Measuring Productivity Performance by Industry in China, 1980-2005

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ABSTRACT

Using the author's recently constructed data set, this article measures the productivity performance of China's 19 manufacturing industries, four mining industries, plus utilities, over the reform period 1980-2005. The approach is based on neoclassical assumptions on institutional settings and behavior of agents. Some of these assumptions are questionable in the case of China, but the results can be used as a starting point for further investigation. We find that the post-reform industrial growth in China had been largely investment-driven and inefficient until the 2000-05 period. Following China's accession to WTO in 2001, Chinese industry experienced the best performance in TFP, accounting for 50 per cent of the growth of industrial value added. However, the mining sector had been most inefficient and had not yet shown a clear sign of improvement by 2005. Traditional labour intensive manufacturing did not appear to be efficient as suggested by the theory of comparative advantage, but there was a sign of significant improvement in 2000-05. By contrast, the capital and technology-intensive industries engaged in consumer goods manufacturing were most efficient throughout the entire period, apparently due to continuous foreign direct investment, high exposure to international competition and less state intervention.

CHINA'S POST-REFORM ECONOMIC growth is unprecedented by many standards. One question that often is asked is how productivity growth in the Chinese economy has performed during such a period of rapid growth. While a growth accounting exercise for aggregate or sectoral economic performance can evaluate the sources of growth in general, [2] it is unable to assess the impact of reform policies on the productivity performance of specific industries.

In transition economies such as China, productivity performance at the industry level is unquestionably related to government policies. On the one hand, different industries have different initial conditions because of the legacy of state policies during the central planning period. On the other hand, China's piecemeal reform has at various stages imposed different policy regimes on selected industries. This has meant that industries have been subject to different levels of state intervention and market competition, with different incentives for managers. With the opening up to the international market, the

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2 See for example the very recent growth accounting exercise for the Chinese economy by Maddison (2007).

piecemeal reform approach also has meant that industries have been subject to different degrees of exposure to foreign trade and direct investment.

Data problems have been a major obstacle to industry-level productivity analysis. This study represents a major effort to: reconcile official industrial statistics based on different classification standards; to remove non-industrial data that were mixed with industrial statistics; and to reconstruct capital stock estimates with a new approach that sidesteps measurement problems inherent in the official data. This study is basically a data-driven exercise that employs the growth accounting approach to assess the productivity performance of China's 19 manufacturing industries, four mining industries, plus utilities between 1980 and 2005. This is the first study of this kind in terms of the level of industry detail and time period. The study does not explicitly analyze how the performance of individual industries has been affected by reform policies, which requires matching data for other variables. But productivity estimates for individual industries over a period of policy regime shifts sheds light on the impact of industry-specific reform policies.

Section one provides policy background to China's industrial reforms, focusing on how such measures may have affected the productivity performance of different industries. We identify the periods of major policy shifts since the economic reform began in 1978 in order to relate policy developments to productivity performance. Section two discusses major data problems and details how the data set used in the study was constructed. Section three discusses the methodological issues and reports on the empirical results. The final section concludes.

Industrial Reform and Productivity Performance

In essence, for a reformist government in a centrally planned economy to ultimately improve the economy's productivity performance, it must initiate pro-market institutions that allow the efficient allocation of resources and give enterprises freedom from administrative controls to make their own production decisions. To achieve such a goal, the government must abandon planning mechanisms and withdraw from the so-called "competitive industries". In other words, the government must concentrate on the industries that provide "public goods", create pro-market institutions in the areas such as banking, accounting and law, and substantially lower the barriers to foreign trade and direct investment.

All these tasks represent major reforms for a transition economy. They could be initiated by a "big bang" as happened in the former Soviet Union and other Eastern Bloc countries, or introduced by a "piecemeal" approach, as has taken place in China. The choice of the approach to reform is largely determined by political considerations. Nevertheless, different reform approaches have different implications for productivity performance. While shocks brought by the "big bang" approach can significantly sacrifice productivity for a certain period, the "piecemeal" approach can create new distortions that may offset some of the productivity gain through the correction of old distortions.[3] From a measurement perspective, unlike the effect of the "big bang", which may take a toll on the productivity of all industries, the effect of the "piecemeal" reform is more difficult to identify, especially when the available data do not allow for the breakdown of ownership types or sectors/industries under different policy treatments at the same level of industry details (e.g.

3 As argued by Murphy, Shleifer and Vishny (1992), resources can be misallocated by partial price liberalization.

the two-digit level of industrial classification used in this study).

Our investigation of the effect of economic reform on China's industrial productivity performance is mainly based on measuring changes of labour productivity, capital intensity (net capital stock per worker employed) and total factor productivity (TFP) across individual industries and over different reform periods. China's reform started from a strong legacy of the Soviet-type heavy industrialization that the government had pursued under central planning. Such industrial development largely ignored China's comparative advantage and hence could not be sustained in the long run.[4] On the other hand, since this development path was implemented through forced savings, it took a heavy toll on agricultural development and consumer welfare. The reform process has been a series of corrections to the previous distortions in the economy, coupled with the growth of activities or industries that are in line with China's comparative advantage and integration with the international market through foreign trade and direct investment. Below we highlight the key policy shifts at different stages of the economic reform process, which we argue have significant implications for the productivity performance of individual industries.

China has experienced two major stages of industrial reform since 1978. The first stage began in 1978 and ended in 1993, and can be divided into two sub-periods by the year 1986. Prior to 1986, the policy focus of the reform was twofold: to improve the performance of state-owned enterprises (SOEs) by granting them autonomy and introducing profit retention schemes; and to create more jobs by encouraging rural enterprises to develop local labour-intensive industries. To help achieve these goals, measures to promote foreign trade and direct investment were implemented to a limited extent. In the absence of pro-market institutions and in the presence of price distortions, one would expect that the effect of the reform might be one-off. SOEs in manufacturing industries facing strong demand (i.e. industries whose products had been in severe shortage) might "improve" their performance, whereas small and inexperienced rural enterprises might lower the overall productivity of labour-intensive industries while increasing output and employment. However, the arrival of foreign enterprises specializing in labour intensive products in newly established special economic zones (SEZs) may have offset some of the negative composition effect of the expansion of rural enterprises on productivity.

By the end of 1985, China's industrial reform had almost come to a standstill due to the lack of comprehensive measures or institutional arrangements to ensure the development of a healthy market. The newly introduced double-track price system for SOEs caused a heated debate between the "comprehensive reform" camp and the "enterprise reform" camp about whether this system represented the introduction of an efficient market system that could turn SOEs into truly market-oriented enterprises. The former believed that without systematic reforms in pricing, taxation and fiscal regimes, a prolonged double-track price system would result in a chaotic rent-seeking situation and eventually end the reform (Guo *et al*., 1985; Wu, 1985). The latter believed that granting SOEs full autonomy through various contract arrangements, following the experience of the agricultural reform, would create enterprises that were responsible for their profits and losses (Li, 1986).

The success of the "enterprise reform" camp resulted in almost a decade long double-track

4 As shown in Table A2 (Appendix), in 1980, compared with consumer goods industries, machinery and equipment industries in general had higher K/L ratios, but lower labour productivity in general.

transition under which the autonomy-enhanced, but soft-budget constrained SOEs did not improve their productivity, but continued to be money losing enterprises.. Therefore, productivity performance in 1986-93 was very mixed across industries. One might have expected that those industries with significant amounts of foreign investment and export orientation in line with China's comparative advantage to have increased investment and labour productivity. But the efficiency improvements in these industries (captured by total factor productivity or TFP) were dampened by distorted prices and a rent-seeking environment.

The second stage of the reform as defined in this study is from 1994 to 2005. The adoption of the "socialist market economy" by the Third Plenary Meeting of the Fourteenth Central Committee of the Communist Party of China (CPC) at the end of 1993 marked the turning point of China's reform. This meeting for the first time removed the ideological barrier to the development of the market system in China. Based on a series of reforms implemented since 1994, we further divide this stage into two sub-periods by 2001 when China joined the World Trade Organization (WTO). The first sub-period 1994-2001 can be labeled as one initiating reforms towards a market system with "socialist characteristics", whereas the second sub-period 2001-05 can be described as one with deepening reforms in conformity with WTO rules. Almost all major reforms were implemented in the first sub-period of this stage. Following the promotion of the "socialist market economy", the state began to withdraw from the competitive industries by a *de facto* privatization of small and medium-sized SOEs as well as rural enterprises run by township-village governments in 1994-2000. This triggered a rapid growth of private enterprises, which increased investment in industries that were newly deregulated. Private enterprises were encouraged because they could absorb workers who lost jobs due to privatization and the closure of hundreds of thousands of SOEs in the late 1990s. This period also saw an unprecedented wave of foreign direct investment encouraged by China's political stability and a series of reforms in foreign exchange, trade, banking and taxation regimes. Large SOEs that were protected during this reform also underwent substantial restructuring and investment to increase their competitiveness. One may argue that this period should have experienced moderate gains in TFP as a result of increased market competition. But the main picture could be an investment-driven labour productivity growth mainly caused by continuous huge domestic and foreign investment.

