Session Number: IB
Title: Measuring Industrial and Regional Productivity in Transition Economies
Organiser: Harry X. WU

Paper prepared for the
IARIW-NBS International Conference
Experiences and Challenges in Measuring National Income and Wealth in Transition Economies
September 18–21, 2007, Beijing, China

Regional Productivity Trends in Chinese Industry

by

Lili Wang* and Adam Szirmai**

*Eindhoven Centre for Innovation Studies
Eindhoven University of Technology

** UNU-MERIT,
Maastricht University

* Lili Wang, Corresponding author: Eindhoven Centre for Innovation studies, Department of Technology Management, P.O. Box 513, 5600 MB, Eindhoven the Netherlands, email: lili.wang@tue.nl; **Adam Szirmai (Eddy), UNU-MERIT, Keizer Karelplein 19, 6211 TC, Maastricht, The Netherlands, email: szirmai@merit.unu.edu

1: Introduction

Rapid aggregate growth in Chinese Industry is accompanied by large disparities across regions. Disaggregated studies of regional economic performance are urgently needed. The main goal of this paper is to provide an examination of the evolution of productivity differentials in Chinese industry. A second goal of the paper is to contribute to the construction of regional datasets for China, in particular with regard to regional time series for capital in industry.

According to the older neo-classical growth theories, diminishing marginal returns to capital offer opportunities for capital flows from rich regions (or countries) with high capital intensities to poorer regions (or countries) with lower capital intensities. In other words, there is a equilibrating mechanism which tends to reallocate capital. This theoretical perspective predicts long-run convergence between countries and regions. Factor mobility contributes to the convergence process by moving labour or capital from regions where they are relatively abundant to regions where they are relatively scarce. The assumption of free access to technological knowledge means that technological change will not result in divergence (Barro and Sala-i-Martin, 1992, 2004). The joint impact of decreasing returns (in the convex production function) and exogenous technological change predict convergence between regions. Some empirical studies of catch up also predict such convergence, showing that countries with lower initial levels of income per capita grow faster than those with higher initial levels (e.g. Mankiw et al., 1992; Barro, 1991). This could also operate at the level of regions within a country.

In contrast, new growth theories and endogenous theories predict long-run divergence of per capita incomes, rather than convergence. They point to increasing returns to the primary inputs (in both capital and labour input). Romer (1986) proposes a long-run growth model with increasing marginal productivity of knowledge inputs. Technology and innovation are the key to augmenting the marginal returns to inputs. As rich countries (and regions) have more advanced technologies than poor ones, rich regions tend to become rich and poor regions tend to lag behind. Romer (1986) and Lucas(1988) show that the divergence in the long-term is also due to the increasing returns to scale.

Catching up and convergence are also seen as possible in evolutionary strands of endogenous theories of growth. They will occur if technologies spill over from leading countries and regions to backward countries and regions. Whether this happens, depends on the size of technology gaps, on the one hand. If they are small there is little potential for catch up. If they are too large, the obstacles to diffusion of technology can become unsurmountable. On the other hand, catch up crucially depends on the learning capabilities and absorptive capacities of the laggard regions. If the laggards have certain abilities to absorb technologies developed in the most advanced economies or regions, they can grow more rapidly than the leaders. They can profit from the advantages of backwardness. If, on the contrary, their absorptive capacities are too low, and the technology gaps are too large, advanced technology may not be appropriate for the laggards. They might be caught in a poverty trap and fall behind. Thus convergence or divergence depends on the balance between the rate of technological advance in the lead countries (or regions) and technology diffusion to the less advanced countries (or regions) (see e.g. Verspagen, 1991, Fagerberg, 2005, Szirmai, 2005, chapter 4).

Barrios and Strobl (2005) have examined the evolution of regional inequalities within European countries. Using a panel of European countries, they conclude that there is an inverted U-shape relationship between national income per capita and the degree of regional inequality. Tamura

(1996) and Lucas (2000) also argue that the regional inequalities first rise and then decline in the course of economic development.

Chen and Fleisher (1996) discuss the convergence, conditional on investment in physical capital, employment growth, human-capital investment, FDI and coastal location, across 25 provinces in China from 1978-1993. They conclude that overall regional inequality as measured by the coefficient of variation is likely to decline modestly but that the coast/non-coast income differentials tend to increase somewhat. Convergence is primarily occurring "*within*" the coastal and non-coastal groups rather than happening "*between*" them.

Jian et al (1996) explore China's regional disparities using time series. They find convergence from 1952 to 1965 and from 1978 to 1990 . Between 1965-78 they find a clear divergence trend. Kanbur and Zhang (2005) use econometric analysis to study the determinants of regional inequality. They find that regional inequality is explained by three policy variables: the share of heavy industry in gross output value, the degree of decentralization, and the degree of openness. The importance of these factors varies from policy period to policy period. According to their analysis, greater decentralization in the post 1978 reform period widened rural-urban disparities.

Many studies of regional inequality in China focus on income differentials, GDP per capita or labour productivity. In this paper, we would like to go a step further and examine total factor productivity and efficiency differentials in industry. This requires estimates of regional capital inputs. Estimations of capital stocks in China are fraught with difficulties, in part due to the lack of long-run series of capital investment consistent with SNA. Several research groups have been working on capital stock investment. In this paper, we will use our own newly created regional capital stocks to analyse the regional differences in TFP productivity and efficiency.

2: Data

The regional data on value added and employment used in this paper derive from national sources such as the China Statistical Yearbooks (CSY), the China Industrial economy Statistical Yearbooks (CIESY), the industrial censuses of 1995 and 1995, the China Labour Statistical Yearbooks (CLSY) and the *Statistics of China's Industry and Transport, 1949-1999 (SCIT, 2000).*

Szirmai, Ren and Bai (2005) and Szirmai and Ren (2007) provide a detailed discussion of the problems of long-term time series of value added and employment. There are major problems of inconsistencies in the series, in terms of concepts and coverage. The authors have made a large number of adjustments to achieve consistency in these series, which will not be discussed in this paper. Our aim has been to make the regional series of employment consistent with the adjusted aggregated national series for total industry. In order to achieve this we have applied the adjustment factors for the national level to all regional data. For the adjustments, the reader is referred to the two publications cited above.

Is industrial employment shrinking or growing after 1999?
The choice of employment data for the years after 1999 needs to be elaborated further here. We have found enormous inconsistencies between two sets of employment data.
One set of data derives from the staff and workers time series in CLSY (2006), p. 25 and 29. This series has been adjusted according to Szirmai and Ren, 2007. There are two upward adjustments, one for the fact that the coverage of the staff and worker series is limited to urban workers, while the output data include rural township workers. Another adjustment corrects for the fact that after

1998 millions of so-called *not-on-post workers* are suddenly excluded, leading to break in the series. We refer to this adjusted time series as series I.

The second employment series – series II - derives from the CSIEY. This series probably has another concept, but the two series roughly are comparable up to 1997. If we make the same adjustment for not-on-post workers as for series I, the two series are roughly comparable up to 2002. Both series indicate that industrial employment is shrinking (see also Banister, 2005).

However, the series II data suddenly stop declining in 2002 and explode upwards from 55.2 million workers in 2002 to 69.0 million workers in 2005, an increase of 13 million workers in three years. In series I, one can also discern an upturn in employment after 2002 but it is much more modest, from 59.4 million workers in 2002 to 61.9 million.

This results in a fundamental difference between the two series. Series I shows a substantial net decline in employment from 1999 to 2005: 70.5 to 61.9 million workers. This is consistent with other assessments of jobless growth in Chinese industry. Series II shows at net increase in employment between 1999 and 2005, 58.1 to 69.0 million. Such discrepancies have immense implications for the analysis of productivity trends. Till this mystery is sorted out, we have decided to limit the time span of the detailed analysis of total factor productivity to the period from 1980 till 2002. We have chosen for the adjusted series of staff and workers deriving from the labour statistics yearbooks. [1]

For the estimation of capital inputs, we refer the reader to annex A of this paper.

3: Methods

Conventional convergence studies use regression methods to calculate the catching-up rate (convergence coefficient β) and dispersion (σ). (Barro and Sala-i-Martin, 2004). If poorer countries (or regions) grow faster than rich ones, then we say there is a β convergence. The coefficient β also shows the rate of convergence. There is a negative relationship between the growth rate (of GDP or income per capita) and the initial level of income per capita. σ measures the dispersion, based on the standard deviation of observations. The Coefficient variation is also used for σ measurement.

The shortcoming of these convergence indicators is that the distribution is described with a single indicator. This does not give an adequate picture of the growth dynamics of all the regions or countries involved. Hence mapping the entire cross-section distribution is needed. (Bianchi, 1997; Desdoigts, 1994)

Distribution dynamics (distribution density) has been accepted as a better solution in analyzing a rather broad or the whole scale of cross-country distribution. (Quah, 1996; Lopez-Bazo, 1999; Bianchi, 1997; Fiaschi and Lavezzi, 2003; Bulli, 2001; Desdoigts, 1996). In addition to traditional measures such as the coefficient of variation this paper uses the distribution density to illustrate distribution of regional GDP per capital, productivity and growth.

[1] In case of the coefficient of variation of labour productivity, we have included 2003-2005, because we are interested in the regional distribution, rather than the level of productivity.

4: Analysis

4.1. GDP per capita

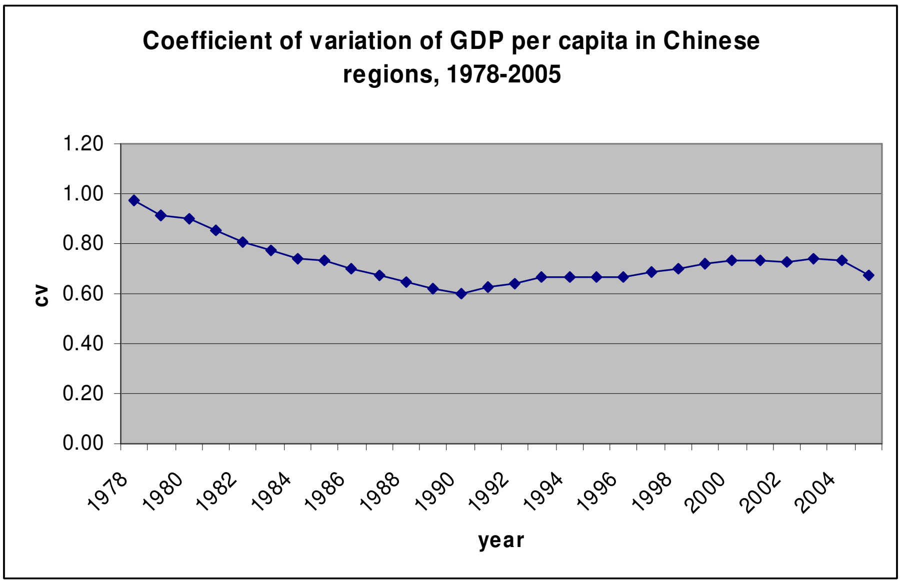
There are huge regional differentials with regard to GDP per capita. In 1978, GDP per capita in Shanghai, the top region, is 13 times higher than the bottom region (Guizhou) in 1978. In 2005, it is 8.7 time higher. Over the whole period 1978-2005, the ratio of the top five to the bottom five regions declines from 5.59 in 1978 to 4.82 in 2005. Zhejiang, Guangdong, Fujian, and Shandong maintain growth rates of more than 11% per year.

Table 1:
Standard Deviation, Mean and Coefficient of Variation of per capital GDP in Chinese regions

	1978	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
standard deviation	444	445	458	450	451	469	510	551	544	558	557	504	525	606
mean	457	489	508	526	559	605	689	754	778	832	866	816	875	966
coefficient of variation	0.97	0.91	0.90	0.85	0.81	0.77	0.74	0.73	0.70	0.67	0.64	0.62	0.60	0.63
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
standard deviation	712	842	900	963	1060	1214	1370	1539	1737	1918	2125	2461	2816	3023
mean	1107	1266	1354	1452	1592	1768	1952	2137	2372	2620	2919	3339	3849	4491
coefficient of variation	0.64	0.67	0.66	0.66	0.67	0.69	0.70	0.72	0.73	0.73	0.73	0.74	0.73	0.67

Note: at 1978 constant price, yuan/person.
Source: GDP and population from regional statistical yearbooks, various issues, price deflator from CSY 2006 (Table 9-1) and CSY 1996 (Table 8-1).

Figure 1: Coefficient of Variation



Source: Table 1.

The coefficient of variation is the highest at the beginning of the period, in 1978. It declines to its lowest level in 1990. It increases somewhat during 1991-2004, dropping again in 2005. The coefficient of 2005 is 69% of that in 1978. Thus, there seems to be strong convergence from 1978 to 1990, some divergence between 1990 and 2000, stability from 2000 to 2004 and a drop in regional inequality in 2005. In the long run regional inequality seems to be decreasing. This will be further examined in the coming paragraphs..

The kernel density distribution – reproduced in figures 2a, 2b and 2c – provides us with a more complete picture of the changes. In the early years we see a bimodal distribution, with two small groups of leading regions and a concentration of lagging regions. In the later years, the distribution becomes unimodal, which is consistent with the convergence trend. The shift from the bimodal to the unimodal distribution takes place gradually. The two leading groups are still visible in 1992. By 2005 the distribution has become unimodal

As the average regional GDP increases, the distribution becomes flatter. This should, however, not be interpreted as a sign of divergence. It is primarily caused by the increase in the mean. In table 1, one can see that the standard deviation increases less than the mean, so that the coefficient of variation is declining.

Figure 2a:
Kernel density of GDP per capita in Chinese regions, 1980-2005

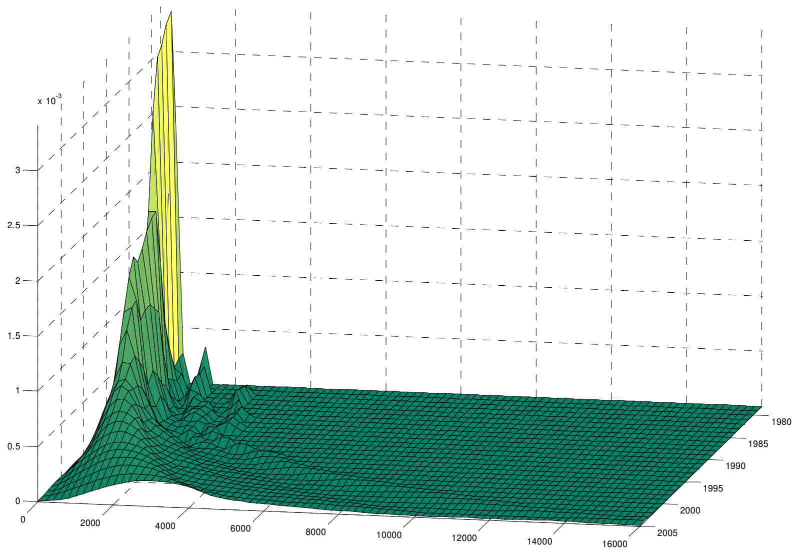


Figure 2b Kernel density: 1978-1992

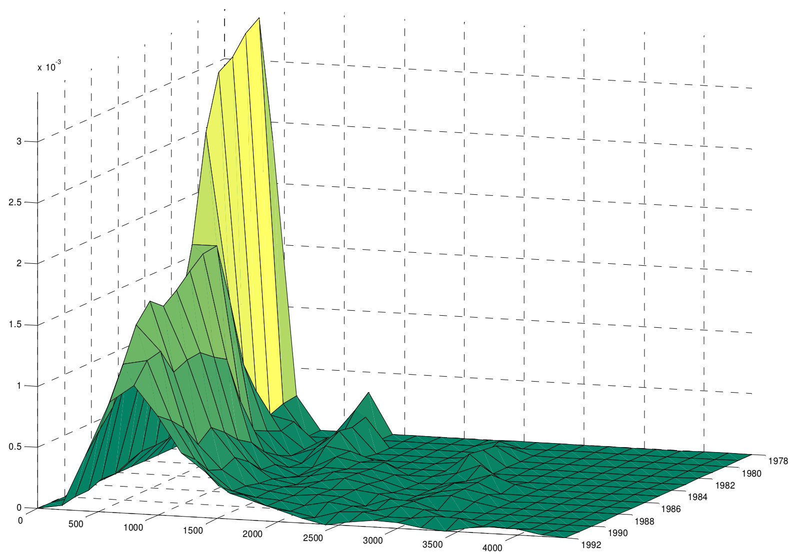
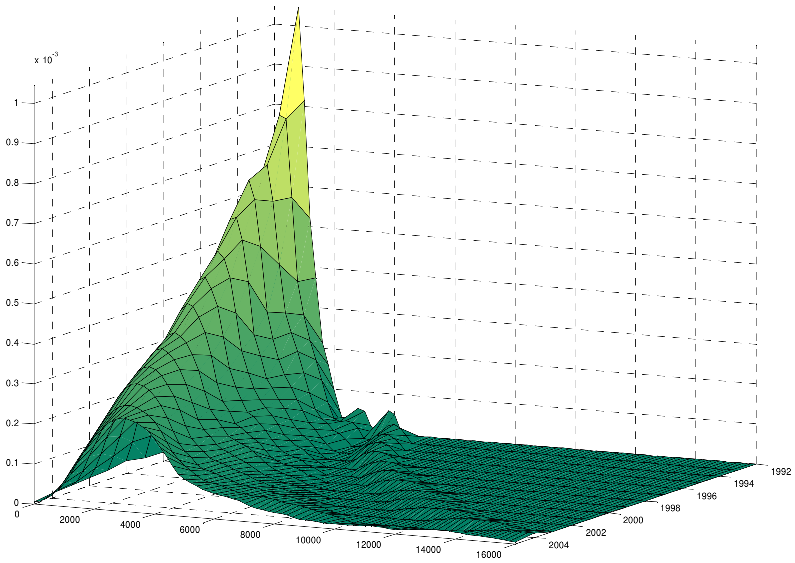


Figure 2c Kernel Density: 1992-2005



Note: GDP per capita at 1978 constant prices, yuan/ person.
Source: CSY, various issues

4.2. Labour productivity

Table 2 and figure 3 provide information about regional disparities in industrial productivity.[2] The trends in value added per worker are rather similar to those for total GDP per capita. The coefficient of variation declines substantially between 1978 and 1989. Between 1989 and 1994, disparities increase quite rapidly. Between 1994 and 2000, the trend stabilises. After 2000, the coefficient of variation declines. In long-run perspective regional inequalities decline. The coefficient of variation in 2005, is 30 per cent lower than in 1978. In general, productivity disparities are much less pronounced than income disparities (table 2 versus table 1).

