1,148,292	297,898	345,461	28,927	238,003	164,747
1978	1,282,380	310,648	406,117	28,761	268,427	182,858
1979	1,385,147	329,853	432,045	29,329	296,960	203,950
1980	1,478,625	325,442	452,294	37,171	331,859	237,464
1981	1,533,415	348,426	464,063	38,350	341,288	232,511
1982	1,667,033	388,896	492,070	39,662	373,203	256,647
1983	1,776,779	421,319	522,231	46,430	393,399	258,354
1984	1,984,541	476,264	563,260	51,469	446,775	286,303
1985	2,177,509	485,380	619,382	62,896	504,926	307,688
1986	2,330,963	501,699	649,453	72,878	553,466	333,309
1987	2,516,035	525,864	689,165	85,902	607,552	360,244
1988	2,658,752	538,783	733,739	92,766	646,732	366,800
1989	2,679,137	555,128	714,050	84,932	662,513	391,679
1990	2,667,617	595,832	685,800	85,940	650,023	376,239
1991	2,837,623	609,892	743,712	94,160	694,929	399,792
1992	3,153,119	638,637	800,201	113,960	800,160	469,199
1993	3,471,069	668,632	906,392	134,470	880,787	515,951
1994	3,762,804	695,502	992,727	152,860	960,858	557,101
1995	4,099,773	730,184	1,122,751	171,810	1,037,514	594,619
1996	4,369,253	767,365	1,193,979	186,430	1,110,739	627,983
1997	4,703,992	794,235	1,312,733	191,310	1,202,857	675,387
1998	4,786,410	822,043	1,194,991	208,560	1,280,408	705,683
1999	5,075,345	845,164	1,264,798	217,490	1,373,947	741,053
2000	5,455,664	865,473	1,400,679	229,820	1,479,846	789,845
2001	5,830,642	889,843	1,498,420	245,409	1,598,485	848,048
2002	6,407,511	915,776	1,768,825	266,975	1,727,967	913,677
2003	6,919,337	938,272	1,973,413	299,235	1,854,208	970,112
2004	7,586,424	997,383	2,250,926	323,563	2,007,276	1,026,730
2005	8,268,554	1,049,553	2,415,023	375,317	2,214,330	1,115,305
2006	9,319,763	1,102,031	2,794,745	439,976	2,491,505	1,237,072
2007	10,469,886	1,143,291	3,120,274	511,190	2,847,565	1,405,249
2008	11,085,571	1,204,783	3,134,781	559,763	3,093,122	1,486,947
2009	11,958,187	1,255,185	3,378,895	663,629	3,330,238	1,596,393
2010	13,074,380	1,308,798	3,787,345	753,010	3,612,614	1,671,774
2011	13,943,693	1,364,428	3,955,100	826,177	3,898,994	1,753,303
2012	14,585,012	1,425,827	3,935,914	903,012	4,160,129	1,825,767

Source: See Section 6 and 7.

TABLE F-7

OFFICIAL ESTIMATES OF CHINESE GDP BY SECTOR, 1952-2012

(In million 1990 yuan)