The sub-period 2001-05 may be too short for a definitive conclusion about China's recent industrial productivity performance. However, there were a number of important forces at play that fostered stronger productivity performance in this period compared with the previous period. First, Chinese manufacturing had huge production capacity that had been built up during the 1990s. Second, one might expect a lagged productivity effect from the market-oriented reforms introduced in the previous period to make Chinese manufacturing, especially labour-intensive manufacturing, more competitive. Third, China's WTO membership now allowed much improved access to a huge international market for goods that could be cheaply and recently readily made in China — indeed this was when the world suddenly became aware of China as "the world factory" for almost all consumer products.

Data Construction

Data problems have been a major obstacle to a reliable measure of China's industrial productivity performance. In 1992, National Bureau of Statistics of China (NBS) officially switched to the System of National Accounts (SNA) and has since continuously improved its national accounts through surveys and censuses. But some concepts and practices used by the NBS are still influenced by the old Material Product System (MPS).[5] In this study, we use and update the data constructed by Wu in earlier studies (Wu, 2002a, 2002b and 2007; Wu and Yue, 2007; Shiu and Wu, 2007) aimed at making official data better conform to international standards.

This study covers China's industrial enterprises that are classified as independent accounting units at or above the rural township level prior to 1998. This includes virtually all urban enterprises (excluding self-employed industrial activities), and all rural enterprise (excluding village factories and self-employed industrial activities). It should be noted that since 1998, the definition of an independent accounting unit in the official industrial statistics has shifted from the previous administrative level criterion to a size criterion. The designated size is 5 million RMB yuan annual sales (around US$700,000 at the current exchange rate of 1 $US = 7.5 yuan). No information is available on how to reconcile the data compiled according to the two different criteria. However, we found no significant break in the annual series in 1998 on the basis of value added per worker or capital stock per worker (see GVA/L and K/L series in Chart 1).[6] The official data are available at the two-digit industry level based on the industrial classification system used at the time of compilation. To make industrial classifications consistent over the whole period, using the 2002 industrial classification system, we re-classified all two-digit level industries into 24 industries consisting of 19 manufacturing industries, four mining industries, plus one industry including all utilities. Table A1 in the Appendix provides a list of the industries.

Output

China's industrial output has been overstated by institutional and methodological factors (Wu, 2000: 479-484). Institutionally, heavy government involvement in businesses with high annual growth targets and administratively managed data reporting system tend to nurture distorted incentives that encourage firms and local officials to exaggerate performance. From a methodological perspective, China's long practice of the Soviet-style "comparable price" approach tends to underestimate inflation because it requires enterprises to report their output at certain "constant prices" that were set ten years ago. Enterprises are not able to include any new product introduced after the base year into price calculations.

A number of empirical studies have attempted to develop alternative output estimates using various approaches, such as physical output index (Wu, 2002a; Maddison and Wu, 2006), alternative price indices (Wu, 2000; Woo, 1998; Ren, 1997; Jefferson *et al.*, 1996), and energy consumption (Adams and Chen, 1996). Despite different results, all studies support the upward bias hypothesis for the official data. Wu's index based on physical output data is perhaps the most independent of official growth estimates.[7] However, since Chinese industrial statistics are based on enterprises rather than establishments, product-based output estimates do not closely match the statistics on labour and capital stock for all industries. In this study, we are forced to base our output data construction on the official

5 See Xu (1999) for a full account of the differences between SNA and current practice in Chinese statistics.

6 As implied by both criteria, we are dealing with only part of China's industrial economy, though the major part. Therefore, our data are not compatible with the national industrial data.

7 Wu (2002a) constructed a Laspeyres quantity index for major industrial branches in 1949-97 using time series data on 200 major industrial products and value added weights from China's 1987 Input-Output Table. His estimates suggest an annual industrial GDP growth of 8.7 per cent in 1978-97, compared with the official rate of 12 per cent. Using the same approach, Maddison and Wu (2006) update Wu's earlier estimates showing an annual industrial GDP growth of 9.8 per cent in 1978-97, compared with the official rate of 11.5 per cent.

data, but use alternative price indices to moderate the upward bias of the official output estimates.

We obtain nominal gross value added (GVA) by industry from the industrial statistics published in *China Industrial Economic Statistics Yearbook* by the Department of Industrial and Transportation Statistics (DITS), which is part of NBS. However, there are no GVA data for the period before 1993, that is before China shifted to SNA. However, for the pre-1993 period, estimates are available for net value of output (NVO), complied following MPS concepts (for details see Wu, 2000). We adjust NVO to obtain GVA by adding back estimated capital consumption (see the estimation of capital stock below). After comparing the official PPI (producer price index) with the implicit CPPI ("comparable price indices") derived from nominal GVO and GVO at different constant prices for individual industries, we choose PPI as the price index to deflate GVA because it implies a higher price level than CPPI.

Labour

Chinese official data on industrial employment have historically contained severe flaws. Before 1998, unemployed (or the so-called "off-post") workers remained on the payroll in all SOEs due to political reasons (categorized as "others"). On the other hand, since non-industrial staff working in enterprises' education and medical care units, commercial outlets, and social and political organizations (also categorized as "others") are usually not distinguished from the industrial work force, they are included in the official industrial statistics.[8] In addition, there have never been regular and systematic surveys on hours worked, even though institutional working hours per week have been changed several times, not to mention non-productive hours that have never been captured by the regular labour statistics. Obviously, any direct use of the officially reported numbers of "industrial workers employed" would be misleading.

Adopting the approach used in Wu and Yue (2007), we first convert the numbers of workers employed, published in *China Industrial Economic Statistics Yearbook* by DITS and based on the 1985 and 1995 Industrial Censuses and the 2004 National Economic Census, to hours worked based on institutional working hours, standard working hours according to different shift arrangements across industries, and assumptions on extra or overtime hours as observed especially in non-SOE enterprises. We then remove non-industrial employees based on occupational structure of industries provided by the censuses. Note that this treatment is only applied to SOEs and semi-SOEs (collective enterprises), not to enterprises with foreign investment. The results on "hours worked" are further converted to "standardized" person-days worked. That is, we define a "standard industrial employee" who has been fully employed for a year as being equal to 300 person-days of work. We have not yet made any labour quality adjustment (see comment made on this point in the concluding remarks).

Net Capital Stock

As discussed in Wu (2002b and 2007), a frequent and serious mistake made in constructing capital stock is to use official statistics on "investment in fixed assets" as the investment variable for estimating capital stock with the perpetual inventory method (PIM).[9] By the offi-

8 As reported by the 1985 industrial census, the number of employees who were categorized as "others" accounted for 17.8 per cent of total employment in SOEs and 8 per cent in non-SOEs. These figures however increased to 21.8 per cent and 11.2 per cent, respectively in 1995 as reported in the 1995 industrial census (Wu and Yue, 2007).

9 For example, see Huang *et al*. (2002), Hu and Khan (1997) and Li at el (1992).

cial definition, "investment in fixed assets" refers to the "workload" of fixed asset investment activities in value terms rather than the ownership transfer-based purchase of fixed capital as defined by the SNA. This is regarded as the key difference between SNA and the Chinese system in measuring fixed asset investment (Xu, 1999:62-63). Apparently, the official investment series represents a flow of activities that mix investment in fixed capital and inventories (work-in-process). As correctly noted in Chow (1993:816), the work performed in the "investment in fixed assets" may not produce results that meet standards for fixed assets in the current period. In fact, some of the work (investment projects) may take many years to qualify as fixed assets and some may never meet the standard, and hence are completely wasted. This is a typical phenomenon in all centrally planned economies and is still true for some state projects in the post-reform era in China.

Official statistics also include capital stock series as the year-end "original value of fixed assets" based on accounting data reported by enterprises covered by the reporting system. This series includes a mixture of the new buildings and equipment and machinery and the existing capital stock valued at acquisition prices. Two problems arise from directly adopting this series as a proxy for capital stock: inaccurate valuation and improper coverage. First, it is impossible to deflate a capital stock series containing assets purchased at different prices in different periods. Second, like the official data on investment, the stock series also includes residential and non-industrial structures. Pioneer studies by Chen *et al*. (1988a, 1988b) derived annual investment flows from the official stock to address the first problem, and removed residential buildings to resolve the second problem. However, these studies underestimated the annual flows by ignoring the effect of scrapings (equipment or structures that had been disposed during the year in question) and unconditionally accepting the official depreciation method (Wu, 2007).