Table 2:
Standard deviation, Mean and Coefficient of Variation of industrial labour productivity in Chinese regions

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
standard deviation	0.13	0.13	0.13	0.13	0.12	0.13	0.14	0.14	0.11	0.11	0.11	0.09	0.10	0.11
mean	0.32	0.34	0.35	0.34	0.35	0.38	0.41	0.41	0.39	0.41	0.43	0.40	0.40	0.42
coefficient of variation	0.40	0.39	0.38	0.38	0.36	0.34	0.34	0.36	0.29	0.26	0.25	0.24	0.25	0.26

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
standard deviation	0.13	0.18	0.20	0.18	0.19	0.25	0.29	0.35	0.45	0.49	0.53	0.66	0.64	0.82
mean	0.47	0.58	0.56	0.52	0.60	0.70	0.88	1.06	1.28	1.46	1.74	2.12	2.39	2.95
coefficient of variation	0.27	0.31	0.35	0.34	0.32	0.36	0.34	0.33	0.35	0.33	0.30	0.31	0.27	0.28

Sources: Value added and employment: CSIEY, various issues,; SCIT (2000), CLSY, various issues; 31 regional yearbooks, various issues.

[2] We would have preferred to perform this analysis for manufacturing, but Chinese regional statistics tend not to distinguish between manufacturing and industry.

Figure 3:

Source: from Table 2.

The rate of convergence can be calculated from the following regression equation

$$\frac{\log(y_{iT} / y_{i0})}{T} = \alpha - \frac{1 - e^{-\beta T}}{T} \log(y_{i0}) + \omega_{i0,T} \quad (1)$$

Table 3: Beta convergence

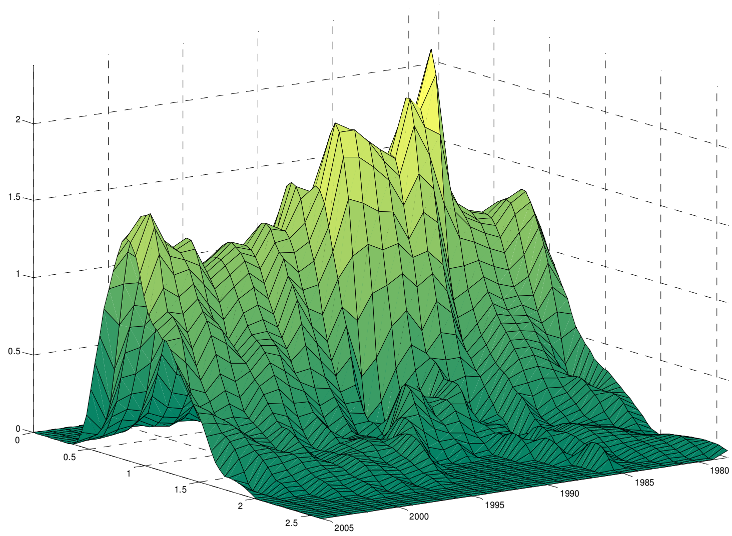
	Number of Years (T)	coefficient of $\log(y_{i0})$	Std. error	β (rate of convergence)	Coefficient α
1978-90	12	-0.053*	0.009	0.084	0.194
1990-2002	12	-0.007	0.014	0.007	0.073
1978-2002	24	-0.027*	0.005	0.044	0.129

* Significant at 1% level
Source: see table 2.

The beta coefficients in table 3 confirm the rapid rate of convergence in the early period and the slower convergence over the whole period. The regression coefficient in the second period, 1990-2002 does not deviate significantly from zero.

The kernel distribution in figure 4 indicates that in contrast to the regional distribution, the distribution of industrial productivity is unimodal over the whole period. There are no clearcut gaps between a club of leading regions and the follower regions. In figure 4, we have chosen to reproduce the density of labour productivity divided by mean productivity. This avoids the flattening of the distribution as a result of increases in the mean, which incorrectly suggests that disparities are widening.

Figure 4 :
Kernel Distribution of Industrial Labour Productivity in Chinese Regions, 1978-2005 (divided by mean).

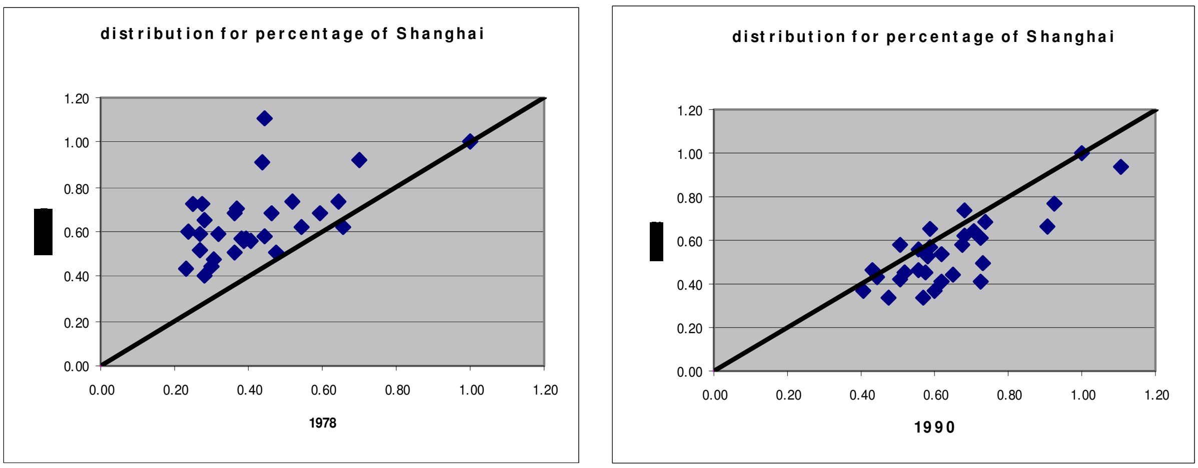


Note: labour productivity is calculated at 1978 constant prices, 10000 yuan/person.
Source: various national and regional yearbooks.

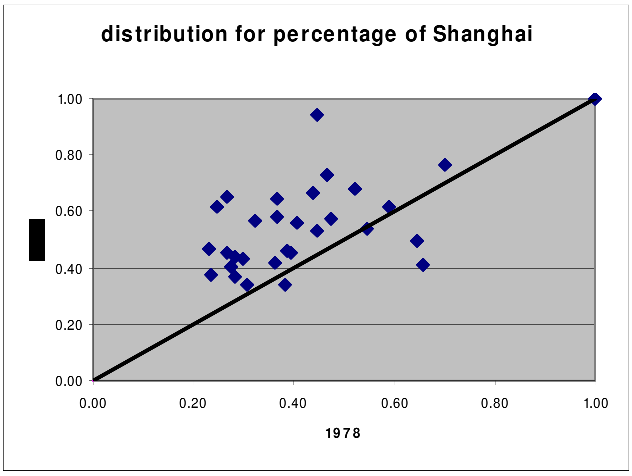
Shanghai has the highest labour productivity in almost all years. The following figures show the distribution dynamics of regional productivity ratios relative to the leading region Shanghai during the period 1978-1990 and the period 1990-2002.

Figure 5:
Regional Labour Productivity as percentage of Shanghai

a. 1978-1990 **b. 1990-2002.**



c. 1978-2002



Between 1978 and 1990 almost all regions have improved their performance relative to the leader, confirming the rapid beta convergence in table 3. In the later period 1990-2002, performance relative to the leader in 1990 worsens somewhat consistent with the divergence trends documented above. However, a great many regions show very little change in their relative performance. Panel c confirms the convergence trends over the whole period, with most regions improving their comparative performance.

From 1978 to 1990, all regions, except only Qinghai, locate above the diagonal. Yunnan has the biggest jump from 45% to 110% of Shanghai from 1978 to 1990. Guangdong and Beijing also have significant increases, from 44% to 99%, and 70% to 92% respectively.

4.3. Comparative Efficiency Trends using DEA

As we have estimated regional capital stocks in addition to the regional data on value added and employment, we can go beyond comparative trends in labour productivity and examine regional differentials in total factor productivity. We will do this using frontier analysis for the 31 regions, which decomposes regional growth into growth at the frontier and changes in efficiency.

TFP change can be decomposed into various, eg. changes of technical efficiency, technological progress, scale efficiency, and allocative efficiency[3] etc. This decomposition can be done using either a parametric approach (stochastic frontier analysis), or a non-parametric approach (data envelopment analysis). SFA includes a "noise" term in its model. Thus, the efficiency of a firm (industry or region) is compared with an best practice level which is estimated econometrically. DEA compares the performance of a firm (industry or region) with the observed best practice. Given that the outcomes of DEA are heavily influenced by outliers most researchers prefer stochastic frontier analysis. We are presently in the midst of this SFA analysis, but the results of the stochastic models examined so far are so unstable, that at this stage we can only present the DEA results.

The DEA approach makes use of a Malmquist index approach The Malquist TFP index was introduced by Caves Christensen and Diewert (1982) and has been often used for the measurement of TFP indexes and efficiency scores. The Malmquist productivity index has two main advantages

[3] Allocative efficiency can only be estimated if input or output prices are also available. This is not the case in this study.

over the Törnquist and the Fisher indexes. One is that price data are not necessary for aggregation and the other one is that it can decompose TFP into various sources[4].

The output-oriented distance function of production set at time t, (based on the technology at time t) is $D_o^t(x_t, y_t)$. Likewise, it will be $D_o^{t+1}(x_{t+1}, y_{t+1})$ for production set at time t+1, (based on the technology of time t+1). Taking the benchmark technology at time t, the output-oriented Malmquist productivity index is

$$MTFP^{t,t+1}(x_t, x_{t+1}, y_t, y_{t+1}) = \frac{D_o^t(x_{t+1}, y_{t+1})}{D_o^t(x_t, y_t)} \qquad (2)$$

Considering that technology at time t and time t+1 can be used in the production of time t+1 and time t, the Malmquist TFP index can be expressed by the following geometric mean

$$MTFP^{t,t+1}(x_t, x_{t+1}, y_t, y_{t+1}) = \left[\frac{D_o^t(x_{t+1}, y_{t+1})}{D_o^t(x_t, y_t)} \bullet \frac{D_o^{t+1}(x_{t+1}, y_{t+1})}{D_o^{t+1}(x_t, y_t)} \right]^{0.5} \qquad (3)$$

Färe et al. (1994) and Farrel (1957) decompose TFP into technological progress and change of technical efficiency, which has been widely adopted by many researchers[5].

Using Malmquist TFP index with panel data, the output-oriented linear program DEA model can be expressed as

$$\left[D_0^t(x_t, y_t)\right]^{-1} = \max_{\phi,\lambda} \phi$$

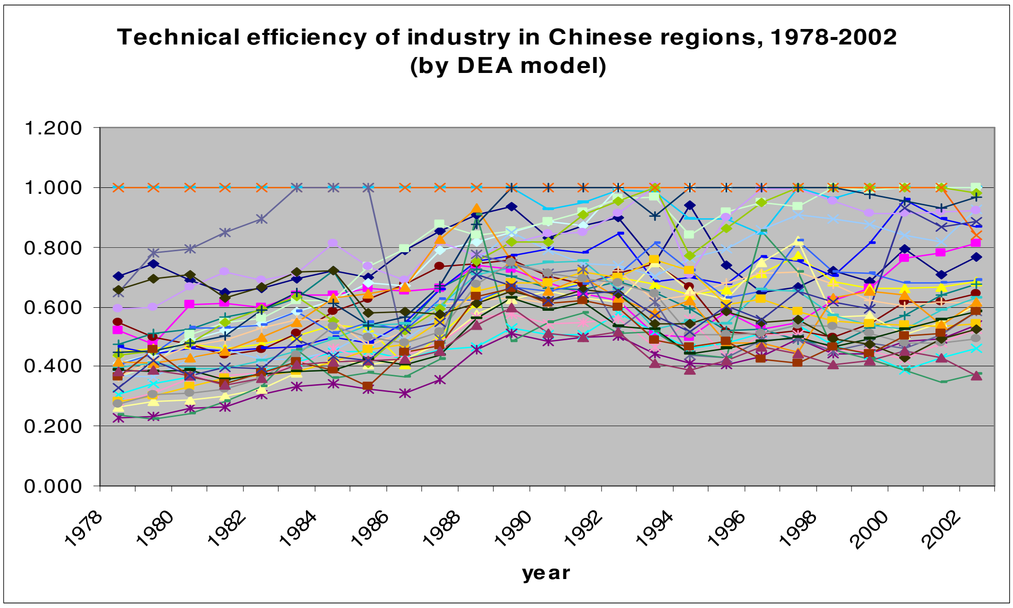
$$\text{subject to} \quad \begin{aligned} & x_{it} - X_t\lambda \geq 0 \\ & -\phi y_{it} + Y_t\lambda \geq 0 \\ & \lambda \geq 0 \end{aligned} \qquad (4)$$

where, *X* is the input (k*n) vector, Y is the output (m*n) vector, and $\lambda = (\lambda_1, \lambda_2, ..., \lambda_n)^T$. Equation (4) shows a distance function for production point (x_{it}, y_{it}) at technology t. To get the geometric Malmquist TFP index from time t+1 to t, both (x_{it}, y_{it}) and (x_{it+1}, y_{it+1}) will be calculated at technologies at both time periods t and t+1. Therefore, there will be 3 parallel linear programmes. (see also in Coelli, 1996, p.27; Färe et al., 1994, p.75). Using the DEA program introduced by Coelli (1996), we have estimated technical efficiency in industry in 31 Chinese regions. This is reproduced in Figure 6 and Table 4:

[4] See Färe et al. (1994) for more comparisons between MPI and other index approaches.