	Total	Agriculture	Industry	Construction	Services	Of which: "Non-material"
1952	237,072	156,385	13,264	4,720	40,392	18,081
1953	265,473	159,356	17,999	6,438	51,651	21,622
1954	272,113	162,065	21,473	6,220	51,167	19,979
1955	289,507	174,869	22,891	7,079	53,328	21,987
1956	320,475	183,087	29,437	11,919	60,993	25,955
1957	332,123	188,763	32,793	11,168	63,953	28,508
1958	373,295	189,518	50,305	16,752	75,663	34,607
1959	376,615	159,385	64,943	17,707	87,398	40,216
1960	358,798	133,246	68,905	17,955	91,945	45,197
1961	283,968	135,111	42,032	6,212	68,193	35,773
1962	276,231	141,191	36,442	7,691	61,854	32,801
1963	303,015	157,146	41,288	9,683	64,576	34,255
1964	349,592	177,417	51,858	12,162	74,699	41,243
1965	397,307	194,627	65,238	13,451	86,631	49,271
1966	432,285	208,640	80,764	14,715	84,752	41,338
1967	422,229	212,604	68,569	13,980	85,023	42,969
1968	408,416	209,203	62,946	11,337	85,733	46,536
1969	454,123	210,876	83,718	15,249	97,044	49,809
1970	517,024	227,114	113,187	19,885	103,863	50,889
1971	545,559	231,429	127,109	22,291	110,036	55,343
1972	563,210	229,346	136,770	21,822	115,597	55,923
1973	607,721	249,987	148,806	22,564	121,976	57,588
1974	622,097	260,237	150,294	23,963	123,909	60,214
1975	663,905	265,441	174,341	27,270	130,194	63,536
1976	653,510	260,663	168,936	28,443	130,683	65,898
1977	693,422	254,929	193,263	28,927	143,048	69,792
1978	767,151	265,490	224,935	28,761	162,396	76,827
1979	823,474	281,775	244,409	29,329	174,950	81,940
1980	871,002	277,597	275,343	37,171	186,496	92,101
1981	929,842	296,981	280,133	38,350	205,601	96,824
1982	1,014,058	331,220	296,302	39,662	230,318	113,762
1983	1,129,803	358,797	325,107	46,430	264,424	129,378
1984	1,306,660	405,012	373,397	51,469	316,310	155,839
1985	1,490,245	412,480	441,390	62,896	376,240	179,002
1986	1,626,079	426,168	483,949	72,878	422,928	202,771
1987	1,812,608	446,216	548,040	85,902	485,142	237,834
1988	2,010,195	457,569	631,629	92,766	548,299	268,367
1989	2,065,845	471,639	663,559	84,932	574,881	304,046
1990	2,140,565	506,200	685,800	85,940	588,842	315,059
1991	2,335,698	518,348	784,500	94,160	643,552	348,415
1992	2,671,218	542,715	950,570	113,960	733,012	402,051
1993	3,031,013	568,231	1,141,540	134,470	821,935	457,099
1994	3,419,043	590,964	1,357,420	152,860	914,043	510,287
1995	3,789,262	620,516	1,548,030	171,810	1,006,011	563,115
1996	4,160,603	652,168	1,741,620	186,430	1,097,629	614,873
1997	4,543,724	674,991	1,938,780	191,310	1,211,174	683,704
1998	4,906,541	698,610	2,111,330	208,560	1,313,315	738,591
1999	5,294,492	718,172	2,291,140	217,490	1,434,797	801,903
2000	5,744,255	735,408	2,515,350	229,820	1,573,676	883,675
2001	6,216,676	756,000	2,733,437	245,409	1,731,393	980,957
2002	6,772,152	777,924	3,005,974	266,975	1,906,989	1,092,698
2003	7,453,581	797,371	3,389,260	299,235	2,083,618	1,199,521
2004	8,224,190	847,606	3,779,364	323,563	2,293,111	1,312,565
2005	9,156,328	891,942	4,216,885	375,317	2,573,158	1,474,132
2006	10,335,741	936,539	4,759,855	439,976	2,944,938	1,690,505
2007	11,822,248	971,603	5,469,398	511,190	3,427,740	1,985,423
2008	12,980,575	1,023,861	6,012,531	559,763	3,778,245	2,172,069
2009	14,146,477	1,066,694	6,537,467	663,629	4,144,841	2,410,996
2010	15,683,508	1,112,256	7,326,129	753,010	4,551,273	2,610,433
2011	17,194,146	1,159,532	8,086,508	826,177	4,976,238	2,830,548
2012	18,540,071	1,211,711	8,709,169	903,012	5,381,817	3,047,454

Sources: Various issues of *China Statistical Yearbook* deflated by the implicit national accounts sectoral deflators.