Following Wu's earlier work (2002b) and his recent revision and update (Wu, 2007), we estimate net capital stock in 1995 constant yuan through the following procedures. First, we derive annual flow of investment by subtracting the last from the current end-of-year stock and adding back the value of scrapings by an assumed scraping function and timing. Second, based on the information on the type of fixed assets in investment from internal surveys by the ECNH (2002), we identify and remove non-industrial assets from the derived annual investment flow. Third, we construct deflators for individual industries using detailed (6-digit) annual asset evaluation data for the period 1984-2000, compiled by the Ministry of Finance. As for the period 2001-05, we construct the deflators by taking a geometric mean of the PPIs for building materials and machinery. Finally, the widely used perpetual inventory method is adopted to construct the industry-level net capital stock using the aforementioned estimates.[10]

10 Following Hulten and Wykoff (1981a and 1981b), we assumed a geometric function of depreciation to reflect changes in economic efficiency of different types of fixed assets. Thus, a constant depreciation rate is assigned to PIM, $K_t = I_t + (1 - \delta)K_{t-1}$. As the depreciation ($\delta$) of an asset equals its declining-balance rate (R) divided by its service live (T) (i.e. δ=R/T), we need to estimate proper R and T for equipment and structures of each industry. In this study, we adopt the US Bureau of Economic Analysis estimates of Rs for major industrial equipment and structures as found in Kaze and Herman (1997:72-3) which are mainly based on the empirical work by Hulten and Wykoff. To gauge the service lives of assets in Chinese manufacturing, we rely on three sources of information: 1) the depreciation rates (by the straight-line approach) used since 1963 by the Ministry of Finance; 2) a detailed list of the standard service lives for fixed assets issued by the State Council (No. 63 Circular, 1985); and 3) a new regulation on service lives by the Ministry of Finance (No. 574, 1992) (for details see Wu, 2007). However, the so-constructed net capital stock is not yet adjusted for quality change due to unfinished data work (see comment made on this point in the concluding remarks).

Methodology and Results

As indicated at the beginning of the article, our growth accounting exercise in principle follows the Solow model. For TFP estimates over different periods, we use the compound growth rate approach to derive the "Solow residual" with average income shares of factors derived from *China Input-Output Tables* for each period as further explained below. In the time series estimates of TFP, we adopt the Jorgenson type of translog production functions (Jorgenson, Gollop and Fraumeni 1987), but use the value added production function rather than the gross output production function, that is, we do not include intermediate inputs as one of the explanatory variables in the production function (largely due to data problems). As we ignore the links between industries through intermediate inputs, we suggest the reader refer to the results of the industrial sector as a whole for China's industrial productivity performance on average (Chart 1), while using estimates for individual industries as references against the average (Chart 2).

As indicated in the data section, both labour and capital data are not adjusted for changes in quality. This means that we implicitly assume that changes in the stocks of labour and capital represent the flows of services provided by labour and capital. As for the output elasticity of inputs, we use variant income shares rather than certain pre-assigned income shares. In this exercise, we accept the assumption of constant returns to scale. The income shares for labour and capital services provided in a given year are estimated based on *China Input-Output Tables* (based on data from the User Tables) that have been constructed since 1987 every five years, with a reduced form published between benchmark years. Gaps are filled by interpolations. The only problem is that the input-output table follows the national accounts concept that covers all industrial activities, whereas our data at this level of detail only cover activities at or above the township level (or at or above the designated size since 1998). Excluding output by small labour-intensive activities at the village level and by the self-employed may slightly underestimate the labour share in value added in labour intensive industries.

Tables 1 and 3 report the estimates of the annual compound growth rate of input and output at different stages of the reform, and Tables 2 and 4 report the growth accounting results at the same stages as in Tables 1 and 3. The time series estimates for the total industrial productivity performance and its breakdown by major sectors in mining, manufacturing and utilities are depicted in Chart 1 and those for individual industries are depicted in Chart 2.

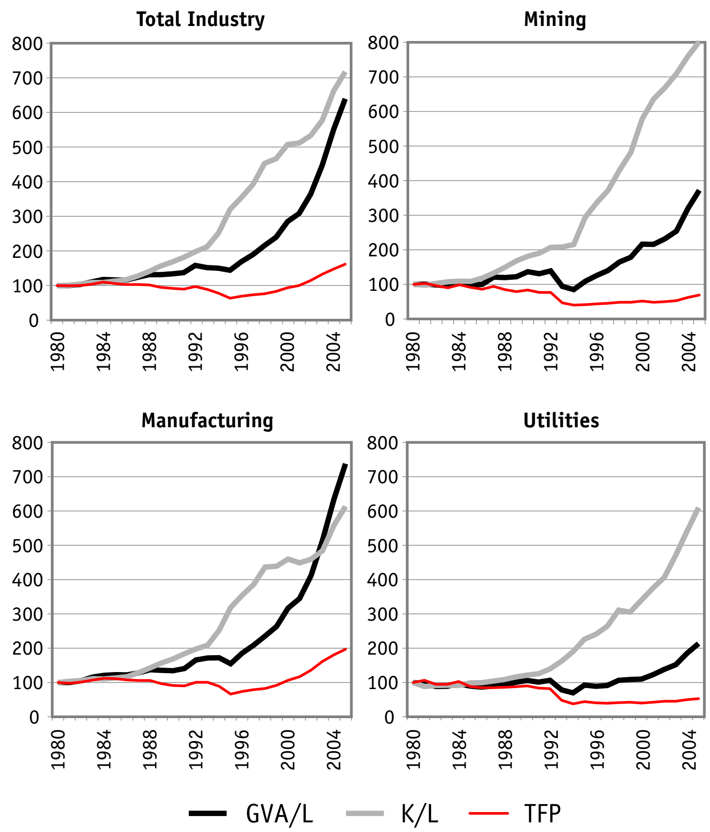
Overall Performance

Let us begin with a general picture. Chart 1 depicts China's industrial performance on a per worker basis for the entire period of the reform with a breakdown by the three major sectors. Clearly, for industry as a whole there was a small one-off effect of the reform in the early 1980s as shown by the TFP index, then followed by a stagnation and decline in TFP which lasted until 1995. The turning point appears to be in 1996. The TFP index only returned to the benchmark (1980) level in 2000. The performance of the value added per worker (GVA/L) and capital-labour ratio (K/L, a capital intensity measure) as depicted in their indices suggest that almost over the entire period, productivity growth was investment-driven. But the rapid growth of investment as reflected by K/L was clearly inefficient in that it could not maintain a proportional growth in labour productivity in the early 1990s. However, the growth of labour productivity accelerated in the late 1990s and the two indices eventually met in 2004-05. The performance of manufacturing presents a similar, but better pattern to that of the total industry aggregate because of its dominant weight and much better performance than that of mining and utilities. Obviously, both mining and utilities failed to close the gap between the GVA/L and K/L indices since the early 1990s. This trend appears to be continuing given the increasingly strong demand for energy and minerals, which has made it possible to maintain a strong sellers market and heavy state involvement in these industries.

Chart 1

Growth Indices of Labour Productivity, Capital Intensity and TFP in Chinese Mining, Manufacturing and Utilities, 1980-2005

(1980=100)



Source: Author's estimates based on a translog production function. See Tables 1 and 2 for sources of the basic data.

Productivity Performance, 1980-93

The first impression from Table 1 is that the industrial development at the first stage of the reform (1980-93) was clearly input-driven, with average annual growth of labour at 4 per cent and net capital stock at 10.2 per cent. However, with similar capital stock growth rates (10.0 per cent), manufacturing achieved the highest output growth among the three major sectors at 8.4 per cent per annum, whereas utilities achieved 5.2 per cent and mining 3.2 per cent.

Breaking down this stage of reform into two sub-periods (1980-85 and 1985-93), Table 1 shows that while capital stock growth accelerated after 1985, the growth of both labour and output slowed down in the three major sectors. This indicates that while the output elasticity of investment declined, the substitution of capital for labour speeded up, suggesting that investors in general were still under soft-budget constraints whose impact appeared to be worsened in 1985-93. One would expect that this could certainly reduce the efficiency of industrial investment and hence take a heavy toll on the TFP performance at this stage.