[5] There has been some criticism on further decomposition of dividing into the technical efficiency change into pure technical efficiency change and scale efficiency change. Namely, first step of their decomposition (on technology progress and change of technology efficiency) is taken under the assumption of constant return to scale (CRS), however, on the second step, the technical efficiency is decomposed in the condition of various return to scale (VRS). In our paper, to avoid this inconsistency, we assume only constant return to scale, and don't take into consideration of the scale efficiency change.

Figure 6:



Technical efficiency of industry in Chinese regions, 1978-2002
(by DEA model)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
year

Table 4: Regional efficiency scores, 1978-2002

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Beijing	0.703	0.742	0.690	0.648	0.663	0.695	0.721	0.699	0.791	0.855	0.906	0.933	0.833	0.873	0.899	0.747	0.938	0.740	0.648	0.668	0.723	0.685	0.794	0.708	0.765
Tianjin	0.522	0.475	0.606	0.610	0.598	0.638	0.637	0.662	0.651	0.662	0.737	0.727	0.679	0.643	0.622	0.505	0.497	0.583	0.525	0.546	0.622	0.661	0.762	0.780	0.811
Hebei	0.445	0.459	0.473	0.462	0.475	0.504	0.538	0.529	0.408	0.506	0.612	0.666	0.653	0.684	0.697	0.674	0.639	0.658	0.713	0.771	0.683	0.664	0.662	0.666	0.684
Shanxi	0.305	0.341	0.364	0.342	0.385	0.415	0.449	0.452	0.424	0.455	0.467	0.528	0.508	0.505	0.578	0.518	0.459	0.481	0.510	0.540	0.468	0.437	0.389	0.429	0.460
Inner Mongol	0.230	0.233	0.262	0.263	0.305	0.334	0.341	0.326	0.308	0.357	0.454	0.509	0.485	0.498	0.504	0.442	0.412	0.407	0.433	0.493	0.443	0.444	0.482	0.494	0.537
Liaoning	0.546	0.499	0.476	0.438	0.454	0.512	0.586	0.625	0.675	0.733	0.742	0.758	0.700	0.675	0.710	0.745	0.667	0.517	0.505	0.519	0.496	0.545	0.616	0.618	0.643
Jilin	0.475	0.510	0.526	0.568	0.588	0.631	0.721	0.532	0.529	0.662	0.723	0.702	0.664	0.658	0.683	0.650	0.593	0.519	0.523	0.487	0.468	0.528	0.568	0.637	0.675
Heilongjiang	0.466	0.441	0.462	0.451	0.460	0.464	0.498	0.479	0.547	0.657	0.751	0.771	0.793	0.781	0.842	0.684	0.698	0.676	0.765	0.754	0.702	0.811	0.960	0.895	0.867
Shanghai	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.924	0.949	0.990	0.985	0.896	0.894	0.846	1.000	0.963	1.000	1.000	1.000	1.000
Jiangsu	0.410	0.442	0.486	0.520	0.541	0.585	0.622	0.679	0.669	0.787	0.818	0.848	0.884	0.870	0.997	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.997	0.999	0.999
Zhejiang	0.367	0.408	0.505	0.549	0.561	0.618	0.621	0.736	0.794	0.878	0.840	0.852	0.887	0.918	0.962	0.967	0.840	0.916	0.947	0.934	0.999	0.992	0.999	0.999	0.999
Anhui	0.266	0.284	0.289	0.303	0.325	0.378	0.424	0.404	0.426	0.479	0.576	0.627	0.651	0.628	0.614	0.748	0.654	0.627	0.750	0.823	0.568	0.570	0.504	0.549	0.602
Fujian	0.368	0.363	0.425	0.458	0.426	0.426	0.450	0.514	0.487	0.569	0.756	0.848	0.788	0.743	0.741	0.702	0.761	0.794	0.857	0.908	0.897	0.878	0.840	0.819	0.925
Jiangxi	0.281	0.312	0.359	0.370	0.381	0.403	0.461	0.423	0.438	0.480	0.567	0.573	0.541	0.546	0.560	0.465	0.555	0.435	0.508	0.505	0.455	0.452	0.425	0.478	0.523
Shandong	0.591	0.598	0.667	0.716	0.689	0.711	0.813	0.734	0.687	0.818	0.770	0.812	0.843	0.849	0.913	1.002	0.708	0.897	0.994	0.994	0.953	0.914	0.914	0.916	0.920
Henan	0.363	0.420	0.471	0.489	0.530	0.556	0.555	0.468	0.513	0.606	0.623	0.630	0.611	0.619	0.719	0.621	0.641	0.679	0.711	0.715	0.678	0.621	0.601	0.617	0.612
Hubei	0.404	0.442	0.530	0.531	0.539	0.585	0.509	0.549	0.520	0.626	0.622	0.667	0.654	0.677	0.708	0.810	0.719	0.631	0.653	0.820	0.718	0.712	0.681	0.682	0.687
Hunan	0.395	0.410	0.391	0.392	0.418	0.454	0.492	0.537	0.541	0.600	0.708	0.729	0.749	0.753	0.659	0.525	0.553	0.544	0.655	0.655	0.568	0.537	0.527	0.588	0.630
Guangdong	0.438	0.454	0.481	0.549	0.591	0.635	0.554	0.411	0.519	0.595	0.753	0.815	0.819	0.908	0.953	1.001	0.773	0.860	0.948	1.000	1.000	1.000	1.000	1.000	0.983
Guangxi	0.284	0.303	0.334	0.359	0.370	0.384	0.415	0.458	0.476	0.553	0.653	0.680	0.682	0.715	0.698	0.758	0.721	0.606	0.625	0.586	0.553	0.542	0.539	0.536	0.543
Hainan	0.414	0.412	0.429	0.450	0.498	0.547	0.630	0.641	0.668	0.826	0.929	0.753	0.652	0.699	0.630	0.578	0.622	0.479	0.478	0.449	0.630	0.651	0.639	0.541	0.615
Chongqing	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.841
Sichuan	0.646	0.781	0.796	0.851	0.895	1.001	1.001	1.001	0.450	0.492	0.775	0.745	0.712	0.726	0.524	0.615	0.436	0.430	0.487	0.495	0.450	0.480	0.462	0.507	0.583
Guizhou	0.275	0.305	0.312	0.326	0.363	0.440	0.532	0.495	0.478	0.516	0.677	0.746	0.711	0.695	0.680	0.646	0.507	0.508	0.513	0.539	0.535	0.512	0.481	0.477	0.494
Yunnan	0.446	0.453	0.480	0.500	0.589	0.648	0.612	0.541	0.564	0.672	0.877	0.999	0.999	0.999	0.999	0.905	0.999	0.999	0.999	0.999	0.999	0.975	0.955	0.931	0.968
Tibet	0.238	0.224	0.241	0.285	0.332	0.456	0.359	0.380	0.366	0.424	0.908	0.486	0.546	0.578	0.510	0.515	0.441	0.430	0.853	0.718	0.455	0.423	0.386	0.348	0.373
Shaanxi	0.387	0.384	0.387	0.357	0.372	0.385	0.389	0.423	0.407	0.439	0.559	0.629	0.588	0.617	0.535	0.524	0.441	0.460	0.482	0.497	0.463	0.495	0.526	0.555	0.585
Gansu	0.659	0.693	0.709	0.630	0.668	0.714	0.720	0.577	0.586	0.577	0.612	0.654	0.619	0.658	0.643	0.545	0.543	0.582	0.546	0.558	0.493	0.476	0.431	0.494	0.525
Qinghai	0.365	0.456	0.364	0.342	0.378	0.414	0.386	0.335	0.448	0.469	0.634	0.662	0.612	0.620	0.597	0.486	0.465	0.483	0.427	0.412	0.466	0.442	0.501	0.511	0.585
Ningxia	0.383	0.390	0.368	0.340	0.359	0.404	0.416	0.419	0.422	0.451	0.537	0.596	0.510	0.498	0.518	0.412	0.389	0.422	0.465	0.442	0.406	0.419	0.452	0.429	0.368
Xinjiang	0.327	0.418	0.370	0.396	0.391	0.492	0.432	0.418	0.527	0.548	0.705	0.671	0.620	0.642	0.654	0.572	0.515	0.602	0.558	0.654	0.618	0.594	0.932	0.866	0.886
Standard dev	0.190	0.191	0.189	0.189	0.184	0.181	0.183	0.183	0.166	0.169	0.144	0.138	0.140	0.143	0.165	0.189	0.184	0.190	0.195	0.203	0.209	0.208	0.220	0.206	0.194
mean	0.443	0.464	0.483	0.490	0.510	0.550	0.565	0.551	0.546	0.608	0.701	0.711	0.689	0.699	0.703	0.673	0.633	0.627	0.660	0.677	0.646	0.646	0.664	0.665	0.684
CV	0.428	0.412	0.391	0.385	0.360	0.329	0.325	0.332	0.304	0.277	0.206	0.193	0.203	0.204	0.235	0.280	0.290	0.304	0.296	0.300	0.324	0.322	0.332	0.310	0.283

Shanghai and Chongqing are always at the efficiency frontier throughout 1978-2002.[6] Zhejiang, Jiangsu, Guangdong also are near the top ranks at a later stage.

Figure 7 presents the coefficient of variant of the regional efficiency scores. Again the long convergence trend is clearly visible. Efficiency scores converge till 1990, diverge quite substantially till 2001 and the converge again.

Figure 7:

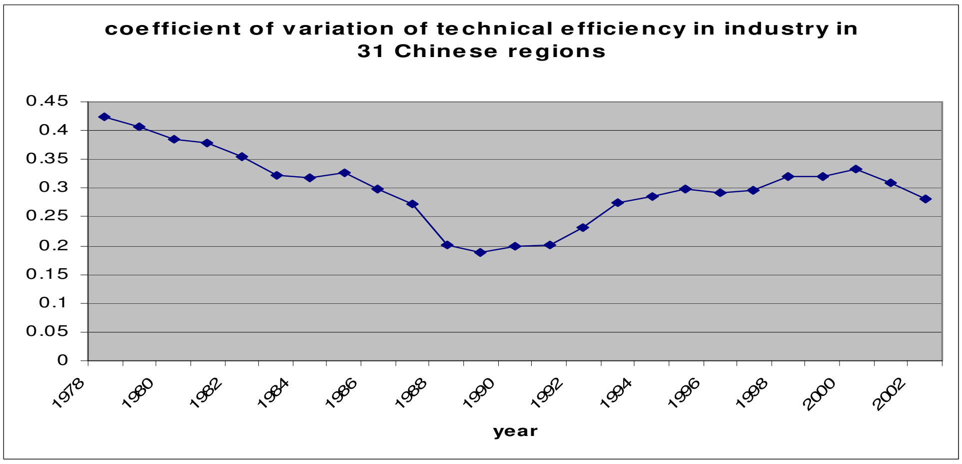
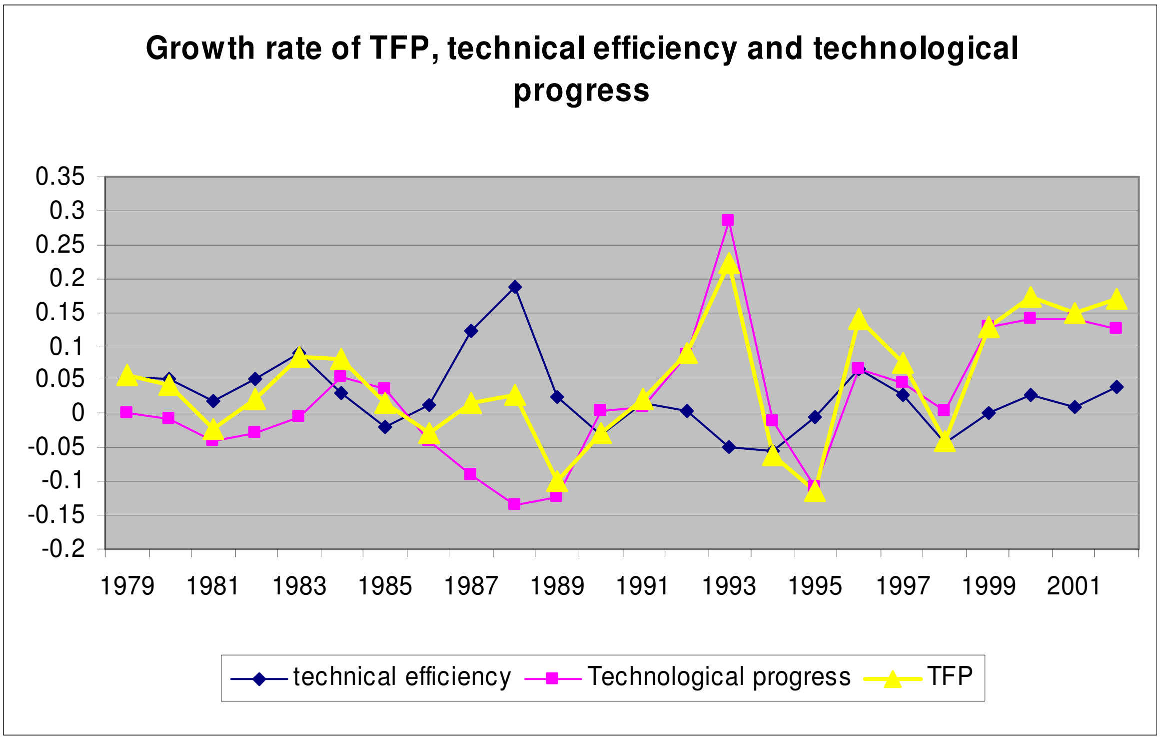


Figure 8:



[6] Chongqing figures should be treated with caution. Many assumptions had to be made to estimate the capital stock. Before 1997, the Chongqing data were included in Sichuan. The level of capital and labour input and the level of labour productivity are very low.

Figure 8 plots the average growth rates of TFP, technical efficiency and technological progress in industry in 31 Chinese regions. In the earlier years, changes in technical efficiency contribute much more to the TFP growth than technological progress. This is reversed after 1991, when technological progress is far more important than changes in technical efficiency (with the exception of one year 1996).

Summary and Conclusions

This paper combines two strands of work. One strand is the construction of regional datasets, which are consistent with aggregate national figures. In the annex to this paper, we have discussed the methods we used to construct regional capital stock figures, which have been used in the main body of the paper. The second strand of work has to do with regional productivity trends and the analysis of regional convergence and divergence. We have analysed a wide range of indicators including GDP per capita, labour productivity and comparative efficiency scores, using a variety of techniques.

According to public perceptions of the Chinese growth experience, China is characterised by increasing regional inequality. This was also our initial working hypothesis, when we embarked on this research project. The empirical results point in the opposite direction. There is no long-run divergence trend between Chinese regions since 1978. On the contrary, there has been substantial regional convergence from 1978 to around 1990. This has been followed by a period of modest divergence up till around 2001. After 2001, convergence trends resumed. Whatever indicator was used, the degree of regional inequality was substantially lower than at the beginning of the reform period.

An analysis of the relative importance of technological change and efficiency provides an interesting interpretation of the Chinese reform experience. In the early stages of the Chinese reform process efficiency changes predominate. Once efficiency differentials between regions have been reduced in the process of efficiency convergence, technological change at the frontier becomes more important as a driver of growth in Chinese industry.

Annex A: Estimation of Regional Capital Inputs in Chinese Industry

A. 1: Introduction

As an important part of the production process, the capital input is normally very difficult to estimate. The main reason for this is that, otherwise than labour inputs, fixed assets are "produced" inputs that can be used repeatedly or continuously in production processes. Varying service lives and the decline of the productive capabilities of fixed assets over time make it almost impossible to measure the aggregate capital stock exactly.

For China, things are further complicated by the fact that fixed assets acquired in different years are normally valued at their acquisition prices and book values. According to SNA, the capital cost in the production process, should "reflect underlying resource costs and relative demands at the time the production takes place. It should therefore be calculated using the actual or estimated prices and rentals of fixed assets prevailing at the time and not at the times the goods were originally acquired." (Paragraph 6.180, SNA, 1993). Capital inputs are measured by the volume of capital services, which represent the productive contributions the stock of capital stock, rather than by the value or price of the past investments.