TABLE F-8

ESTIMATES OF CHINESE NET CAPITAL STOCK, 1949-2012

(In billion 1990 yuan)

	By Official Investment Deflator			By Alternative Investment Deflator		
	(δ=0.05)	(δ=0.06)	(δ=0.07)	(δ=0.05)	(δ=0.06)	(δ=0.07)
1952	328	328	328	328	328	328
1953	334	331	327	339	336	332
1954	344	338	331	356	350	343
1955	355	346	337	373	364	354
1956	381	368	356	403	390	378
1957	400	384	369	430	414	398
1958	448	429	412	493	473	455
1959	509	488	467	581	557	535
1960	575	550	526	642	615	589
1961	591	562	534	663	631	600
1962	594	560	528	673	636	601
1963	601	563	528	694	652	614
1964	622	580	542	716	670	628
1965	654	608	567	763	713	667
1966	696	647	602	824	769	719
1967	721	667	620	861	801	746
1968	742	684	633	891	826	768
1969	784	722	668	950	880	817
1970	851	785	727	1,044	969	902
1971	921	851	789	1,137	1,056	984
1972	990	915	849	1,233	1,145	1,068
1973	1,063	983	912	1,333	1,238	1,155
1974	1,148	1,062	986	1,445	1,343	1,253
1975	1,251	1,158	1,078	1,603	1,492	1,395
1976	1,345	1,245	1,159	1,742	1,622	1,517
1977	1,440	1,333	1,240	1,901	1,771	1,657
1978	1,558	1,443	1,344	2,082	1,940	1,816
1979	1,674	1,550	1,443	2,256	2,102	1,967
1980	1,798	1,665	1,550	2,428	2,261	2,115
1981	1,893	1,750	1,626	2,594	2,412	2,254
1982	2,014	1,861	1,728	2,781	2,585	2,413
1983	2,155	1,990	1,848	2,986	2,774	2,588
1984	2,348	2,172	2,020	3,242	3,012	2,812
1985	2,573	2,384	2,221	3,513	3,264	3,048
1986	2,822	2,619	2,443	3,828	3,560	3,326
1987	3,149	2,929	2,740	4,214	3,923	3,670
1988	3,499	3,262	3,056	4,622	4,306	4,032
1989	3,760	3,502	3,278	4,877	4,535	4,236
1990	4,023	3,742	3,499	5,123	4,752	4,429
1991	4,344	4,040	3,777	5,445	5,045	4,698
1992	4,772	4,443	4,157	5,885	5,455	5,081
1993	5,322	4,964	4,655	6,387	5,924	5,521
1994	5,988	5,599	5,262	7,083	6,583	6,150
1995	6,740	6,315	5,945	8,069	7,529	7,060
1996	7,577	7,110	6,702	9,201	8,612	8,101
1997	8,438	7,923	7,473	10,345	9,700	9,138
1998	9,411	8,843	8,345	11,497	10,787	10,168
1999	10,376	9,748	9,196	12,648	11,866	11,182
2000	11,413	10,718	10,108	13,884	13,022	12,267
2001	12,565	11,798	11,124	15,213	14,264	13,432
2002	13,889	13,042	12,297	16,805	15,761	14,845
2003	15,506	14,571	13,747	18,720	17,571	16,561
2004	17,363	16,329	15,418	20,955	19,688	18,573
2005	19,223	18,078	17,067	23,150	21,749	20,515
2006	21,426	20,157	19,036	25,742	24,193	22,828
2007	23,739	22,332	21,088	28,326	26,613	25,102
2008	26,809	25,249	23,868	31,590	29,696	28,024
2009	30,314	28,580	27,043	35,247	33,151	31,299
2010	34,296	32,362	30,648	39,395	37,072	35,019
2011	38,809	36,649	34,730	43,961	41,384	39,104
2012	43,855	41,437	39,286	48,878	46,016	43,481

Source: See Section 8 and Tables 10-12.

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