This is exactly what is shown in Table 2. For industry as a whole, in 1980-85 the capital-labour ratio (K/L) rose by 2.5 per cent per annum to support the growth of labour productivity (GVA/L) by 3.1 per cent per annum, but in 1985-93, while the annual growth of labour productivity maintained a similar or slightly higher rate (3.4 per cent), the annual growth of the capital-labour ratio jumped to 8.1 per cent. Such an over-investment was accompanied by a decline in the growth of TFP from 1.3 per cent a year in 1980-85 to -2.2 per cent a year in 1985-93. This evidence strongly supports the argument made by the "comprehensive reform" camp that more management autonomy to SOEs in the absence of clear property rights and strict market principles, which warrant a hard budget constraint, would lead the reform astray.

Mining and utilities were mainly responsible for the unsatisfactory industrial productivity

Table 1
Growth of Gross Value Added, Employment and Net Capital Stock in Chinese Industry during the First Stage of Reform: 1980-93
(annual compound growth rate in percent; capital stock and gross value added at 1995 prices)

	Reform I: 1980-93			(Ia) 1980-85			(Ib) 1985-93		
	GVA	L	K	GVA	L	K	GVA	L	K
01. CLM	2.7	2.7	6.6	4.2	4.1	6.9	1.9	1.8	6.5
02. OIL	3.7	8.7	15.8	6.1	10.1	10.1	2.1	7.9	19.5
03. MTM	2.6	5.8	5.3	8.4	9.3	3.7	-0.8	3.7	6.3
04. NMM	2.4	4.1	9.5	0.4	7.0	7.7	3.7	2.4	10.6
05. FDB	13.4	5.2	14.7	11.7	9.5	16.3	14.5	2.6	13.6
06. TOB	10.5	6.1	23.8	14.0	6.4	23.7	8.4	5.9	23.8
07. TEX	7.7	6.4	13.9	8.1	10.8	16.0	7.4	3.8	12.6
08. WEA	14.7	9.3	19.3	15.0	16.6	21.1	14.5	4.9	18.2
09. LEA	13.3	7.5	15.3	12.0	9.4	13.6	14.1	6.2	16.3
10. WDF	5.0	4.9	11.6	5.4	10.5	13.5	4.8	1.6	10.4
11. PAP	7.1	5.2	11.2	8.5	5.5	10.0	6.3	5.0	11.9
12. PET	0.9	9.9	12.8	4.4	9.2	6.2	-1.2	10.3	17.1
13. CHE	8.7	4.9	9.8	9.3	3.6	7.4	8.3	5.8	11.3
14. RBP	8.9	7.1	14.1	10.5	12.2	14.8	7.9	4.0	13.7
15. SCG	8.1	3.2	11.5	10.3	5.8	12.3	6.8	1.7	11.0
16. PFM	5.7	5.4	8.7	6.5	3.7	3.7	5.3	6.5	12.0
17. MET	10.8	4.7	11.1	9.8	7.2	8.6	11.4	3.2	12.6
18. MCH	6.8	0.5	4.2	10.8	-3.2	2.8	4.3	2.8	5.1
19. TRS	12.8	1.7	7.3	14.2	4.6	3.4	11.8	-0.1	9.8
20. ELE	12.0	3.3	12.1	14.4	11.2	7.2	10.5	-1.3	15.2
21. ICT	13.5	3.1	12.2	19.4	3.6	9.1	10.0	2.8	14.1
22. INS	8.1	1.1	8.4	8.1	4.6	5.9	8.1	-1.0	10.0
Utilities	5.2	7.2	11.2	6.3	8.7	8.4	4.5	6.2	13.0
Mining	3.2	3.7	9.7	5.2	5.6	7.3	2.0	2.5	11.2
Manufacturing	8.4	4.0	10.0	9.4	5.0	7.7	7.8	3.3	11.5
Total	7.4	4.0	10.2	8.4	5.2	7.8	6.8	3.3	11.7

Source: Author's estimates based on data from *China Statistical Yearbook* (NBS, various issues), *China Industrial Economy Statistical Yearbook* (DITS, various issues), and *Industrial Census* in 1985 and 1995 and *Economic Census* in 2004 (NBS). See text and references in the data section for details of data construction. See Table A1 in the Appendix for the abbreviation of industries.

performance during the first stage of reform (Table 2). This was especially the case in 1985-93 when a substantial rise in the capital-labour ratio did not produce positive labour productivity growth in these two sectors and actually resulted in a huge drop in TFP growth of 6-7 per cent a year! This suggests that inefficient investment was a much greater problem in industries with high levels of state monopoly or control.

It is interesting to examine productivity performance within the manufacturing sector. The corrective effect of the reform at this early stage was clearly reflected by the growth of industries producing goods in strong demand because of insufficient investment in those industries under central planning. One might reasonably expect labour-intensive light industries that concentrated primarily on consumer goods (e.g. food,

Table 2

Growth of Labour Productivity, Capital-Labour Ratio and TFP in Chinese Industry During the First Stage of Reform: 1980-93

(annual compound growth rate in percent; capital stock and gross value added at 1995 prices)

	Reform I: 1980-93			(Ia) 1980-85			(Ib) 1985-93		
	GVA/L	K/L	TFP	GVA/L	K/L	TFP	GVA/L	K/L	TFP
01. CLM	0.0	3.8	-1.2	0.1	2.7	-0.8	0.0	4.6	-1.4
02. OIL	-4.7	6.5	-10.6	-3.6	0.0	-3.6	-5.3	10.8	-15.2
03. MTM	-3.0	-0.5	-2.7	-0.9	-5.1	2.3	-4.3	2.5	-5.8
04. NMM	-1.6	5.1	-4.8	-6.1	0.7	-6.6	1.3	8.0	-3.5
05. FDB	7.8	9.0	0.2	2.0	6.2	-3.4	11.6	10.8	2.7
06. TOB	4.2	16.6	-9.8	7.2	16.3	-6.9	2.4	16.8	-11.6
07. TEX	1.2	7.0	-3.2	-2.4	4.7	-5.6	3.5	8.5	-1.5
08. WEA	5.0	9.2	-0.3	-1.4	3.8	-3.7	9.1	12.7	2.1
09. LEA	5.4	7.3	1.8	2.3	3.8	0.3	7.4	9.5	2.8
10. WDF	0.1	6.4	-4.0	-4.6	2.8	-6.5	3.1	8.7	-2.2
11. PAP	1.8	5.7	-2.0	2.8	4.3	-0.2	1.2	6.6	-3.1
12. PET	-8.2	2.6	-10.5	-4.4	-2.8	-1.9	-10.4	6.2	-15.9
13. CHE	3.6	4.6	-0.1	5.5	3.7	2.5	2.4	5.2	-1.6
14. RBP	1.7	6.5	-3.1	-1.6	2.3	-3.3	3.7	9.3	-2.8
15. SCG	4.8	8.0	-0.3	4.3	6.2	0.2	5.1	9.2	-0.5
16. PFM	0.3	3.2	-1.9	2.7	0.0	2.6	-1.1	5.2	-4.6
17. MET	5.8	6.1	1.5	2.4	1.3	1.5	8.0	9.2	1.8
18. MCH	6.3	3.7	4.1	14.4	6.1	10.6	1.5	2.2	0.3
19. TRS	10.9	5.5	6.5	9.2	-1.2	10.2	11.9	9.9	4.3
20. ELE	8.4	8.5	2.4	2.9	-3.6	5.5	12.0	16.7	0.6
21. ICT	10.1	8.8	3.9	15.3	5.3	11.3	7.0	11.0	-0.5
22. INS	6.9	7.2	2.5	3.3	1.2	2.5	9.2	11.2	2.9
Utilities	-1.9	3.8	-4.8	-2.2	-0.3	-2.0	-1.6	6.4	-6.2
Mining	-0.5	5.8	-5.0	-0.3	1.6	-1.6	-0.6	8.5	-7.1
Manufacturing	4.2	5.8	0.1	4.1	2.6	2.2	4.3	7.9	-1.2
Total	3.3	5.9	-0.9	3.1	2.5	1.3	3.4	8.1	-2.2

Source: As provided in Table 1, plus data from *China Input-Output Table* (NBS, various issues). See Table A1 in the Appendix for the abbreviation of industries.

textiles, wearing apparel, leather products, paper, wood, rubble and plastic products) to be more responsive to the reform policies and their development to be more efficient than heavy industries because they could easily gain from China's comparative advantage. However, our findings show that although these industries in general underwent rapid output growth, their labour and capital input grew even more rapidly (Table 1). Therefore, they ended up with a negative growth in TFP in 1985-93, except for food, clothing and leather industries which recorded low but positive TFP growth (Table 2). Such an inefficient development of China's labour-intensive manufacturing at this stage may not be a major surprise given that local governments were heavily involved in the operations of rural enterprises because they not only created jobs (which was politically important), but also provided tax revenues.