Partly due to the difficulty of directly observing capital services, the *productive capital stock* and the *wealth capital stock* are often confused in practice. As primary inputs into the production process, capital services are something other than capital stocks in field of income, wealth and business accounts. To use the wealth capital stock (either gross or net) in production analysis is theoretically wrong, because capital service, like labour input, is a flow rather than a stock. In some literature, the term productive capital stock is used to denote capital services. To avoid the confusing word "stock", however, we prefer to use the term *volume indices of capital service* (as explained in OECD, 2001a, p.21, 84; see also Triplett, 1996, 1997,

As fixed assets age, the decline in their productive capability is represented by their age-efficiency profiles. The decline in the market value of assets can be explained by their age-price profiles. The age-efficiency profile is used in estimates of capital services in productivity analysis, The age-price profile is relevant to the measurement of the net capital stock and consumption of fixed capital. (OECD, 2001a, p.15; OECD, 2001b, p.53; Hulten and Wykoff, 1996, p.13).

Due to lack of sufficient published data on fixed assets and a measurement system that deviates from the SNA, it is difficult to make satisfactory capital estimates in China. Some attempts at measurement are constrained by an inappropriate conceptual framework. Most of those studies simply use the wealth capital account derived from information about gross fixed assets and economic depreciation. (Chow, 1993; Chen et al. 1988; Holz, 2006).

Our estimates of capital inputs into Chinese manufacturing will be based on the production and productivity analysis in Jorgenson's work, in line with the framework of 1993 SNA, and complementary literature on the difference between productive capital stock and wealth capital stock (Triplett, 1996, 1997; Hulten ,1990; Hulten and Wykoff, 1996). For depreciation we will use a hyperbolic pattern, in accordance with OECD (2001a, p. 86).

A. 2 Measurement of Capital Stocks in China: Basic Concepts:

Measuring capital stocks in China is even more difficult than in other countries, as the National Bureau of Statistics (NBS) in China uses a framework which deviates from the SNA, and because even the published statistics are not consistent in various years.

Basic concepts and variables with regard to fixed assets in China:
The commonly used variables related to capital estimates are as follows:

- *Total Investment in Fixed Assets (TIFA)*. TIFA includes the "volume of activities in construction[7] and purchases of fixed assets and related fees" (China Statistical Yearbook 2005). However, this term is broader than the formation of fixed assets in two ways. First, it includes "activities" that will never be transformed into fixed assets[8]. Next, besides productive fixed assets according to the SNA conception, TIFA also includes the non-productive part of investment in fixed assets, such as inventories and residential capital stock.

Prior to 1996, total investment in fixed assets had a coverage of 50 thousand yuan per year and above. However, except for the investment in real estate development, rural collective investment and individual investment, the coverage changed to 500 thousand yuan and above from 1997 onwards. The data for 1996 are published for the two types of coverage. They show that the investment with the more limited coverage is only 0.26% lower than the investment with the more extend coverage of the earlier series. This is not a serious discrepancy (see, CSY 2005, Table 6-2).

- ***Newly Increased Fixed Assets (NIFA).*** NIFA is defined in the China Statistical Yearbooks as "the newly increased value of fixed assets, constructed or purchased, that have been transferred to the investors". This concept is narrower than TIFA because investment activities that are not transformed into fixed assets are deducted. Hence NIFA is an useful concept according to the SNA framework. NIFA Since 1981, NIFA is published in the statistical yearbooks of fixed assets investment in China. Note that NIFA still includes the non-productive part of investment in fixed assets**.**

-The Rate of Projects of Fixed Assets Completed and Put into Operation. This concept refers to the ratio of the newly increased fixed assets to the total investment made in the same period" (China Statistical Yearbook 2005, p.252). This ratio seems to be a complementary variable for "*Total investment in fixed assets*". However, in practice, it is not such a useful concept as it is based on incomparable data. The realization of fixed assets in the current year resulting from the investment undertaken some years ago is compared with the total investment in the current year. Given that it might take quite some years for an investment to result in fixed assets, it may be misleading to apply this ratio to estimate the newly increased fixed assets (NIFA) from total current investment (TIFA).

- *The Original Value of Fixed Assets (OFA).* OFA represents the fixed assets valued at their historical purchasing prices. Hence, the OFA of total fixed assets is an cumulated value of assets purchased in different years at different prices. Using historic valuation results in an asset stock valued at a mixture of prices. Therefore, the OFA data published in statistical yearbooks cannot be used directly to estimate capital stocks, They can be used to derive annual investment figures as has been done by Chen et al. (1988). (See the later part of this paper for a more detailed explanation of this method)

[7] The "construction" here used in Chinese yearbooks is not an appropriate word, which can be substituted by "creation".
[8] State-owned units normally have a higher rate than the average of total economy that some part of TIFA will not be turned into fixed assets (DSIFA, 2002, p.77).

- *The Net Value of Fixed Assets (NFA)*. NFA is the value of OFA minus cumulative depreciation.

$$NFA_t = OFA_t - \sum_{i=0}^{t} depreciation_i$$

The difference between OFA and NFA is equal to depreciation. Unfortunately, Chinese statistical yearbooks do not provide any information about the depreciation rates used to derive the depreciation figures. Furthermore, the use of depreciation rather than decay implies wealth accounting, rather than production analysis

- *Accumulation of Fixed Assets.* *Accumulation of fixed assets* refers to "the value of the increased fixed assets (including the value of major repairs) in a certain period minus the values of basic depreciation and major repair fund of the fixed assets". This concept is found in the older statistical series prior to 1993, based on the material product system)**.** One way of calculating it is by deducting the net value of fixed assets (NFA) at the beginning of the accounting period from the net value of fixed assets (NFA) at the end of the accounting period. The other way is to subtract the values of basic depreciation and major repairs of fixed assets from the value of the newly increased fixed assets (NIFA) (i.e. the actual investment in fixed assets minus the costs that do not increase the value of fixed assets). (DSIFA, 1997, p.451). accumulation of fixed assets is also a wealth accounting concept.

A. 3 Discussion of Chinese capital estimates in the literature

(1) *Depreciation versus decay*. Most of the literature on capital deals with capital estimation from the wealth point of view instead of from the point of view of production analysis. However, estimates based on these two angles can be different (OECD 2001a).

In SNA *depreciation* normally equals the consumption of fixed capital, which denotes "the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage." (SNA1993 Glossary). In the SNA framework, the same term *depreciation*[9] is also used to refer to the decay of the productive capacity of fixed assets in the production process. This provides an indication of the quantity of productive capital services, rather than a figure in the balance sheets in the business sector.

Based on the concepts of 1993 SNA, Triplett (1997), Hulten and Wykoff (1996) make a distinction between the concept of "productive capital stock" used in productivity analysis and the concept of "wealth capital stock" used in wealth accounting (OECD, 2001b, p.53).

The index of capital services is the appropriate capital input in TFP measurement. If data on capital services are lacking, we can use the index of stocks of productive fixed assets as a proxy for the index of capital services.

Some of the literature on Chinese capital estimates (Holz, 2006; Chow, 1993; Jefferson and Rawski, 2000; Wang and Yao, 2003; Hsueh and Li, 1999) uses wealth accounting capital stock concepts and apply them in TFP analysis, for which they are is not really appropriate. Huang et al. (2002) are

[9] In order to avoid confusion, in this paper we will consistently use decay in the context capital service and productivity analysis, and depreciation in the wealth accounting field.

among the few researchers who give explicit consideration to difference between depreciation and efficiency decline of fixed assets.

Age-efficiency and age/price profiles are related, but not identical. Besides the physical factors influencing productive capabilities, obsolescence is an important factor in age-price profiles. Obsolescence does not affect the amount of capital services provide by fixed assets in the production process. For instance, the introduction of a newly invented (similar) fixed asset will reduce the value of the existing fixed asset considerably. However, the capital service of the existing asset will remain unchanged. The market value of fixed assets might decline greatly in the first years of use, while the productive capability might decline much less in the initial period. Using depreciation figures directly from published yearbooks implicitly denotes a choice for the wealth accounting concept. In practice however, depreciation is often used to measure decay.

(2) Choice of investment concepts

- *TIFA versus NIFA*

The published investment figures in Chinese official reports or yearbooks are usually the total investment in fixed assets (TIFA)[10]. For instance, Hsueh and Li (1999), Wang and Yao (2003), Huang, Ren and Liu (2002) use TIFA to construct the gross capital stock, which would overestimate the final size of the capital stock. We argue in favour of NIFA as the more appropriate concept.

- *Accumulation of fixed assets versus NIFA*

The accumulation data consist of fixed assets and circulating funds. The accumulation of fixed assets is the part needed for estimating the capital stock (see Chow, 1993, p. 816-817). In principle, the productive part of accumulation in fixed assets is equal to the productive part of investment in newly increased fixed assets (NIFA) minus depreciation.[11] Chow (1993) uses the accumulation of fixed assets variable to derive a series for newly increased fixed assets.

Holz (2006, p. 143) states that the published data on accumulation of fixed assets used by Chow (1993) seem to have a zero depreciation rate. To check whether this is indeed the case we put together a table comparing AFA and NIFA for years in which both figures are available.

Annex Table 2: Comparison of NIFA and accumulation of fixed assets

	Accumulation of Fixed Assets		NIFA		
	Total (1)	#Productive (2)	total (3)	#Productive (4)	[(4)-(2)]/(4)
1981	778	393	824.53	473.28	16.96%
1982	969	487	992.47	569.68	14.51%
1983	1125	586	1187.23	681.47	14.01%
1984	1453	829	1490.96	855.81	3.13%
1985	1883	1156	1950.03	1119.32	-3.28%
1986	2196	1350	2633.52	1767.09	23.60%
1987	2718	1690	3100.73	2080.59	18.77%
1988	3360	2012	3808.64	2555.60	21.27%
1989	2835	1701	3758.43	2521.91	32.55%

[10] As mentioned in the former section, TIFA is not the real investment in fixed assets. Not all investment is transformed into productive assets, which is better denoted by the term NIFA.

[11] As we are interest in the annual net invesrt figures, there is no objection to using the depreciation figures here.

1990	3008	1685	3995.34	2680.87	37.15%
1991	3768	2176	4649.8	3110.72	30.05%

Note: at current prices, 100 million yuan.
Source: CISFA, 1950-1995, p. 10; CSY1992, P.40; and CSY1993, p.43.

According to the concepts discussed in CISFA1950-1995 (page 451), the difference between NIFA and the accumulation of fixed assets should be equal to basic depreciation and the major repair fund in fixed assets in that year. The difference between column 4 and column 2 provides a rough estimate of depreciation. The comparison of total productive accumulation (col.2) and productive NIFA(col.4) shows that the depreciation as a percentage of fixed assets is greater in later years than in earlier ones.

(3) Neglect of Scrap value

The scrap value is the value of an asset discarded at the end of its service life. Some researchers neglect it because they think the scrap value is a rather small proportion of the total capital stock. Disregarding scrap values also simplies the capital calculations. In Chen et al. (1988, p. 244), the original value of fixed assets at year t is stated as previous year's original value of fixed assets plus the newly increased fixed assets[12] in the current year. Therefore, they estimate newly increased fixed assets in each year by IN(t)= OFA(t) - OFA(t-1).[13] This equation disregards scrapping. The same problem can be seen in the publications of Jefferson et al. (1992, p.261, equation A4;1996, p.174; 2000). They obtain investment through deducting the original value of fixed assets (OFA) in year *t*-1 from OFA of year *t*, disregarding scrap values. As it is assumed to be small and also to simplify capital calculations the scrap value is often neglected (e.g. Chen et al. 1988 and Jefferson et al. 2000).

In theory, the difference of original value of fixed asset in two continuous years, is equal to the NIFA minus the scrap value in that year, i.e. $OFA_{t-1} – OFA_t = NIFA_t - Scrap_t$ We can get scrap value for each year by the following equation $Scrap_t = NIFA –(OFA_t - OFA_{t-1})$

Holz (2006, p. 148) includes the scrap value in the equation IN(t)= OFA(t)- OFA(t-1), as follows OFA(t)- OFA(t-1) = IN(t) – scrap value(t). He criticises Chen et al. (1988) for disregarding scrap values. We would argue that Holz overestimates the significance of the scrap value in his criticism of Chen.

If our purpose is to construct the gross capital stock, rather than to derive *investment*[14]*,* the scrap value is estimated first. Then it has to be deducted from investment before deriving the gross capital stock, as follows:

Disregarding price deflation, the gross capital stock, can be estimated by

$$K_t^G = OFA_0 + \sum_{i=1}^{t} (IN_i - scrap_i)$$

[12] Chen et al. (1988) use "newly-commissioned fixed assets" which equals NIFA.

[13] Chen et al. (1988), write that KFO(t)=KFO(t-1)+I(t). In order to keep those concepts consistent with others in this paper, we rewrite this equation using OFA and IN instead of KFO and I respectively.

[14] Investment used here is NIFA, which is different from the aforementioned TIFA (gross investment). In the equations of subsequent parts of this paper, NIFA will be also denoted as IN.

where K_t^G is gross capital stock at time t; OFA_0 is the initial gross capital stock, which is approximated as the original value of fixed asset in 1952; IN_i is (real) investment at time i.
If a price index is involved, the investment should be deflated at year-i prices, while scrap value should be deflated to a price T (service life of fixed assets) years earlier than i. Then we have

$$K_t^G = OFA_0 + \sum_{i=1}^{t} (\frac{IN_i}{p_i} - \frac{scrap_i}{p_{i-T}})$$

Given that investment can be estimated from OFA and the scrap value.

$$IN_t - scrap_t = OFA_t - OFA_{t-1}$$

If there is no price deflator influence, we shouldn't make an adjustment for the scrap value at all in constructing the gross capital stock, not because scrap value is very small, but it is already incorporated when using OFA to estimate investment.

$$K_t^G = OFA_0 + \sum_{i=1}^{t} (IN_i - scrap_i) = OFA_0 + \sum_{i=1}^{t} ((OFA_t - OFA_{t-1} + scrap_t) - scrap_t)$$

Combining with price deflation, we have (see also Holz, 2006, p.151)

$$K_t^G = OFA_0 + \sum_{i=1}^{t} (\frac{OFA_i - OFA_{i-1}}{p_i} + scrap(\frac{1}{p_i} - \frac{1}{p_{i-T}}))$$

The last item on the right hand of above equation shows the effect from price index. It is a T-year lagged price influence on the scrap value.

For instance, we use the price index of 2004 and 1991 $\frac{1}{p_i} - \frac{1}{p_{i-T}}$=1/1.9677-1= -0.4918 .

This means that neglect of the scrap value only leaves out only half of the scrap value. Therefore, the neglect of the scrap value by Chen et al (1988). is not such a big problem as suggested by Holz. The scrap value is only around 3-5% of OFA $_{t-1}$ It is not necessary to make adjustments for such a modest figure in the approximate estimation of capital services.

Another point worth making is that the scrap value is more important in the calculation of the gross capital stock than the net capital stock or the capital service. For instance, if one uses gross capital stock (e.g. Holz, 2006), the scrap value will be the original price of a fixed asset, which is normally not negligible. However, if we use net capital stock or capital service series, after deducting for the decay of a fixed asset, the residual part will be very small at the end of its service life. Thus the scrap value will not make all that much difference.

(4) Gross or net fixed assets?

Besides the confusion between productive capital service and wealth capital stock, there is a controversy about the use of gross or net fixed asset concepts. This has to do with the choice of the decay pattern of fixed assets. The gross capital concept assumes that there is no decay of productive capacity during the life time of an asset.

Holz (2006) argues that net fixed assets should not be used as the capital stock in the production function. Instead, he argues in favour of measuring fixed assets at the original purchasing value of all fixed assets. He says "...the appropriate fixed asset measure is a count of the fixed assets used during the production period. ... Even a machine that is completely written off is included in the account 'original value of fixed assets', at its purchasing prices, as long as it is still in use; as long as the machine is still in use, it is likely to potentially operate at the same capacity as at its purchasing data." (Holz, 2006, p.144-145). Thus, Holz opts for the one-hoss-shay pattern where there is no productivity decline during the life time of an asset.

We disagree with this statement for two reasons. Admittedly there are certain types of assets that may "contribute as much to production as a new machine of the same quality" as in the case of the computer example (p.144). However, most of other assets truly deteriorate and age over time during the production process. Therefore, the applicability of the one-hoss-shay efficiency pattern (assets contribute fully as new ones as long as they are still in use) is limited to very few fixed assets. OECD (2001b, p.62) shows that using the gross capital stock in productivity analysis generally results in over-estimation of the volume of capital services.