Nevertheless, our results show that the best productivity performers were those traditionally capital- and technology-intensive heavy industries, such as machinery, transportation equipment, electrical equipment, and information and communication equipment. Their very impressive TFP growth in 1980-85 (Table 2) is simply reflected by the fact that their output grew much faster than their inputs on a per capita basis, just opposite to the performance of those light industries. It is also worth noting that in 1985-93 when most industries experienced negative TFP growth, some of these industries still recorded impressive TFP growth. These industries were state dominated. One possible explanation for this finding is that they had been equipped with the best human and physical capital stocks by the time of the reform because of favorable policies under central planning. The market-oriented reform provided opportunities for them to shift from heavy machinery to motorcycles, home electrical appliances and consumer electronics, supported by huge state investment in new equipment (with favorable terms for loans and imports). On the other hand, state involvement might also have a negative effect on efficiency. However, before substantial foreign investment began to enter these industries in the 1990s, these industries enjoyed high prices and relatively monopolistic status.

Productivity Performance, 1993-2005

During this second stage of China's industrial reform, the growth of output (GVA) accelerated to 12.2 per cent per annum compared with 7.4 per cent during the earlier stage (Table 3). Capital stock growth remained strong at 10.2 per cent per annum. Since employment growth turned negative in many industries, growth in the capital-labour ratio nearly doubled that of the previous period, at 10.7 per cent per year compared with 5.9 per cent in 1980-93 (Tables 2 and 4). However, labour productivity growth was nearly four times that of the previous period (12.7 per cent versus 3.3 per cent), which implies a significant change in TFP performance. For industry as a whole, TFP growth is estimated 6.1 per cent per annum compared with -0.9 per cent in 1980-93, this means that half of the 12.2 per cent annual growth of industrial output could be explained by TFP growth.

Among the three major sectors, manufacturing was again the best performer in terms of TFP growth in 1993-2005 (7.2 per cent per year), followed by mining (3.9 per cent) and utilities (1.2 per cent), all presenting a significant improvement from the first stage of reform (Table 4 compared with Table 2). The positive effect of the reform emerged clearly and significantly in both manufacturing and mining industries. The relative poor performance of utilities is understandable because of continuous heavy state control and huge investment, with capital stock growth 14.8 per cent a year (Table 3), in order to support rapid growth in the economy.

China's industrial productivity performance in 2000-05 has been much superior to that in 1993-2000. As shown in Table 4, for the industry as a whole, the growth of value added per worker and TFP was 17.5 per cent and 12.9 per cent per annum, respectively, in 2000-05, compared with 9.4 per cent and 1.4 per cent per annum in 1993-2000. For manufacturing, the corresponding growth rates were 18.4 per cent and 14.7 per cent in 2000-05, compared with 9.2 per cent and 2.0 per cent in 1993-2000. Utilities also saw faster labour productivity and TFP growth between the two sub-periods (14.2 per cent per year versus 5.0 per cent and 6.1 per cent versus -2.2 per cent respectively). Mining only saw faster TFP growth (6.8 per cent per cent versus 1.7 per cent).

The productivity growth acceleration since 2000 in our view may be only a short-term phenomenon brought about by China's accession to

Table 3
Growth of Gross Value Added, Employment and Net Capital Stock in Chinese Industry During the Second Stage of the Reform: 1993-2005
(annual compound growth rate in percent; capital stock and gross value added at 1995 prices)

	Reform II: 1993-2005			(IIa) 1993-2000			(IIb) 2000-05		
	GVA	L	K	GVA	L	K	GVA	L	K
01. CLM	9.2	-3.0	6.7	0.1	-7.2	3.7	23.3	3.3	11.0
02. OIL	5.4	1.0	9.1	4.0	-5.9	8.0	7.4	11.6	10.7
03. MTM	15.8	-3.6	5.6	8.5	-7.9	2.4	26.9	2.7	10.3
04. NMM	5.3	-11.5	-1.3	-2.9	-15.8	2.3	17.9	-5.2	-6.2
05. FDB	10.7	-1.7	8.1	4.4	-5.6	8.3	20.1	4.0	7.9
06. TOB	9.9	-3.7	11.2	6.4	-3.3	16.7	15.1	-4.4	3.8
07. TEX	7.5	-2.2	5.8	-0.9	-7.5	3.4	20.5	5.6	9.4
08. WEA	9.7	4.7	8.8	3.3	5.6	7.9	19.3	3.5	9.9
09. LEA	12.0	7.9	8.1	4.7	9.8	5.3	23.1	5.3	12.2
10. WDF	16.5	1.7	10.5	8.7	-4.9	8.1	28.4	11.6	13.8
11. PAP	12.0	-1.4	12.0	5.6	-3.6	11.2	21.5	1.8	13.2
12. PET	2.0	0.6	11.3	-3.8	-1.7	14.9	10.5	4.0	6.6
13. CHE	12.6	-0.4	8.8	7.9	-2.9	8.9	19.6	3.1	8.8
14. RBP	11.9	3.0	10.8	6.7	2.5	9.0	19.6	3.7	13.3
15. SCG	8.9	-6.1	7.6	1.7	-10.8	7.1	19.9	0.9	8.3
16. PFM	12.1	0.3	10.0	2.5	-2.0	8.6	27.1	3.7	12.0
17. MET	13.3	-0.2	7.9	5.3	-2.5	7.1	25.5	3.1	9.0
18. MCH	13.7	-3.1	5.0	3.5	-8.8	2.8	29.7	5.4	8.1
19. TRS	15.8	3.2	10.0	8.6	3.5	9.7	26.6	2.7	10.4
20. ELE	17.8	6.6	10.2	11.8	4.5	9.8	26.6	9.8	10.7
21. ICT	26.6	11.0	19.2	25.2	12.3	16.7	28.6	9.4	22.8
22. INS	16.6	3.2	7.6	7.4	6.3	3.0	30.9	-1.1	14.3
Utilities	11.8	2.8	14.8	8.4	3.3	14.8	16.7	2.1	14.8
Mining	7.7	-4.0	7.5	2.8	-8.7	5.6	15.0	3.1	10.1
Manufacturing	12.7	-0.2	9.1	5.6	-3.3	8.2	23.4	4.2	10.4
Total	12.2	-0.5	10.2	5.5	-3.6	9.2	22.3	4.0	11.5

Source: As provided in Table 2. See Table A1 in the Appendix for the abbreviation of industries.

WTO. There was a huge surplus capacity in manufacturing accumulated in the 1990s (as a result of apparently inefficient investment) that was readily available to meet the strong demand in the international market for the manufacturing goods that China could produce at attractive prices. There were also other one-off institutional effects in this period. Most importantly, around 2000-2001 China made tremendous efforts to clean up the mess of numerous internal regulations, local government ad hoc policies, unlawful levies, and hidden trade barriers. It should be noted that in our growth accounting exercise in Table 4, all these effects are captured by the growth of TFP. However, as long as China adheres to the rules of WTO, continuously opening up to foreign trade and direct investment while reforming its domestic institutions, some of the post-WTO gains in the rate of growth of productivity may be maintained in the future.

Employment developments suggest that China is developing a more flexible labour mar-

Table 4
Growth of Labour Productivity, Capital-Labour Ratio and TFP in Chinese Industry During the Second Stage of the Reform: 1993-2005
(annual compound growth rate in percent; capital stock and gross value added at 1995 prices)

	Reform II: 1993-2005			(IIa) 1993-2000			(IIb) 2000-05		
	GVA/L	K/L	TFP	GVA/L	K/L	TFP	GVA/L	K/L	TFP
01. CLM	12.5	9.9	8.5	7.9	11.7	3.8	19.3	7.5	15.7
02. OIL	4.3	8.0	-2.4	10.4	14.8	-1.7	-3.7	-0.8	-3.1
03. MTM	20.2	9.6	14.9	17.8	11.2	12.2	23.6	7.4	18.9
04. NMM	18.9	11.5	12.9	15.3	21.4	4.6	24.3	-1.1	24.9
05. FDB	12.5	10.0	5.3	10.5	14.7	0.1	15.4	3.7	12.6
06. TOB	14.2	15.5	2.9	9.9	20.6	-4.7	20.5	8.7	14.0
07. TEX	10.0	8.3	5.2	7.1	11.7	0.3	14.0	3.6	12.0
08. WEA	4.7	3.8	2.9	-2.2	2.2	-3.2	15.3	6.3	12.1
09. LEA	3.8	0.2	3.7	-4.7	-4.1	-2.8	16.9	6.5	13.6
10. WDF	14.6	8.7	9.8	14.2	13.7	6.9	15.1	2.0	13.9
11. PAP	13.5	13.6	6.1	9.5	15.3	1.7	19.4	11.2	12.7
12. PET	1.3	10.6	-6.7	-2.1	16.9	-14.9	6.2	2.4	4.4
13. CHE	13.1	9.3	7.1	11.1	12.1	3.3	16.0	5.5	12.3
14. RBP	8.6	7.6	4.1	4.1	6.4	0.3	15.3	9.3	9.6
15. SCG	16.0	14.6	8.0	13.9	20.0	3.3	18.9	7.3	14.7
16. PFM	11.8	9.6	6.2	4.6	10.8	-1.2	22.6	8.0	17.4
17. MET	13.6	8.1	9.0	8.1	9.9	2.8	21.7	5.7	18.4
18. MCH	17.4	8.4	12.8	13.5	12.7	6.7	23.0	2.6	21.6
19. TRS	12.2	6.6	8.3	4.9	6.0	1.5	23.3	7.6	18.7
20. ELE	10.4	3.3	8.5	7.0	5.1	4.2	15.4	0.9	14.8
21. ICT	14.0	7.4	9.8	11.6	4.0	9.3	17.6	12.3	10.1
22. INS	13.0	4.3	10.8	1.0	-3.1	2.6	32.3	15.6	23.9
Utilities	8.7	11.7	1.2	5.0	11.1	-2.2	14.2	12.4	6.1
Mining	12.1	11.9	3.9	12.6	15.7	1.7	11.5	6.8	6.8
Manufacturing	12.9	9.4	7.2	9.2	11.9	2.0	18.4	5.9	14.7
Total	12.7	10.7	6.1	9.4	13.3	1.4	17.5	7.2	12.9

Source: As provided in Table 2. See Table A1 in the Appendix for the abbreviation of industries.

ket that has facilitated rapid economic restructuring. In general, the decline of employment observed in 1993-2000 (-3.6 per cent per year) stopped in the 2000s and turned into a strong positive growth in 2000-05 (4.0 per cent per year), thanks to the WTO, which was even faster than the growth of employment achieved in 1985-93 (3.3 per cent) (Table 3 compared with Table 1). In fact, while most industries experienced a decline of employment in 1993-2000, with falls as large as 10 per cent per year in some industries (e.g. non-metallic mining and building materials), some export-oriented industries such as clothing, leather goods, electrical equipment, information-communication equipment, and instruments (including official equipment) recorded very fast employment growth, ranging from about 5 to 12 per cent a year. Between the two sub-periods of the second stage of reform, employment growth in some industries continued to be strong while and other industries experienced a shift from significant declines to rapid growth (e.g. wood and furniture machinery and equipment, oil and gas extraction, textiles) or vice versa (e.g. instruments and office equipment). This suggests that China's labour market was becoming more flexible in response to developments in product markets, especially to the world market following China's accession to WTO.

In 2000-05, there was no industry with negative TFP growth except for oil and gas extraction and all industries experienced faster TFP growth than in 1993-2000. As shown by the indices in Chart 2, over this period some industries continuously improved their TFP performance exhibiting an upward trend that began around 1995-96 (e.g. coal mining, metal mining, chemicals, building materials, metal products, machinery, transportation equipment, electrical equipment, information-communication equipment and instruments), whereas other industries managed to regain their benchmark (1980) level TFP after a long decline (e.g. non-metallic mining, textiles, wearing apparel, leather, wood, paper, rubber-plastic and basic metals). Oil and gas extraction, petroleum refinery and tobacco industries, which are all state monopolized, are still the most inefficient industries as shown in Chart 2, though tobacco started to improve in 2000-05.

Conclusion

This study has examined China's industrial productivity performance over the economic reform period (1980-2005) by applying the standard growth accounting approach to a set of recently constructed data for individual industries. Based on the main findings, which are still preliminary and subject to further data work, and discussions against the background of the major shifts of policy regimes, we conclude this study with the following remarks.

First, China's industrial reform has been largely investment-driven. Over-investment in

Chart 2

Growth Indices of Labour Productivity, Capital Intensity and TFP

(1980=100)

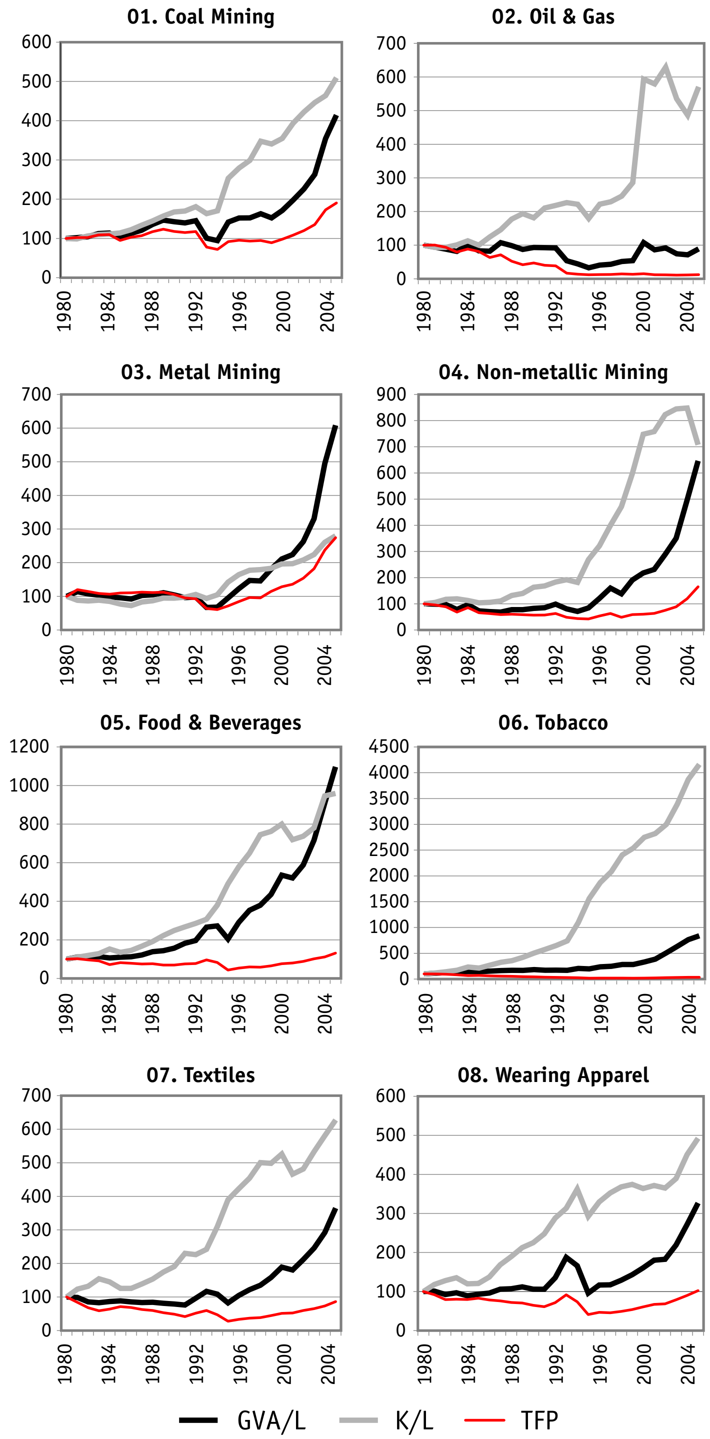
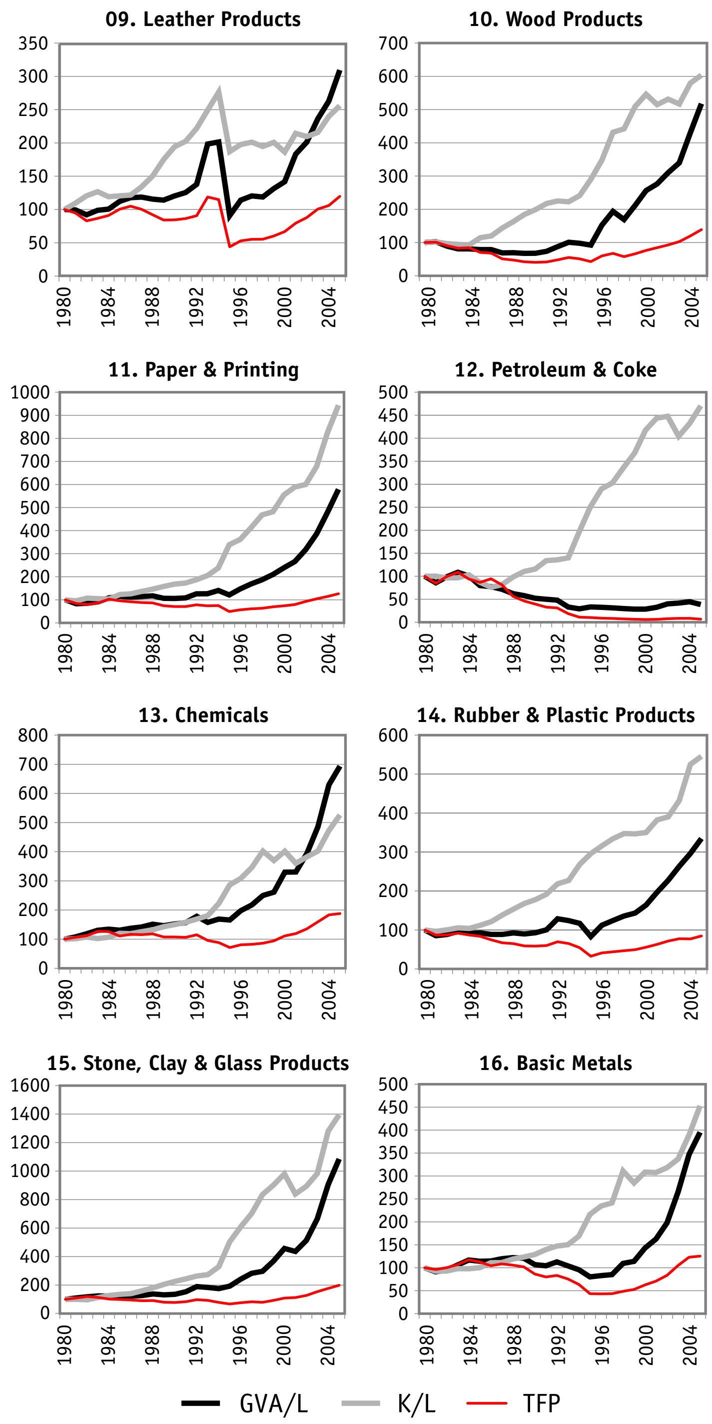