Next, Holz seems to confuse wealth depreciation with productive decay. It is correct that sometimes a machine is written off by a certain depreciation method in the "balance sheet" while it might be still in use in the production. This judgment is mainly based on the understanding of business account concept of depreciation. Note that the meaning of *depreciation* in business accounts - "allocating the costs of past expenditures on fixed assets over subsequent accounting periods" - is different from the one used in SNA, which refers to the decay of capital services, as discussed in the first part of this paper.

(5) Non-productive fixed investment

We need to distinguish between investment in non-productive assets and investment in productive fixed assets. The non-productive part of fixed assets includes the residential housing stock, but it includes more than this. According to most China statistical yearbooks, the non-productive part of fixed assets is 30% of all assets in the total economy, while the residential part is only a little more than 10% of all assets. If we only exclude investment in residential capital stock from the total investment in fixed assets, this will result in overestimation of the productive capital stock.

However in some literature, the productive fixed assets are derived by deducting only the residential housing stock. Chen et al. (1988) use housing ratios to derive the productive part of the capital stock, which seems incomplete[15].In reality, the non-productive part of capital stock includes a variety of other non-productive assets along with the residential housing stock. Holz includes non-productive fixed assets in the total capital stock in his "economy-wide output" analysis. (Holz, 2006, p.145) .

(6) Types of investment included

Since 1986, total investment in fixed assets (TIFA) consists of four types, *basic construction*, *technical renovation* (also called technical updates and transformation in recent yearbooks), *real estate development* and *others.*[16] However, the data on newly increased fixed assets in published sources are available mostly only for two of the categories: basic construction and technical renovation. The real estate development category is usually neglected by researchers. Chen et al. (1988) and Huang et al. (2002) distinguish only three categories: basic construction, technical renovation and miscellaneous.

[15] The non-productive ratio in industry might be smaller than that in the total economy, considering the big proportion of real estate development in total economy, however, it is inappropriate to take housing ratio as non-productive part. In other words, the non-productive ratio of total TIFA is more than 30%, because industry doesn't have so much real estate development as in total economy, the non-productive ratio should be lower than the ratio from total economy. Thus it might be between 10%-30%.

[16] Before 1980, the category of *others* was included in the *technical renovation* category. Figures on *Real estate development* are available from 1986 onwards. Before that year they were included in basic construction.

(7) No breakdown of investment in fixed assets into different types.
Different types of fixed assets are not homogenous. For reasons of simplicity, most studies, only consider one aggregate result. Although it is almost impossible to distinguish all different categories of fixed assets, the use of an aggregated capital series may produce rather big errors because of the various price deflators for different types of fixed assets and the different lifetimes of different kinds of assets.

Chen et al. (1988) decompose newly increased fixed assets into four types: non-residential construction, equipment, housing and others The structural ratio used for industry is from the national proportion They used proportions from the total economy to break down industrial investment into these four categories of fixed assets within industry. They consider housing as non-productive investment. But as we have argued above, the notion of non-productive assets is broader than that of housing.

(8) Revaluation problems.
After 1993, many fixed assets have been revalued. As a result, the original value of fixed assets is a mix of assets valued at their historical acquisition prices and revalued assets. Therefore the published data on the original value of fixed assets and cumulative depreciation have to be used with caution. (for a good discussion see Holz, 2006, p.145 and 148). Chen et al (1988) present a very good method to estimate newly increased fixed assets (which is called as investment in their paper)., However, this method cannot be directly used from the 1990s onward because of revaluation of fixed assets in the enterprises.

A.4 The Structure of Total Investment (TIFA) and Newly Increased Fixed Assets (NIFA)

A. 4.1 Categories of TIFA

Total investment (TIFA) in fixed assets includes four types[17] of investment: 1) investment in basic construction[18], which refers to "the new construction projects or extension projects and the related work of the enterprises, institutions or administrative units mainly for the purpose of expanding production capacity or improving project efficiency covering only projects each with a total investment of 500,000 RMB yuan and over".[19] 2) investment in technical renovation[20], which refers to "the renewal of fixed assets and technological innovation of the original facilities by the enterprises and institutions as well as the corresponding supplementary projects and the related work (excluding major overhaul and maintenance projects) covering only projects each with a total

[17] To avoid confusion, we use the term 'types of investment' to refer to to the breakdown in basic construction, renovation, real estate and other investment. We will use the term 'content of investment' to distinguish fixed structures, machinery and equipment and other investment. For instance Chen et al,(1988) distinguish 3 types of investment and four content categories.
[18] Basic construction is also called as *capital construction* in some yearbooks.
[19] The definitions for these four categories are from CSY, 2000. The coverage was 50,000 RMB yuan prior to 1996, the same rule applies also to coverage in other categories.
[20] It is also referred to as *innovation* which is not the most appropriate term, or in some publications as *technical updates and transformation*.

investment of 500,000 RMB yuan and over". 3) investment in real estate development[21], which includes the investment by the real estate development companies, commercial buildings construction companies and other real estate development units of various types of ownership in the construction of house buildings, such as residential buildings, factory buildings, warehouses, hotels, guesthouses, holiday villages, office buildings, and the complementary service facilities and land development projects, such as roads, water supply, water drainage, power supply, heating, telecommunications, land leveling and other projects of infrastructure. It excludes the activities in simple land transactions. 4) *other investment* in fixed assets[22].

Before 1980, the third and fourth types of investment were included in the first two. Real estate development is available since 1986, other investment since 1983. The complete four groups are available since 1986. Between 1980 and 1986, we can a residual category of real estate plus other by deducting basic construction and technical renovation from the total. In figure 1, real estate development and other are combined for the whole period 1980-2003, so as to assess long-term trends.

The share of basic construction in TIFA is decreasing slightly in the period 1981-2001, while the share of other investment is increasing.

---

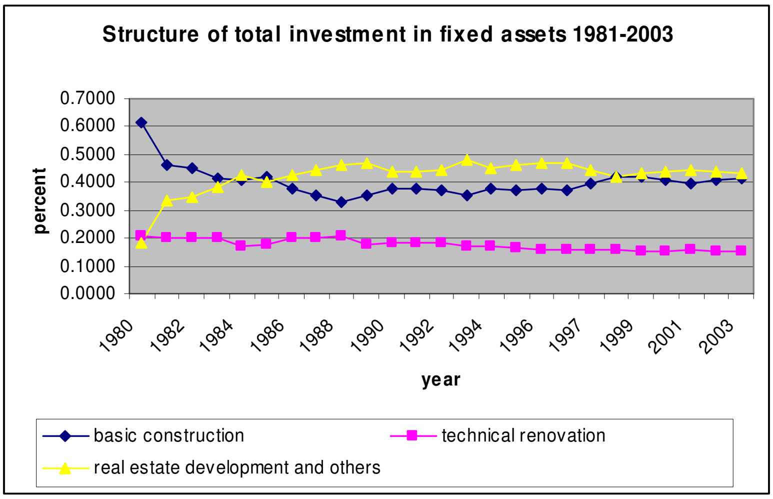
[21] Investment in real estate development refers to the investment by the real estate development companies, commercial buildings construction companies and other real estate development units of various types of ownership in the construction of house buildings, such as residential buildings, factory buildings, warehouses, hotels, guesthouses, holiday villages, office buildings, and the complementary service facilities and land development projects, such as roads, water supply, water drainage, power supply, heating, telecommunications, land leveling and other projects of infrastructure. It excludes the activities in pure land transactions. (from CSY 2005). Unfortunately, investment inreal estate development and basic construction are not mutually exclusive. Some investment in non-residential fixed structures is also included in basic construction.

22 According to China Statistical Yearbook 2000, this category includes: A) The following projects of the state-owned units with the total planned (or actually needed) investment of 500,000 yuan and over, which are not included in the plan of capital construction and the plan of innovation: (1) projects of oil fields maintenance and exploitation with the oil fields maintenance funds and petroleum development funds; (2) opening and extending projects with the maintenance funds in coal, ore and other mining enterprises and logging enterprises; (3) project of reconstruction of the original highways and bridges with the highway maintenance funds in the department of communication; (4) projects of construction of warehouses with the funds of simple construction in the commercial department.

B) The investment in fixed assets by urban collective units: refer to projects of construction and purchases of fixed assets with the planned total investment of 500,000 yuan and over by all collective units in cities and county towns and in townships which are approved by the State Council or provincial governments, excluding investment by collective units under township enterprise administration offices.

C) The projects of construction and purchases of fixed assets by the enterprises, institutions or individuals other than those mentioned above with total investment of 500,000 yuan and over, which are not included in the plan of capital construction and the plan of innovation.

Annex figure 1



Real estate development is a special investment category in China, which emerged from early 1980s onwards. Investment in housing (including residential housing, offices, factories and warehouses) is included in the investment in fixed assets. Before 1980s, housing investment is included in the basic construction category, which was carried out by normal production companies or organizations. In the process of enterprises reform (*zhufang zhidu gaige*), housing construction investment is transferred to the real estate companies.

The investment in *real estate development* mainly consists of four parts as published in Chinese Statistical Yearbooks in recently years: residential buildings, office buildings, houses for business use, and others. The productive part of real estate development (investment in office buildings and houses for business) is rather small, as showed in the table below.

Annex Table 3:
Breakdown of investment in real estate development

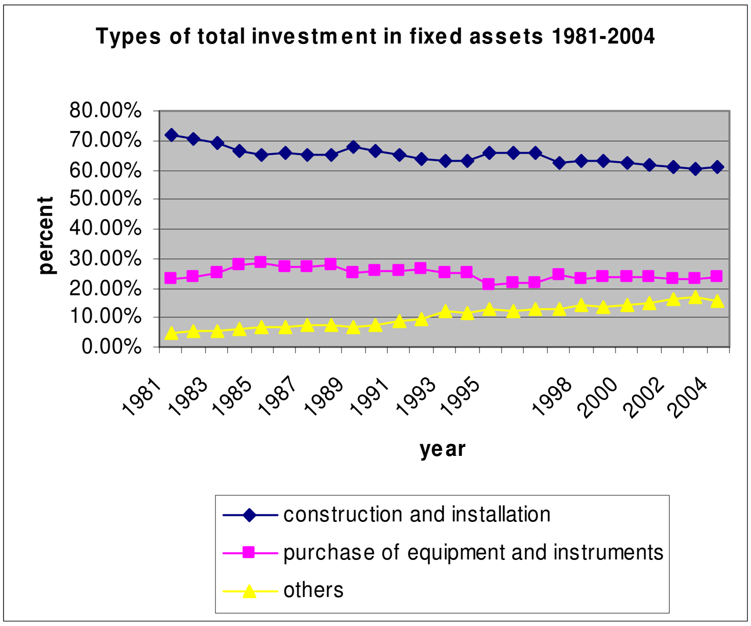
	Total investment	Percentage shares of				#Productive Investment (%)
		residential buildings	office buildings	houses for business	other use	
1997	**3178.37**	0.484	0.122	0.134	0.259	0.256
1998	**3614.23**	0.576	0.120	0.132	0.172	0.252
1999	**4103.20**	0.643	0.083	0.118	0.156	0.201
2000	**4984.05**	0.665	0.060	0.116	0.159	0.176
2001	**6344.11**	0.665	0.049	0.119	0.168	0.168
2002	**7790.92**	0.671	0.049	0.120	0.160	0.169
2003	**10153.80**	0.667	0.050	0.128	0.154	0.178

The officially published data for basic construction and technical renovation for the total economy between 1953 and 1980 (CSY, 2002, Table 6-6; CSY, 2004, Table 6-6 & DSIFA, 1997, p.20, p.71) are actually only from the state-owned units. This means that the investment data are incomplete. They exclude investment by other types of firms, such as e.g. collective owned enterprises.

A. 4.2 Content of investment

By content, all categories of total investment (TIFA) can be classified into three categories: 1) construction and installation (i.e. fixed structures) [23], 2) purchase of equipment and instrument 9i.e. machinery and equipment [24], and 3)other investment. The share of construction and installation part in TIFA decreased by more than 10 percentage points from 1981 to 2004.

Annex Figure 2



The share of construction and installation primarily decreased in the technical renovation category, while it did not show much change in the basic construction category.

In table 4, these three types of investment have been crosstabulated with the four investment categories.

[23] *Construction* here represents various houses, buildings and foundations etc. It is a different term from the somewhat misleading term *basic construction* used in section 4.1. According to CSY, 2000, construction refers to the construction of various houses and buildings and installation of various kinds of equipment and instruments, including construction of various houses, equipment foundations and industrial kilns and stoves, preparation works for project construction, and clearing up works post project construction, pavement of railways and roads, drilling of mines and putting up of oil pipes, construction of projects of water conservancy, construction of underground air-raid shelters and construction of other special projects, installation of various machinery equipment, testing operation for pre-testing the quality of installation projects. It is the Chinese equivalent of the investment in fixed structures. The value of equipment installed is not included in the value of installation projects. Equipment belongs to the second expenditure type.

24 refers to the total value of equipment, tools, and vessels purchased or self-produced which come up to standards for fixed assets. Equipment, tools and vessels purchased or self-produced for new workshops by newly established or expanded units are categorized as ”purchase of equipment and instruments” no matter whether they come up to the standards for fixed assets or not. (from CSY, 2002).

Annex Table 4:

		Type of investment			
		Basic construction	Technical renovation	Real estate development	Other
Content of investment	Construction and installation	Yes	Yes	Yes	Yes
	Purchase of equipment and instrument	Yes	Yes	No	Yes
	Other expenses	Yes	Yes	No	Yes

In the published yearbooks, there only two of the content categories - basic construction and technical renovation – are broken down by type of investment. We assume that real estate development can be totally classified as construction and installation, since it involves only housing or office construction. There is no direct information on the breakdown of fourth content category, *other*. In order to arrive at a more complete picture of the breakdown of the different content categories by type of activity, we have put together the following table.

Assuming that the residuals in each category refer to the content category other investment, we can derive the breakdown of the category ‘other’ by type of investment from table 5. In table 5, column XIV represents the sum of those three residuals. The figures in this column exactly equal the published data for the fourth content category, *other investment* (from CSY,2004, Table 6-6). Hence, this method, provides us with a breakdown of the content category *other investment* by type of investment (columns V, IX and VIII)

Annex Table 5: Content of investment by type of investment

	Construction and installation					Purchase of Equipment and machinery				Other investment				sum of 3 residuals
	Total	from BC	from TR	total RE	residual 1	Total	from BC	from TR	residual 2	Total	from BC	from TR	residual 3	
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)	(XIII)	(XIV)
1978		300.85					165.78				34.36			
1979														
1980		381.07	74.21				136.53	59.65			41.29	3.52		
1981	689.83					223.64				47.54				
1982	871.12					291.41				67.87				
1983	993.32					358.31				78.43				
1984	1217.58					509.23				106.06				
1985	1655.46	726.71	196.23		732.52	718.08	217.39	224.94	275.75	169.65	130.27	27.97	11.41	1019.68
1986	2059.66	770.6	267.8	100.96	920.30	851.95	260.34	308.58	283.03	208.99	145.17	42.83	20.99	1224.32
1987	2475.65	856.76	349.18	149.88	1119.83	1038.78	325.19	353.29	360.30	277.26	161.15	56.11	60.00	1540.13
1988	3099.66	1010.15	477.76	257.23	1354.52	1305.37	372.61	430.87	501.89	348.77	191.55	71.92	85.30	1941.71
1989	2994.59	998.73	377.25	272.65	1345.96	1115.31	380.94	355.89	378.48	300.00	172.07	55.64	72.29	1796.73
1990	3008.72	1045.37	372.91	253.25	1337.19	1165.54	453.76	397.36	314.42	342.74	204.69	59.92	78.13	1729.74
1991	3647.68	1308.83	426.33	336.16	1576.36	1460.19	521.22	513.35	425.62	486.63	285.76	83.54	117.33	2119.31
1992	5163.37	1889.39	620.64	731.2	1922.14	2125.14	667.34	715.34	742.46	791.58	455.92	125.12	210.54	2875.14
1993	8201.21	3018.74	945.27	1937.51	2299.69	3315.92	899.55	1070.93	1345.44	1555.18	697.22	179.65	678.31	4323.44
1994	10786.52	4123.89	1258.72	2554.08	2849.83	4328.26	1402.84	1419.79	1505.63	1928.08	910.01	240.09	777.98	5133.44
1995	13173.33	4641.13	1343.62	3149.02	4039.56	4262.46	1635.04	1682.2	945.22	2583.48	1127.44	273.53	1182.51	6167.29
1996	15153.41	5345.27	1396.77	3216.4	5194.97	4940.79	1861.15	1900.5	1179.14	2879.83	1404.42	325.47	1149.94	7524.05
1997	15614.03	6215.22	1540.77	3178.37	4679.67	6044.84	2060.6	2033.74	1950.50	3282.25	1641.2	347.43	1293.62	7923.79
1998	17874.53	7695.75	1681.38	3614.23	4883.17	6528.53	2101.83	2445.24	1981.46	4003.10	2118.84	390.13	1494.13	8358.76
1999	18795.93	8543.598	1667.61	4103.2	4481.52	7053.04	2132.297	2465.7	2455.04	4005.74	1779.389	351.767	1874.58	8811.14
2000	20536.26	8936.811	1943.25	4984.05	4672.15	7785.62	2457.876	2776.41	2551.33	4595.85	2032.586	387.93	2175.33	9398.81
2001	22954.90	10154.63	2206.06	6344.11	4250.10	8833.80	2473.293	3297.88	3062.62	5424.80	2192.176	419.82	2812.80	10125.53
2002	26578.90	11865.82	2598.03	7790.92	4324.13	9884.50	2780.18	3635.32	3469.00	7036.60	3020.623	517.193	3498.78	11291.91
2003	33447.20	15426.44	3420.13	10153.8	4446.83	12681.90	3495.777	4460.51	4725.62	9437.50	3986.383	744.223	4706.89	13879.34
2004														

Note: BC: basic construction, TR: Technological Renovation, RE Real Estate Development: 100 mill yuan at current prices. (V)=(I)-(II)-(III)-(IV); (IX)=(VI)-(VII)-(VIII); (XIII)=(X)-(XI)-(XII).
Source: DSIFA,2002, p.288; CSY,2005, p.186; CSY, 2004, Table 6-8 and Table 6-21.

Real estate development includes only one type of investment: construction and installation. For the other three categories, basic construction, technical renovation and others, the following figures represent the breakdown by type of investment *Basic construction* has the most detailed data in the published resources. The categories *technical renovation* and *others*, are only distinguished since since 1980s.

Annex Figure 3:
Content Proportions of Total Investment in Basic Construction, 1950-2003

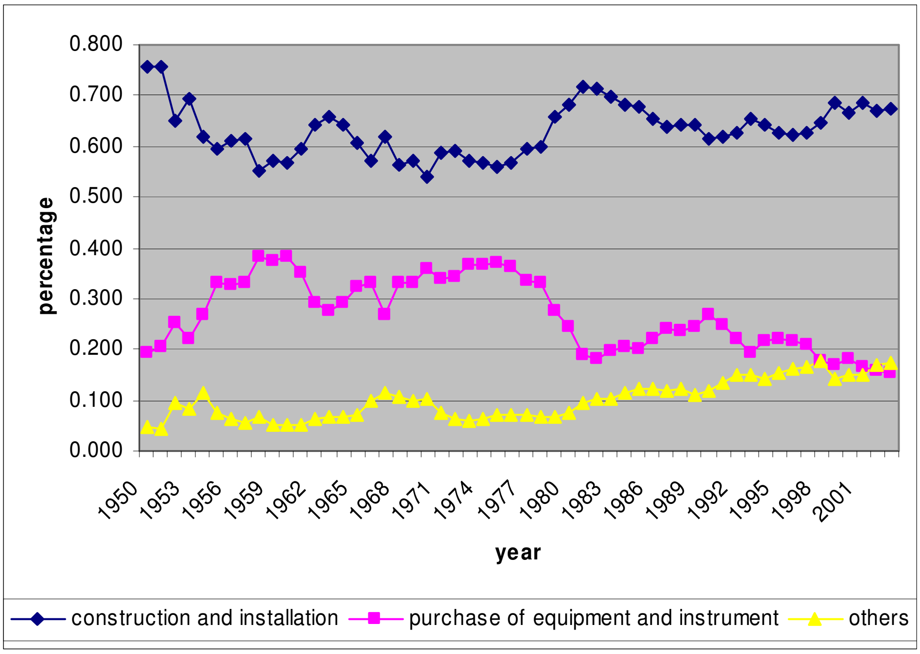


Figure 4 Content proportions of total investment in technical renovation, 1980-2003

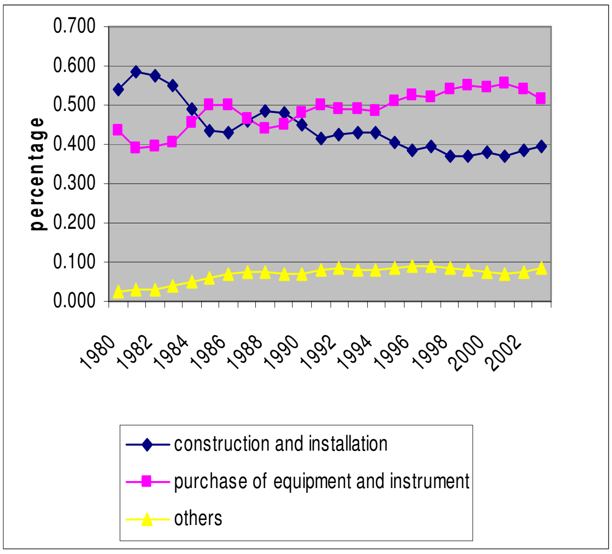
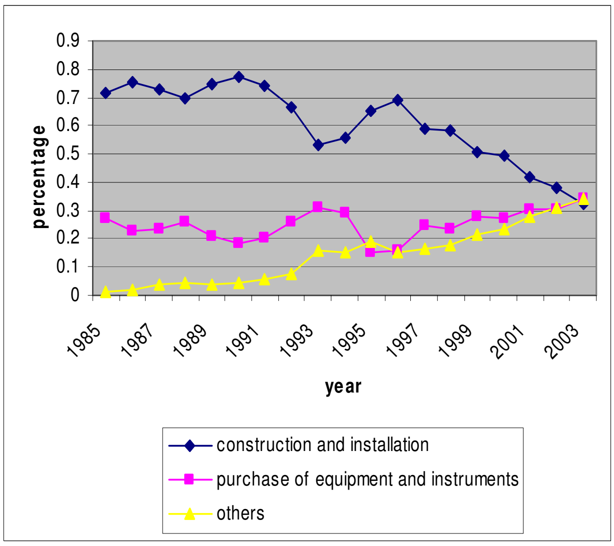


Figure 5 Content proportions in total investment in other, 1985-2003



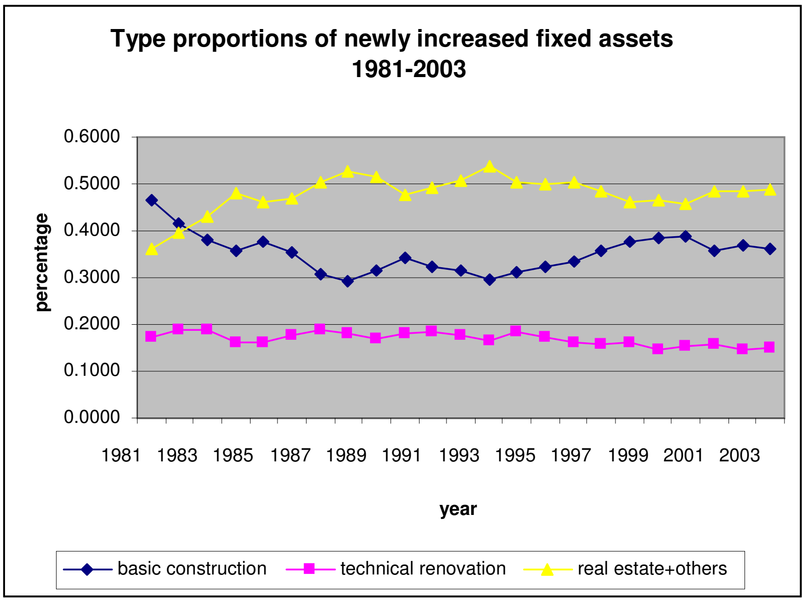
Adjusting for the changing coverage of TIFA

There is a problem with the coverage of the published statistics on TIFA. For the years 1952-1979, the available TIFA data for the total economy only refer to state-owned units (SOU. (e.g. DSIFA , 1997, p.25).Therefore we have to estimate the TIFA in the total economy by TIFA in SOU 1952-1979[25].

A. 4.3 Newly increased fixed assets:
As indicated in the section 2, total investment in fixed assets (TIFA) is not the real investment in the formation of capital stock. The more appropriate concept is newly increased fixed assets (NIFA). NIFA shares the same content classification as TIFA, i.e. basic construction, technical renovation, real estate development and others.

The classification of investment into basic construction and technical renovation only in Chen et al (1988, p.260 Table A2) is somewhat misleading. Figure 6 shows that real estate and others are a substantial proportion of total NIFA, though the productive part in of the real estate category may be small.

Annex Figure 6



A. 5 New estimates of capital service inputs in Chinese Industry

To estimate capital service in productivity analysis (equ.2), we need data on investment (or gross fixed capital formation), the service lives of fixed assets, decay coefficients, price indexes and retirement patterns are needed.[26]

A.5.1 The gross capital stock (in total economy, industry and manufacturing)
The gross capital stock is the value of fixed assets still in use after deduction of the scrap value. The gross capital stock cannot be substituted by the concept original fixed assets (OFA) published in Chinese yearbooks, because OFA includes all fixed assets (in use) valued at historic prices from

[25] First, according to the original value fixed assets in industry, we can get the ratio of non-SOU/SOU in industrial OFA (which we call ratio-a here). Then we calculate the growth rate of this ratio. Meanwhile, we have TIFA-SOU since 1952, but TIFA in total economy is available only from 1980. So we can calculate the ratio of non-SOU/SOU TIFA after 1980 (which we call ratio-b). Then we use the relationship of ratio-a and ratio-b, to create the earlier part of ratio-b during 1953-1980. (Averagely, ratio-b is 1.056 times of ratio-a). Thus we estimate the TIFA in the total economy during the period 1952-1979.

[26] When the scrap value is taken into account, the retirement pattern is also needed. As explained in section xx of this paper, the scrap value as percentage of investment is very low. We will disregard it..

various acquisition years. Though OFA does not provide an indication of the gross capital stock, it can be used to calculate the yearly increase in fixed assets. Subsequently we can estimate the gross capital stock from the accumulated NIFA and an initial capital stock.

A.5.1.1 *Newly increased fixed assets* (NIFA)
As explained above, newly increased fixed assets is a useful capital variable relatively consistent with SNA, except that NIFA includes some non-productive elements. The newly increased fixed assets in the total economy is available for the period 1981-present. The statistical yearbooks prior to 1986 provide data on two subcategories of NIFA: *basic construction* and *technical renovation* Given that the category of *real estate development* was include in basic construction before the1980s, NIFA prior to 1980 can be created from the NIFA-basic construction (NIFA-BC) However, as in the case of TIFA, the published NIFA data on basic construction only refer to the state-owned units. Thus we have to modify this NIFA-BC in SOU to a NIFA in SOU, and then, change it to the NIFA in total economy. We apply the ratio of TOTAL /SOU TIFA, to get the NIFA in the total economy.

Next, before getting a long term investment series, we have to solve another coverage problem. Prior to 1997, the published TIFA series include all investment of sums of 50 thousand yuan or more. After 1997, coverage changes to investment of 500 thousand yuan and above. In order to maintain consistency in coverage for the whole time series, we adjust the NIFA data before 1997 to a coverage of 500 thousand yuan and above. We opt for leaving the more recent data unchanged, since recent investment has a higher weight in PIM than investment of the earlier years.

A.5.1.2 Productive NIFA (P-NIFA)
To be consistent with SNA concepts, the non-productive productive part (e.g. residential housing and other non-productive investment) has to deducted from NIFA. In theory, there are two ways to derive the productive part of NIFA:

(1) NIFA data in four categories (*basic construction, technical renovation, real estate development* and *others*) are multiplied by the productive ratios in those four groups respectively, and then summed up the total data. This method provides detailed information on the value and productive ratios in different categories. For instance, the productive ratio in real estate development is very low, about 17%-26% during 1997-2003. However the ratio and NIFA value in *other* category is not available.

(2) The other method is to apply the ratio of productive to total investment for total NIFA to each of the four investment types. We use this method in our paper. Note that NIFA is only published since 1980.

A.5.1.3 Productive NIFA in industry (P-NIFA-Industry)
To create NIFA in industry, Chow et al. (1988) and Wu and Xu (2002) use original fixed assets (OFA) data from published yearbooks (Wu, p.16)

$$NIFA_t = OFA_t - OFA_{t-1}$$

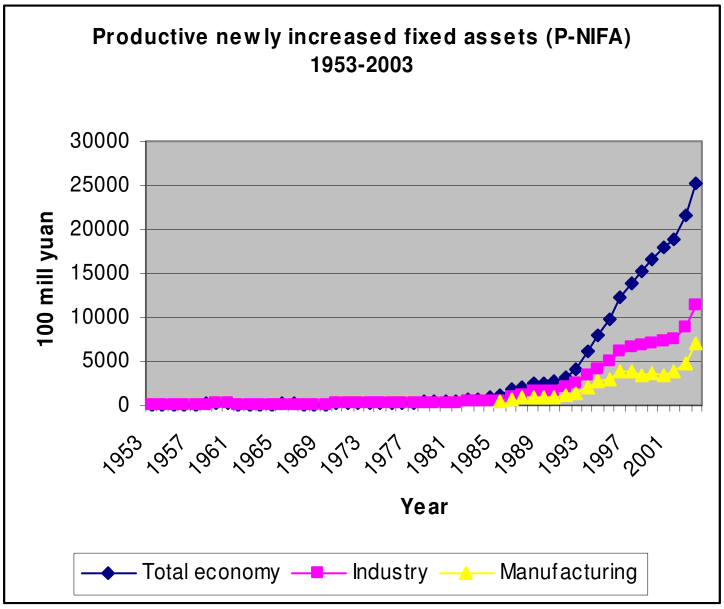
Using OFA to create NIFA, pioneered by Chen et al. (1988), solves a practical problem of the lack of direct data on industrial investment in fixed assets, though in theory, it ignores scrap value[27]. In estimating the productive (or efficient) NIFA, Chen et al. (1988) deduct the residential housing part from total NIFA. This is not an adequate solution because residential housing part is only one part of investment in non-productive fixed assets.

[27] As we have explained in early section that scrap value can be neglected estimating investment.

In our paper, after obtaining the productive NIFA in total economy, we use the ratio of capital investment in industry to capital investment in the total economy (investment in NIFA-basic construction and NIFA technical renovation. to derive an estimate of productive NIFA in the industrial sector for the period 1985-2003[28]. Comparing the P-NIFA-industry series with the series of NIFA derived by deducting OFA(t-1) from OFA(t) from our database, we can calculate the share of productive to total investment in fixed assets in industry. The average ratio for the whole period is 87.4%. This indicates that the use of an average ratio of residential to total fixed assets of 8.2% in Chen et al (1988) will result in an overestimation of the real productive NIFA in industry.

With the productive ratio and estimated NIFA-industry from OFA (1953-1984), we can get the P-NIFA in industry between 1953 and1984. For manufacturing, however, we can derive P-NIFA only from 1985 onwards.