Chart 2
(continued)



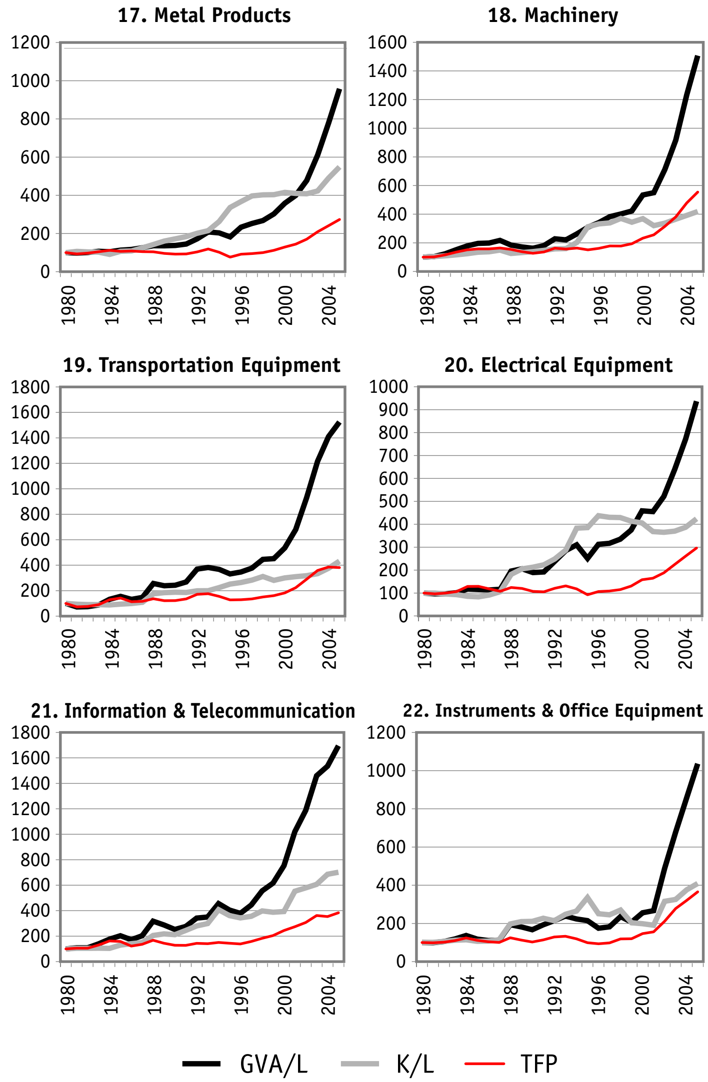
many industries has brought about strong growth and rapid welfare improvement through rising labour productivity, but it is inefficient and unlikely to be sustainable. The improvement of efficiency, as measured by TFP growth, since the mid to late 1990s is mainly attributed to the development of private enterprises and the integration with the world economy through foreign trade and direct investment. China's WTO accession has played an important role since the 2000s, but its effect may not be lasting if the pace of domestic reforms slows.

Second, China's energy and mining industries are particularly inefficient largely because of heavy state controls and soft-budget-constrained investment that have nurtured distorted incentives. Increasingly strong demand that has been fueled by continuous over-investment has created a strong sellers market and lessened the pressure for efficiency improvement. The consequence of this situation has been twofold. First, manufacturing industries are driven to introduce more energy and materials-saving technologies. Second, these industries may pressure the government for more price subsidies. This situation will continue to make China's economic growth a major driver of global energy and mineral prices.

Third, China's traditional labour-intensive industries may not be as efficient as the theory of comparative advantage would imply. The explanation may be heavy involvement by local government in these industries for job creation and taxation purposes. Local protectionism and subsidies may thus have played a major role in affecting the efficiency performance in these industries. This situation appears to have begun to change only very recently. This is a very good sign for healthy growth given that there is still huge surplus and underemployed labour in the countryside.

Fourth, contrary to what many may have expected, China's machinery, electrical and electronic industries appear to have experienced the most rapid TFP growth over the 1980-2005 period and have been the major contributor to the improvement of China's industrial produc-

Chart 2
(continued)



Source: Author's estimates based on a translog production function. See Tables 1 and 2 for the source of the basic data, and also see the data section in text for the data construction.

tivity performance. This is likely a consequence of various factors working in different directions. On the one hand, state interventions especially in the producer goods production of these industries may have had significant negative effects on the productivity performance of these industries. On the other hand, these traditional heavy industries have benefited from their long cumulated human capital and physical assets because of favorable state policies under central planning. During the earlier period of the reform, when the rapidly growing consumer goods market provided a good opportunity, some of these industries shifted to the manufacturing of consumer goods. Yet they were still supported by favorable bank loans, state projects, and subsidies on imported equipment, which have helped shift the technological frontier of these industries outward. Later, the performance of these industries may have been attributed to the privatization of small and medium sized state enterprises, and increasing foreign direct investment and exposure to international competition. Further competition, pro-market reforms and less government interventions may eventually make a few very large corporations in these industries major players in the world economy.

Last but not least, it should be realized that the existing data problems may affect the current results. Since we do not take into account the quality of labour and capital inputs, TFP growth may be capturing changes in the quality of inputs; therefore the estimated growth of TFP may have been over-stated. This is likely more significant in the recent period because after two decades of market-oriented reform, the quality of labour and capital should have been substantially improved (through increasing market competition) and therefore make a larger contribution to the growth of output. On the other hand, we have not been able to taken into account under-utilization of production capacity. It is reasonable to expect that after continuous over-investment since the 1990s, the problem of surplus capacity is severe in many industries. As a result, the contribution of capital service is likely to be overestimated (because in our exercise we assume that net capital stock is a proxy for capital service); therefore the estimated growth of TFP may have been underestimated.

Appendix

Table A1
Industrial Classification in This Study

		Industry			Industry
01	CLM	Coal mining	13	CHE	Chemicals & allied products
02	OIL	Oil & gas extraction	14	RBP	Rubber & plastics products
03	MTM	Metal mining	15	SCG	Stone, clay & glass products
04	NMM	Non-metallic minerals mining	16	PFM	Primary & fabricated metals
05	FDB	Food products & beverages	17	MET	Metal products
06	TOB	Tobacco products	18	MCH	Machinery & equipment
07	TEX	Textile mill products	19	TRS	Transportation equipment
08	WEA	Wearing apparel & other textile products	20	ELE	Electrical equipment
09	LEA	Leather & leather products	21	ICT	Information & communication equipment
10	WDF	Wood or saw mill products, furniture & fixtures	22	INS	Instruments & office equipment
11	PAP	Paper products, printing & publishing	23	OTH	Others or miscellaneous manufacturing industries
12	PET	Petroleum & coal products	24	UTL	Power, steam, gas & tap water supplies

Note: "Others" (23) industry serves as a "residual" in the data construction due to problems in the official data. Therefore, this industry is excluded in individual industry analysis.