Annex Figure 7
Productive newly increased fixed assets in total economy, industry and manufacturing



Note: at current prices. The coverage is 500 thousand yuan and above.
Source:

A.5.2 Content categories of fixed assets and price indexes (investment deflators):

As explained above, we have three content categories of investment in fixed assets: construction and installation, purchase of equipment and instruments, and other expenses. However, as a main part of non-productive fixed assets, the residential housing part is included in the construction and installation. To apply the proportions of three types of fixed assets in TIFA to the productive NIFA, we have to deduct the residential housing part from construction and installation in TIFA. After this

[28] This method, using ratio in basic construction + technical renovation (NIFA-industry/NIFA-total), cannot be applied to get NIFA-industry from NIFA-total, because real estate development has a rather big share in NIFA total. However, this ratio can be used to get Productive-NIFA-industry from the productive-NIFA-total, given that the real estate development category mainly consists of non-productive housing investment that is excluded from P-NIFA.

deduction we can calculate the proportions of non-residential construction and installation; purchase of equipment and instrument, and other investment.[29]

Annex Table 6
Proportions of Investment Types of fixed assets in TIFA (%)
(Total economy)

	Non-residential construction and installation	Equipment and machinery	Others
1981	0.592	0.336	0.071
1982	0.589	0.334	0.078
1983	0.569	0.353	0.077
1984	0.550	0.372	0.078
1985	0.533	0.378	0.089
1986	0.547	0.364	0.089
1987	0.538	0.365	0.097
1988	0.536	0.366	0.098
1989	0.560	0.347	0.093
1990	0.550	0.348	0.102
1991	0.534	0.350	0.116
1992	0.542	0.334	0.124
1993	0.529	0.320	0.150
1994	0.527	0.327	0.146
1995	0.552	0.279	0.169
1996	0.523	0.309	0.168
1997	0.522	0.297	0.182
1998	0.515	0.309	0.176
1999	0.511	0.307	0.181
2000	0.504	0.307	0.189
2001	0.497	0.294	0.209
2002	0.485	0.295	0.220
2003	0.492	0.303	0.205
2004	0.523	0.309	0.168

Note: Proportions are calculated after the deduction of residential housing from TIFA. The residential housing construction data are only available from 1981-2000, we apply the average residential ratio in TIFA (1997-2000) to 2001-2004.
Resource: From Statistics on Investment in Fixed Assets of China, 1950-2000, p.30, and China Statistical Yearbooks, p.186.

Price indices play also an important role in measuring the value of fixed assets at constant prices, given that NIFA is available at acquisition price. We apply specific price indexes for each of the three categories: construction and installation, purchase of equipment and machinery, and others for the period 1992-2004. Due to the lack of specific deflator for these types of investment expenditure, we have to use the aggregate price index for fixed assets for the period 1953-1991.

A.5.3 Initial capital stock

To assess the initial level of the capital stock (e.g. year 1952 in our paper), PIM requires the use of a long time series of investment preceding the initial year. However, when sufficiently long time series are unavailable, we need to estimate the initial capital stock by proxy methods.(e.g. Huang

[29] As we know, the non-productive part includes and *residential housing* and *others*. It would be perfect if we can also distinguish the *others* (e.g. infrastructure) from these three types of fixed assets. Considering it is very difficult to draw out the other non-productive part, since it is involved in all three types without any indications from published resources, and it is a rather small part compared with residential housing, we assume the *other* non-productive part share the same type structure with productive part.

and Ren (2002). Timmer (1999) has estimated initial capital stocks by applying the average of incremental value added-output ratios in the initial years to total value added in the initial year. Osada (1994) has used incremental capital-output ratios for t his purpose (ICORs) (Osada, 1994). The assumption underlying these procedures is that the capital output ratio is sufficiently stable, so that incremental capital output ratios approximate the capital output ratios.

Another method is to estimated the initial capital stock is to use the average growth rate of investment and the depreciation rate (Reinsdorf and Cover, 2005). Namely the initial capital stock can be expressed as

$$V_0 = IN_0 \cdot \frac{g+1}{g+d}$$

where g is the average growth rate of investment before the initial year, and d is the constant geometric rate of depreciation.

Chow and Li (2002) use a capital stock series "with an initial stock of 221.3 billion yuan at the end of 1952" reaching 1411.2 billion yuan at the end of 1978. Wang and Yao (2003) create a capital stock series by assuming 175 billion yuan (at 1952 prices) capital stock in 1952 and using a 5% depreciation rate. Chen et al (1988) have a 14.88 billion initial capital stock in industry in 1952. Jefferson , Rawski and Zheng (1992) get a series of deflated net value of productive fixed assets in 1980 is 228.59 billion yuan (at 1980 price) in industry.

Applying the ICVAR method, averaging the ICVARS for 1952 to 1957, we find a capital stock in 1952 of 843.23 million yuan (at 1952 prices) in the total economy and a capital stock of 198.68 million yuan (at 1952 prices) in industry. Due to the lack of data in manufacturing in the early years, we construct capital stock series for manufacturing from 1986 onwards, with an initial capital stock at 4078 million yuan (at 1952 prices).

A.5.4 Service life

Service lives are extremely difficult to estimate. (see Erumban, 2006). In 1985 the State Department of China issued the Regulation of fixed assets and depreciation in State-owned enterprises[30], which is so far the most informative available document on service lives of fixed assets. It offers service lives for three types of fixed assets: ordinary machinery, special purpose machinery and construction. The average service life is 16 years for machinery and equipment, and 30 years for construction. There is no information on the category of *others*, we assume 7 years for it.

On fixed assets in industry, there is a widely used document, Regulation of Industrial Enterprises[31], published by the Financial Department of China and valid since 1993. With the data from this resource, we get an average life time 14 years for equipment and machinery, and 27 years for construction in industrial fixed assets. These service lives are somewhat shorter than the ones for state-owned enterprises. There are two possible explanations for this difference. One is that the first estimates are for the total economy, while the second are for industry. Service lives may be somewhat shorter in industry. The second explanation may be that service lives of fixed assets are getting shorter as time progresses. The second regulation is from 1992 while the first one is from 1984. We prefer the second explanation to the first one, mainly because there are more product innovations in the market and the obsolescence rates are increasing especially in high-tech sectors such as in the areas of computer and internet (OECD, 2001a, p.50).

[30] http://www.86148.com/chinafa/shownews.asp?id=1247 issued on 26 April 1985.
[31] http://www.bjab.gov.cn/flfg/showsingle.asp?which=99 issued on 30 December 1992, and valid since 1993.

Summarising for the period 1952-1989, we assume a service life of 30 years for construction, 16 years for equipment and machinery, and 7 years for others. From 1990 onward, we use service lives of 27 years for construction, 14 years for equipment and machinery, and 6 years for others.

A.5.5 Efficiency patterns

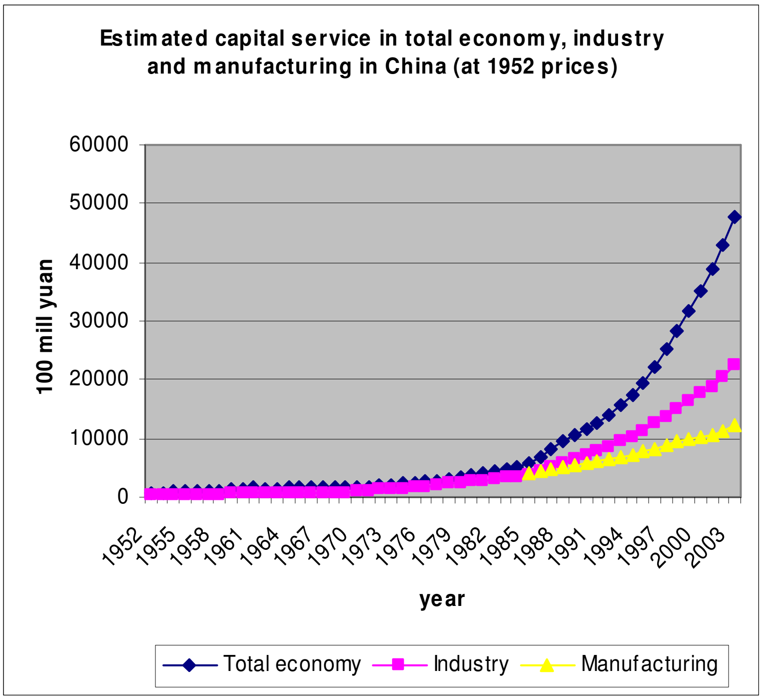
As explained in the early part of this paper, efficiency coefficients can be obtained either through assuming a certain pattern, or by means of tracking the relationships between age-efficiency and age-price profiles if rentals and economic depreciation rates are available. Admittedly, the former choice is a better one if there are no rental prices. In this paper, we apply hyperbolic decay functions proposed by BLS and ABE to derive the efficiency of fixed assets in Chinese total economy, industry and manufacturing. The hyperbolic age-efficiency function used by BLS and ABE is

$$\phi_s = (T - s)/(T - \beta s)$$

T is the service life of fixed asset, and s is the age of current fixed asset, and β is a parameter determining the hyperbolic shape, which takes 0.5 for equipment and 0.75 for structures.

A.5.6 Estimates of the Capital Stock in Industry at National Level

Annex Figure 8: Estimates of the capital stock, total economy, industry and manufacturing, 1952-2003 (at 1952 prices)



Annex Table 7: Productive NIFA and estimated productive capital stock

	Productive NIFA (at current prices)			Estimated productive stock (at 1952 prices)		
	Total Economy	Industry	Manufacturing	Total Economy	Industry	Manufacturing
1952				843.23	198.68	
1953	50.26	22.63		867.43	215.30	
1954	55.93	38.36		893.37	246.88	
1955	60.83	26.15		921.83	265.59	
1956	81.53	31.30		857.23	262.47	
1957	95.24	46.64		912.38	301.37	
1958	179.47	90.23		1050.05	385.47	
1959	219.31	122.83		1198.31	490.79	
1960	247.01	132.51		1349.78	597.63	
1961	100.32	70.35		1405.80	651.20	
1962	59.64	48.82		1406.57	677.38	
1963	76.97	30.86		1409.41	681.01	
1964	110.64	55.18		1432.06	702.61	
1965	164.11	80.81		1483.18	740.25	
1966	153.52	73.32		1500.72	761.93	
1967	81.33	49.17		1408.04	748.58	
1968	59.62	46.73		1411.25	763.78	
1969	112.12	62.24		1472.70	797.15	
1970	208.24	155.09		1630.10	928.82	
1971	196.07	144.45		1762.35	1041.16	
1972	200.71	198.07		1884.01	1199.69	
1973	266.27	211.66		2068.77	1367.90	
1974	262.41	158.75		2252.24	1479.48	
1975	314.07	219.86		2485.06	1649.18	
1976	256.51	215.76		2647.72	1808.66	
1977	328.99	252.11		2865.43	1986.66	
1978	426.00	316.80		3171.54	2223.77	
1979	512.47	284.37		3540.13	2408.11	
1980	531.06	287.86		3888.82	2577.02	
1981	472.05	324.91		4154.83	2769.78	
1982	568.20	366.14		4478.68	2976.26	
1983	679.70	412.08		4880.24	3205.18	
1984	853.59	450.35		5377.76	3436.36	
1985	1116.41	561.29	350.49	5998.60	3708.92	4078.00
1986	1762.51	987.30	685.27	7006.94	4257.63	4450.29
1987	2075.19	1241.01	799.83	8167.49	4945.75	4852.15
1988	2548.97	1545.89	1009.56	9414.86	5692.92	5285.87
1989	2515.37	1521.78	886.25	10481.62	6331.08	5038.04
1990	2673.92	1665.10	968.82	11526.36	6984.20	5292.59
1991	3102.65	1949.69	1166.95	12625.96	7684.87	5550.46
1992	4173.32	2414.39	1444.18	13923.63	8427.53	5785.04
1993	6191.31	3304.21	2113.47	15435.00	9196.51	5968.36
1994	7948.13	4155.70	2641.27	17225.75	10080.75	6510.51
1995	9689.84	4917.67	3025.86	19302.84	11069.14	7065.49
1996	12334.39	6175.27	3866.35	21811.42	12232.95	7726.70
1997	13852.79	6540.39	3772.03	24738.37	13502.12	8317.15
1998	15138.93	6757.67	3466.76	27876.46	14763.66	8723.56
1999	16480.21	6971.54	3574.19	31216.08	16008.96	9022.82
2000	17957.43	7319.64	3320.63	34774.64	17261.40	9060.13
2001	18855.68	7513.00	3881.73	38426.29	18495.34	9698.09
2002	21611.51	8793.31	4775.20	42586.55	19962.93	10501.95
2003	25242.71	11314.43	7028.38	47410.23	21997.95	11872.08
2004						

Note: 100 million yuan.

Resource:
1) P-NIFA in total economy is from DSIFA, 1997, p62; DSIFA, 2002, p77; and productive ratio in DSIFA, 1997, p.98
2) P-NIFA in industry (1953-1984) is from the (CIESY04-p.25, CIESY95-p.53) after applying (calculated) industry productive ratio; the P-NIFA in industry (1985-2003) is from the P-NIFA-total with using the ratio (of industry/total) in NIFA in basic construction and technical renovation. (CSY04-6-27, & 6-28). (CSY04, 6-14& 6-15）
3) P-NIFA in manufacturing is from the P-NIFA-total wit using the ratio (of manufacturing/total) in NIFA in basic construction and technical renovation (CSY04-6-27, & 6-28). (CSY04, 6-14& 6-15）

A. 5. 6 Regional Capital Estimates in Industry

The steps laid out above have been replicated for each of the 31 Chinese regions, using regional investment data from DSIFA supplemented by investment data from regional statistical yearbooks. We have assumed that the national proportions discussed in detail above, apply to all Chinese regions. In subsequent of this research, we will try to develop regional proportions for each region using the regional information from the regional yearbooks.

The results are reproduced in Annex table 8, which is serves as input for our productivity analysis in the main body of this paper.

Annex Table 8: Estimated productive capital stock in industry by regions

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total	2212	2397	2566	2760	2967	3197	3429	3702	4252	4942	5691	6331	6984	7685	8428	9197	10081	11069	12233	13502	14764	16009	17261	18495	19963	21998
北京	83.3	92.9	103.5	113.4	121.9	132.3	145.1	161.1	191.5	230.7	270.4	302.1	335.1	364	393.9	425.8	511.6	526.2	565	591.5	620.6	652.1	681	722.5	720.6	727.8
天津	52.4	60.6	67	75.5	84.3	94.4	103	113.5	131.8	150.4	168	184.6	199.8	221.9	242.4	255	274.7	325.5	359.4	382.2	418.2	458.4	481.8	514.5	545.7	580.3
河北	106.6	118.5	128.7	138.2	148.3	159.7	169	178.1	198.2	223.7	253.8	279.5	304.9	329.5	359.4	388.5	419.9	475	543.3	604.4	666.3	765.5	835.8	917.7	967.1	1063.2
山西	72.4	78.4	83.9	88.9	95.3	103.8	115.9	129.1	151.9	174.8	195	215.2	236.5	259	277.6	292.6	305	326.2	343.1	379.8	414.4	427.5	465	495.3	609.2	666.1
内蒙古	35.7	42.1	46.3	50	54.9	62.2	69.5	76.6	86.8	97.6	108.6	119.5	131.8	147.3	166.2	186.2	202.6	240.3	255.3	265.4	290.9	332.5	330.4	337.8	383.3	481.1
辽宁	143.6	152.4	163.8	178.6	191.5	204	218	236.1	278	333	392.2	444.4	489.7	538.4	585	634.5	682.1	743.1	815.8	888.6	960.6	981.4	1033.3	1082.3	1127.1	1208.4
吉林	58.6	63.8	67.9	73	78.5	83.7	88.1	93.5	104.9	120	138.2	151.1	163.3	177.2	192.4	210	226	244.4	309.3	350.7	392	417.7	451.4	489.3	529.1	579.4
黑龙江	103.5	111.2	121.1	134.2	146.1	160.8	172	182.3	206.7	236.3	266.1	291.6	315.8	338.6	359.7	377	395.1	425.7	453.4	504.6	565.5	609.1	656.4	716.7	774.3	844.6
上海	66.3	75.2	86.8	103	122.1	142	162.4	183.1	224.2	278.4	340.7	393.6	443.9	491.6	534.4	594.1	676.4	739.7	830.1	926.3	1003.6	1209.8	1302.7	1336.4	1337.5	1396
江苏	65.7	74.9	84.2	93.3	103.5	115.3	127.5	142.9	174.8	217.1	262.2	295.7	326.2	361	404.2	445.7	484.7	560.9	635.2	702	791.9	887	989.1	1095.8	1219.2	1394.7
浙江	35	39.3	44.1	49.7	56.2	62.3	68.9	76.8	93.4	113.1	133.7	152.4	170.5	189.6	212.3	238.9	269.4	305.1	346.9	413.1	465.8	519.7	575.6	687.2	820.1	905.9
安徽	59.1	63.4	67.5	71.9	77.2	83.1	89.3	96.7	113.7	131.1	148.3	163.4	178.4	193.9	211.9	226.7	242.4	271.9	326	374.1	389	416.9	459.4	485.8	514.4	559.6
福建	30.6	33.9	37.3	41.5	45.9	50.7	56	63.6	76.7	93.4	109.3	123.4	138.4	154.5	172	192.5	216.1	234	253.8	295	334.7	375.4	418.1	454.6	501.3	537.9
江西	40.8	43.5	46.4	49.4	53.4	58.6	64.1	68.4	77.7	87.7	98.5	108.7	119.7	131	142.5	154.4	167	184.1	195.7	224.1	235.9	244.5	260	267.9	282.6	327.6
山东	95.2	105.2	115.3	125	136.5	148.7	159.9	173.2	203.2	242.8	292.3	329.2	366.6	407.3	453	495.6	539.4	607.2	674.8	783.7	870.1	965.2	1095.4	1220.6	1385.4	1685.7
河南	95.9	103	108.4	116.9	124.8	133.1	141.7	150.9	169.3	190	216.3	238.5	258.9	285.5	311.2	337	369.9	428.2	497.5	587.7	652.8	698.8	733.3	800.8	881.8	974.2
湖北	136.4	145.7	153.7	162	169.3	176.7	183.2	190.8	208.4	231	256.1	272.1	291	310.1	334.3	360.9	395.3	422	512.7	576.4	656.4	709.2	756.4	802.1	855.1	1001.2
湖南	73.5	78.5	83	88.2	94.4	100.3	105.9	112.6	126.5	143.3	161.6	176.5	192.2	210.8	234.2	253.2	273.2	295.1	324.3	358.6	375.7	399.5	427.6	452.1	475	537.9
广东	90.6	98.5	106.3	120	138.2	157.4	181.3	214.1	270.1	328.8	397.5	454.7	521.4	592	678.6	770.5	883.3	965.4	1068.2	1143.5	1258.6	1333.3	1422.9	1484.2	1640.1	1752.5
广西	44.4	47.7	50.5	53.3	56.5	59.7	62.5	66.2	76.3	88.8	103.6	114.4	123.6	134.6	149.4	169.8	190	229.6	246	256.6	267.4	280.6	322.6	335.3	344.2	385.1
海南											5.4	13.8	22.9	31.6	42.3	57.7	74.2	89.6	102.1	111.3	115	116.9	118.7	116.5	114.8	119
重庆																				18	52	72.8	89.8	107.1	146.2	179
四川	161.2	169.3	176.3	184.2	191.9	202.2	210.9	223.8	250.6	286.9	324.6	360.4	397.2	437.7	477.2	512	547.3	602.3	640.9	683.7	766.2	807.8	842.6	869.1	901.6	973.1
贵州	53.9	56.1	58	61	62.5	64.5	66.7	69.4	75.3	82.1	89.6	96.7	104.2	111.9	119.7	125.5	131.2	145.9	163	173.1	181.1	212.6	241.4	261.9	281	304.6
云南	59.5	63.6	66.9	70.4	75.2	79.1	83.1	88	96.8	106.7	118.1	126.8	137.3	151	166.4	185.1	203.4	233.3	267.3	291.7	320.8	341.5	354.6	383	415.5	436.8
西藏	5.7	6.6	7	7.4	7.8	8.4	9.9	11.4	12.7	13.9	15.1	16.2	17.9	20.1	21.9	23.8	25.4	27.4	27.5	27.5	26.6	27.4	29.9	29.9	30.3	31.8
陕西	87.4	91.4	96.3	100.3	104.7	109.4	113.2	117.9	129.9	145.2	161.2	176.7	192.3	206.5	217.9	231.4	242.2	252.7	273.7	289	311.8	347.8	370	401.2	438.5	492.2
甘肃	66.4	69.4	71.1	73.3	75	77.7	80.5	83	90.4	100.6	111.7	120.4	130.6	140.3	148.6	152.8	157.2	164	178.2	203.2	217.9	240.9	265.3	291.1	308.2	351.8
青海	25.2	29.3	31.2	33.2	35.5	38	40.2	42.3	46.6	51.7	57	60.2	63.2	66.1	68.1	70.4	71.5	74.8	83.1	97.1	103.6	112	114.9	125	129.3	128.6
宁夏	17.2	18.6	19.4	20.2	20.9	22	23.2	24.8	28.9	33.7	37.2	40.3	44.2	48.4	52.1	54.6	57.2	59.7	63.6	75.8	80.9	83.5	92.6	107.7	117.5	132.9
新疆	42.7	48.6	54.5	60.4	66	72.1	77.6	83.4	92.7	103.3	116.2	128.5	145.6	163.7	186.8	209.3	229	268.5	295.1	337.3	370.8	397.9	461.4	506.5	545.5	600.8
Not classified	202.8	215.1	220.1	223.3	228.6	234.3	240	248.9	264.2	305.7	342.4	380.2	421.2	469.7	512	564.9	618.2	601.2	582.6	586.5	586.6	563.8	582	597.8	621.5	637.9

Note: at 100 mill yuan, 1952 constant price

References main text

Banister, J., (2005), ‘Manufacturing employment in China’, Monthly Labor Review, July, 2005, pp. 11, ff.

Barro, R.J. and X. Sala-i-Martin, (1991), Convergence across states and regions: Comments and Discussion'' , *Brookings Papers on Economic Activity*, Vol. 1, pp. 107-158.

Barro, R.J. and X. Sala-i-Martin, (1992), ‘Convergence, *The Journal of Political Economy*, Vol. 100, No.2: 223-251.

Barro, R.J. and X. Sala-i-Martin, (2004), *Economic Growth*, MIT.

Battese, G.E. and T.J. Coelli, (1992), ‘’Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India’, *The Journal of Productivity Analysis*, Vol. 3, pp. 153-169.

Battese, G.E. and T.J. Coelli, (1995), ‘A model for technical inefficiency effects in a stochastic frontier production function for panel data’, *Empirical Economics*, Vol. 20, pp. 325-332.

Bianchi, M. (1997), Testing for convergence: Evidence from non-parametric multimodality tests'' , *Journal of Applied Econometrics,* Vol. 12, No. 4, pp. 393-409.

Bulli, S. (2001), ‘Distribution dynamics and cross-country convergence: A new approach’, *Scottish Journal of Political Economy*, Vol. 48, No. 2, pp. 226-243.

Chen, J and B.M.Fleisher, (1996), ‘Regional income inequality and economic growth in China, *Journal of Comparative Economic*s, 22: 141-164.

Coelli, T.J. (1996), A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation, CEPA Working Papers, No. 7/96.

Coelli, T.J., D.S.P.Rao, C.J.O'Donnell, and G.E.Battese, (2005), *An Introduction to Efficiency and Productivity Analysis*, Second Edition, Springer Science+Business Media, Inc.

Dowrick, S. and D. Nguyen, (1989), ‘OECD comparative economic growth 1950-85: Catch-up and convergence’, The *American Economic Review*, Vol. 79, No. 5, pp. 1010-1030.

Fagerberg, J. and M. M. Godinho, ‘Innovation and Catching Up, in J. Fagerberg, D.C. Mowery, and R.R. Nelson’(eds), *The Oxford Handbook of Innovation*, Oxford, Oxford University Press, 2005, Chapter 19.

Färe, R., S. Grosskopf, M. Norris and Z. Zhang, (1994), Productivity growth, technical progress, and efficiency change in industrialized countries, The American Economic Review, Vol. 84, No. 1, pp. 66-83.

Farrell, M.J. (1957), The measurement of productivity efficiency, Journal of the Royal Statistical Society, Series A, Vol. 120, Part 3, pp. 253-282.

Jian., T, J.D. Sachs, and A. M. Warner, (1996), ‘Trends in regional inequality in China’, China *Economic Review*, Vol. 7, No. 1, pp. 1-21.

Kanbur, R. and Zhang, X. (2005)’, Fifty years of regional inequality in China: a journey through central planning, reform, and openness’, *Review of Development Economics*, 9 (1), 87-106.

Kumbhakar, S.C. and C.A.K.Lovell (2000), *Stochastic Frontier Analysis*, Cambridge University Press.

López-Bazo, E., Vayá, E., Mora, A.J. and J. Suriňach, (1999), ‘Regional economic dynamics and convergence in the European union’, *The Annals of Regional Science*, 33: 343-370.

Lucas, R.E. (1988), 'On the mechanics of economic development', *Journal of Monetary Economics*, Vol. 22, pp. 3-42.

Mankiw, N.G., D. Romer, and D.N. Weil, (1992), 'A contribution to the empirics of economic growth' , *The Quarterly Journal of Economics*, Vol. 17, No. 2, pp. 407-437.

Nishimizu, M. and J.M. Page, (1982), Total factor productivity growth, technological progress and technical efficiency change: Dimensions of productivity change in Yugoslavia, 1965-78, The Economic Journal, Vol. 92, No. 368, pp. 920-936.

Quah, D.T. (1996), 'Convergence empirics across economies with (some) capital mobility', *Journal of Economic Growth*, Vol. 1: 95-124.

Romer, P.M. (1986), 'Increasing returns and long-run growth', *The Journal of Political Economy*, Vol. 94, No. 5, pp. 1002-1037.

Szirmai, A and R. Ren, (2007), 'Measuring Labour Productivity in Chinese Manufacturing: Statistical Problems and Solutions', in D. Blades and B. Pant (eds), The National Accounts of the People's Republic of China, Problems, Recent Developments and the Way Forward, Asian Development Bank, 2007, forthcoming

Szirmai, A., R. Ren and M. Bai, (2005), 'Chinese manufacturing performance in comparative perspective, 1980-2002, Yale Economic Growth Center, Discussion Paper No. 920, July, 2005.

Szirmai, A., *The Dynamics of Socio-Economic Development*, Cambridge, Cambridge University Press, 2005.

Verspagen, B, (1991), 'A new empirical approach to catching up or falling behind', *Structural Change and Economic Dynamics*, vol. 2, no. 2, 1991.

Wu, Y. (2000), 'Is China's economic growth sustainable? A productivity analysis', *China Economic Review*, 11: 278-296.

Statistical Sources main text

Census 1985: National Bureau of Statistics, (1987-88), Office of Leading Group of the National Industrial Census under the State Council, Peoples Republic of China, *Industrial Census 1985*, Vol. I-X, China Statistics Press (in Chinese).

Census 1995: National Bureau of Statistics, Office of the Third Industrial Census (1997), Vol: *The Data of the Third National Industrial Census of the People's Republic of China in 1995*, China Statistics Press.

CIESY: National Bureau of Statistics, *Zhongguo Gongye Jingji Tongji Nianjian (Chinese Industrial Economy Statistics Yearbook*), various issues.

CLSY: National Bureau of Statistics, Zhongguo Laodong Tongji Nianjian (China Labour Statistical Yearbook), various issues.

CSY: National Bureau of Statistics, *China Statistical Yearbook*, Beijing: China Statistics Press, various issues.

Regional Statistical Yearbooks, various issues, various regions, 1980-2005.

References Annex A : Estimation of Regional Capital Inputs in Chinese Industry

(1) Chen, K., G.H. Jefferson, T.G. Rawski, H.Wang and Y.Zheng, (1988), New estimates of fixed investment and capital stock for Chinese state industry, The China Quarterly, 114: 243-266.

(2) Chow, G.C. (1993), Capital formation and economic growth in China, The Quarterly Journal of Economics, August:909-842.

(3) Chow, G.C. and K.Li (2002), China's economic growth: 1952-2010, Economic Development and Cultural Change, 51 (1): 247-256.

(4) Erumban, A.A., (2006), Lifetimes of machinery and equipment-Evidence from Dutch Manufacturing, Groningen Growth and Development Centre, GD-87.

(5) Holz, C.A. (2005). China's Economic Growth 1978-2025: What We Know Today about China's Economic Growth Tomorrow.

(6) Holz, C.A. (2006), New capital estimates for China, China Economic Review, 17: 142-185.

(7) Huang, Y, R. Ren and X. Liu (2002), Capital stock estimates in Chinese manufacturing by perpetual inventory approach, China Economic Quarterly, Vol. 1 (2): 377-396.

(8) Hulten, C.R. (1990), The measurement of capital, in Berndt, E.R. and J.E.Triplette, eds. Fifty Years of Economic Measurement: The Jubilee, NBER, Studies in Income and Wealth, No. 54, University of Chicago Press, 1991.

(9) Jefferson, GH., T.G. Rawski, and Y. Zheng, (1992), Growth, efficiency, and convergence in China's state and collective industry, Economic Development and Cultural change, Vol.40, No. 2, pp. 239-266.

(10) Jefferson, G.H., T.G. Rawski, and Y. Zheng, (1996), Chinese industrial productivity: Trends, measurement issues, and recent developments, Journal of Comparative Economics, Vol. 23, pp. 146-180.

(11) Jefferson, G.H, T.G. Rawski, L. Wang and Y.Zheng, (2000), Ownership, productivity change, and financial performance in Chinese Industry, Journal of Comparative Economics, 28: 786-813.

(12) Jorgenson, D.W. (1963), Capital theory and investment behavior, The American Economic Review, Vol. 53, No. 2, pp. 247-259.

(13) Jorgenson, D.W. (1973)...

(14) Jorgenson, D.W. (1990), Productivity and economic growth, in E.R.Berndt and J.E.Triplett, eds. Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth, The University of Chicago Press.

(15) Jorgenson, D.W. (1999), New methods for measuring capital, paper prepared for Canberra Group on Capital Stock Statistics, Washington DC, 8 to 10 November, 1999.

(16) OECD, (1993). Methods Used by OECD Countries to Measure Stocks of Fixed Capital, OECD, Paris OECD.

(17) OECD, (2001a), Measuring Capital-OECD Manual, Measurement of capital Capital stocks Stocks consumption Consumption of fixed Fixed capital Capital and capital Capital servicesServices.

(18) OECD, (2001b), Measuring Productivity-OECD Manual, Measurement of Aggregate and Industry-level Productivity Growth. ,

(19) Osada, H. (1994), Trade liberalisation and FDI incentives in Indonesia: The impact on industrial productivity, The Developing Economics, 32 (4): 479-91.

(20) Reinsdorf, M. and M. Cover, (2005), Measurement of capital stocks, consumption of fixed capital, and capital services, Report on a presentation to the Central American Ad Hoc Group on National Accounts, Santo Domingo, Dominican Republic.

(21) Szirmai, A., M.Timmer and R.van der Kamp, (2002). Measuring Embodied Technological Change in Development. The Core Machinery Approach, Journal of Development Studies, 39, (2), December 2002, pp.155-177

(22) Timmer, M.P. (1999), Indonesia's ascent on the technology ladder: Capital stock and total factor productivity in Indonesian manufacturing, 1975-95, Bulletin of Indonesian Economic Studies, Vol. 35, No.1, pp.75-97.
(23) Triplett, J.E., (1996), Depreciation in production analysis and in income and wealth accounts: Resolution of and debate, Economic Inquiry, Vol. 34, No. 1, pp.93-115.
(24) Triplett, J.E., (1997), Concepts of capital for production accounts and for wealth accounts: The implications for statistical programs, Paper prepared for International Conference on Capital Stock Statistics, March 10-14, 1997, Canberra, Australia.
(25) Triplett, J.E., (1998). A Dictionary of Usage for Capital Measurement Issues, Brookings Institution, Washington D.C., August, 1998.
(26) Ward, M., (1972). The Measurement of Capital, OECD.
(27) Wu, H.X. and X. Wu (2002). 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 2002.
(28) DSIFA (Department of Statistics on Investment in Fixed Assets National Bureau of Statistics of China), (1997), China Statistical Yearbook on Investment in Fixed Assts, 1950-1995, China Statistics Press.
(29) DSIFA (Department of Statistics on Investment in Fixed Assets National Bureau of Statistics of China), (2002), Statistics on Investment in Fixed Assets of China, 1950-2000, China Statistics Press. 2002.