References

Adams, F. Gerard and Yimin Chen (1996) "Skepticism about Chinese GDP growth — the Chinese GDP elasticity of energy consumption," *Journal of Economic and Social Measurement*, Vol. 22, pp. 231-240.

Chen, Kuan, Gary H. Jefferson, Thomas G. Rawski, Hongchang Wang, and Yuxin Zheng (1988a) "New estimates of fixed investment and capital stock for Chinese state industr," *The China Quarterly*, Vol. 114, pp. 243-266.

Chen, Kuan, Gary H. Jefferson, Thomas G. Rawski, Hongchang Wang, and Yuxin Zheng (1988b) "Productivity Change in Chinese Industry: 1953-198," *Journal of Comparative Economics* Vol. 12, No. 4, pp. 570-91.

Chow, Gregory C. (1993) "Capital Formation and Economic Growth in Chin," *Quarterly Journal of Economics* Vol. 108 No. 3, pp. 809-42.

Guo, Shuqing, Lou Jiwei and Qiu Shufang (1985) "All-round Reform Requires for a Comprehensive Design," *Comparative of Economic and Social System*, No.1.

ECNH (Editorial Committee of New Handbook of Regular Data and Coefficients for Assets Evaluation) (2002), *New Handbook of Regular Data and Coefficients for Assets Evaluation*, Vol. 1 (China Statistical Press).

Hu, Zuliu F. and Mohsin S. Khan (1997) "Why is China growing so fast?"*IMF Staff Papers*, Vol. 44, No. 1, pp. 103-131.

Huang, Yongfeng, Ren Ruoen and Liu Xiaosheng (2002) "Capital StockEstimates in Chinese Manufacturing by Perpetual Inventory Approach," *China Economics Quarterly*, Vol. 1, No. 2, pp. 377-396.

Hulten, Charles R., and Frank C. Wykoff (1981a) "The estimation of economic depreciation using vintage asset price," *Journal of Econometrics*, Vol. 15, pp. 367-396.

Hulten, Charles R., and Frank C. Wykoff (1981b) "The measurement of economic depreciatio," in Charles R. Hulten (ed.) *Depreciation, Inflation, and the Taxation of Income from Capital*, (Washington, D.D.: The Urban Institute Press) pp. 81-125.

Jefferson, Gary H., Thomas G. Rawski and Yuxin Zheng (1996) "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Development," *Journal of Comparative Economics*, Vol. 23, pp. 146-80.

Jorgenson, Dale W. (1963) "Capital Theory and Investment Behavior," *American Economic Review*, Vol. 53, No. 2, pp. 247-59.

Jorgenson, Dale W. (1973) "The Economic Theory of Replacement and Depreciation," in W. Sellykaerts (ed.) *Economics and Economic Theory* (New York: Macmillan).

Jorgenson, Dale W., Frank Gollop and Barbara Fraumeni (1987) *Productivity and U.S. Economic Growth* (Cambridge, Mass.: Harvard University Press).

Table A2
Level of Labour Productivity and Capital Intensity by Industry, Selected Years, 1980-2005
(thousand 1995 RMB yuan)

	1980		1985		1990		1995		2000		2005	
	GVA/L	K/L	GVA/L	K/L	GVA/L	K/L	GVA/L	K/L	GVA/L	K/L	GVA/L	K/L
01. CLM	10	21	10	24	15	35	15	53	18	74	43	106
02. OIL	313	148	261	148	292	269	103	266	338	880	279	847
03. MTM	16	31	15	24	16	29	15	44	33	61	95	87
04. NMM	10	8	7	8	8	13	8	22	22	61	64	58
05. FDB	10	11	11	15	15	28	20	55	52	90	106	107
06. TOB	156	13	221	28	285	66	307	204	516	360	1,308	545
07. TEX	16	12	14	15	13	22	13	45	30	61	58	73
08. WEA	10	5	9	6	11	11	10	15	16	18	32	25
09. LEA	11	9	12	11	13	17	10	17	15	17	34	23
10. WDF	11	9	9	11	7	19	10	27	28	51	57	57
11. PAP	14	16	16	20	15	27	17	55	33	90	79	153
12. PET	273	94	217	82	142	109	91	236	78	393	105	443
13. CHE	19	37	24	45	28	56	31	107	62	150	130	196
14. RBP	20	16	19	18	19	29	17	49	33	58	68	90
15. SCG	5	7	7	10	7	16	10	36	25	70	59	99
16. PFM	40	56	46	56	43	72	32	121	58	173	160	254
17. MET	9	11	10	12	13	19	17	38	33	47	88	62
18. MCH	7	19	13	26	11	27	20	60	35	71	99	81
19. TRS	9	30	14	28	22	56	30	76	49	90	139	130
20. ELE	12	16	14	13	22	34	30	62	54	66	111	68
21. ICT	9	17	18	22	22	35	35	60	65	65	147	117
22. INS	10	16	11	17	16	34	21	54	25	32	100	66
Utilities	61	162	54	160	64	198	56	367	67	552	130	990
Mining	22	24	22	26	30	44	24	71	48	139	82	193
Manufacturing	13	17	16	20	17	29	20	56	41	80	95	107
Total	15	21	17	24	20	36	22	68	43	107	96	152

Source: As Tables 1 and 2.

Kaze, Arnold, J. and Shelby W. Herman (1997) "Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-9," *Survey of Current Business*, May, pp. 69-92.

Li, Yining (1986) "BasicPrinciples of Economic Reform," in *Basic Principles of Economic Reform in China* (Beijing: Zhanwang Press).

Li, Jingwen, *et al.* (1992) "Productivity and China'Economic Growth," *The Economic Studies Quarterly*, Vol. 43, No. 4, pp. 337-350.

Maddison, Angus (2007) *Chinese Economic Performance in the Long Run: AD 960-2030*, (Paris: OECD Development Centre).

Maddison, Angus and Harry X. Wu (2006) "China's Economic Performance: How Fast has GDP Grown; How Big is it Compared with the USA, paper presented at World Economic Performance: Past, Present and Future — Long Term Performance and Prospects of Australia and Major Asian Economies, Seminar on the Occasion of Angus Maddison's 80th Birthday, 5-6 December, School of Economics, University of Queensland.

Ministry of Finance (1992) *Service Life of Industrial Fixed Assets*, Appendix 1, Circular No. 574, 30 December.

Murphy, Kevin M, Andrei Shleifer and Robert W. Vishny (1992) "The Transition to a Market Economy: Pitfalls of Partial Reform," *Quarterly Journal of Economics*, Vol. 107, No. 3.

National Bureau of Statistics, various issues, *Statistical Yearbook of China*, Beijing Statistical Publishing House.

Ren, Ruoen (1997) *China's Economic Performance in an International Perspective* (Paris: OECD Development Centre).

Shiu, Alice and Harry X. Wu (2007) "Efficiency and Productivity Performance of Chinese Manufacturing Revisited," paper presented at the IARIW-NBS Conference on Experiences and Challenges in Measuring Income and Wealth in Transition Economies, Beijing, China, September 18-20.

State Council (1985) *Probation Regulation on the Depreciation of Fixed Assets in State-owned Enterprises*, Circular No. 63, 26 April.

Woo, Wing Thye (1998) "Chinese Economic Growth: Sources and Prospect," in M. Fouquin and F. Lemonie (eds.) *The Chinese Economy* (Paris: Economica Ltd.).

Wu, Harry X. (2000) "China's GDP level and growth performance: Alternate estimates and the implications" *Review of Income and Wealth*, Series 46, No. 4 pp. 475-499.

Wu, Harry X. (2002a) "How Fast Has Chinese Industry Grown? —Measuring the Real Output of Chinese Industry," *Review of Income and Wealth* Series 48, No. 2, pp. 179-204.

Wu, Harry X. (2002b) "Measuring the Capital Stock in Chinese Industry – Conceptual Issues and Preliminary Results," paper prepared for the 27th General Conference of International Association for Research in Income and Wealth, Stockholm, Sweden, August 18-24, 2002.

Wu, Harry X. (2007) "Measuring Capital Stock and Capital Service in Chinese Industry: Implications for Productivity Performance," unpublished paper, The Hong Kong Polytechnic University.

Wu, Harry X. and Yue Ximing (2007) "Sources of Quality Change in the Labour Input of Chinese Industr, 1949-2005," unpublished paper, The Hong Kong Polytechnic University.

Wu, Jinglian (1985) "Economic Mechanism and Systematic Refor," in *Essays of Wu Jinglian*, Shanxi People's Press, 1989.

Xu, Xianchun (1999) *On Reform and Development of the Chinese System of National Economic Accounting*, Economic Science Press (in Chinese).