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Research Memorandum GD-99

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RESEARCH MEMORANDUM

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Abstract
This paper provides new estimates of capital inputs in the Chinese economy. Estimates are made for the total economy (1953-2003), for the industrial sector (1978-2003) and for the manufacturing sector (1985-2003). The estimates for industry and manufacturing are broken down by thirty regions. The main contribution of this paperlies in constructing hitherto unvailable estimates of capital inputs at the level of Chinese regions. The paper makes a systematic attempt to apply SNA concepts to the estimation of Chinese capital inputs, according to the Perpetual Inventory Method. It makes a clear distinction between capital services and wealth capital stocks. After a general discussion of theoretical issues in capital measurement, the paper provides a detailed analysis of the relevant Chinese statistical concepts and data. It goes on to discuss previous capital estimates in the light of the modern conceptual and theoretical discussions. It ends with an explanation of the procedures followed in constructing the national and regional capital input series.

Keywords: Capital Inputs, Capital Services, Regions, China, Industry, Manufacturing

JEL Classification : O47 (Measurement of Economic Growth), R11 (Regional Economic Activity).

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* Joint working paper of UNU-MERIT and the Groningen Growth and Development Centre. We thank Derek Blades for valuable comments on an earlier version of this paper. Corresponding author: Lili Wang, Eindhoven Centre for Innovation Studies, Eindhoven University of Technology/UNU-MERIT, Keizer Karelplein 19, 6211 TC, Maastricht, The Netherlands, email: wang@merit.unu.edu; Adam Szirmai (Eddy), UNU-MERIT, The Netherlands, email: szirmai@merit.unu.edu

1 Introduction

This paper provides new estimates of capital inputs in the Chinese economy. Estimates are made for the total economy (1953-2003), the industrial sector (1978-2003) and the manufacturing sector (1985-2003). The estimates for industry and manufacturing are broken down by 30 regions. The main contribution of this paper is constructing hitherto unvailable estimates of capital inputs for Chinese regions.

The measurement of capital inputs is fraught with difficulties. Otherwise than labour inputs, fixed assets are produced inputs that can be used repeatedly in the production process over longer periods. Varying service lives and the decline of the productive capabilities of fixed assets over time make it hard to measure capital inputs accurately.

Partly due to the difficulty of observing capital services directly, the *productive capital stock* and the *wealth capital stock* are often confused in practice. These need to be distinguished. 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 is represented 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 in wealth accounting (OECD, 2001a, p.15; OECD, 2001b, p.53; Hulten and Wykoff, 1996, p.13).

Capital services are primary inputs into the production process. 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. When referring to capital inputs, we will use the term *volume indices of capital service* (OECD, 2001a, p.21, 84; Triplett, 1996, 1997).

In the case of China, things are further complicated by the lack of sufficient published data on investment in fixed assets and a measurement system that still deviates from the SNA. In Chinese statistics, fixed assets acquired in different years are normally valued at their historical acquisition prices. According to the 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" (SNA, 1993, Par 6.180). The lack of adequate data is particularly problematic at the regional level.

Some of the earlier attempts at measurement of capital inputs are constrained by inappropriate conceptual frameworks. Several 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).

The paper is structured as follows. In section 2, we discuss measurement issues with regard to capital inputs. In particular, we focus on the distinction between capital services and the wealth capital stock. Capital services are the appropriate inputs for productivity analysis. The wealth capital stock is the appropriate concept for national accounts. In section 3, we introduce the basic concepts used in Chinese statistics. In section 4 we discuss the different ways in which investment in fixed assets are broken down in Chinese statistical practice. Earlier estimates of Chinese capital inputs are discussed in section 5, in the light of the theoretical and practice issues and problems raised in the sections 2 to 4. Section 6 presents new estimates of capital services for the total economy, for industry and for manufacturing. The final section 7 presents new estimates of regional capital inputs in industry and manufacturing. It specifies the methods and assumptions required for making these estimates.

2 Measuring Capital Inputs into the Production Process

2.1 Capital Services vs. Wealth Capital Stocks

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

In the SNA, the term *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). This is a wealth accounting concept. In the SNA framework, the same term *depreciation* is also used to refer to the decay of the productive capacity of fixed assets in the production process. This relates to the quantity of productive capital services, rather than to figures in the balance sheets in the business sector. In order to avoid confusion, in this paper we consistently use *decay* in the context of productivity analysis, and depreciation in the context of wealth accounting.

Volume indices of capital services measure the contribution of capital to the production process. They reflect the productive capability of capital and are used in productivity analysis. Thus, for the analysis of TFP, the index of capital services is the most appropriate capital input. In contrast, the wealth capital stock reflects the market valuation of fixed assets, used especially in business accounts. The main differences between the different capital concepts are listed in the following table.

Table 1: Capital Concepts

	Capital services	**Productive capital stock**	**Wealth capital stock**
Object	Flows of capital services	Productive capital stock	Stock of capital goods
Field of Application	Production and productivity analysis	Production and Productivity analysis	Income and wealth, business accounts
Focus of Measurement	Capability or efficiency	Capability or efficiency	Capital value
Deterioration	Decay in productive capability	Decay in productive capability	Economic depreciation/capital consumption
Value	Age-efficiency profile	Age-efficiency profile	Age-price profile
Price weights for aggregation	Rental prices (or user cost)	Deflated acquisition prices of fixed assets	Acquisition prices of fixed assets adjusted to current values

The decay of productive capabilities and economic depreciation are separate concepts, but they are not independent of each other. In the following section, we will discuss the relationships between rental prices and asset prices. We shall see that capital service is an important basis for determining the value of fixed assets (in wealth accounting), but not the other way around.

2.2 Measuring Capital Services

In theory, to construct volume indices of capital services (VICS), different types of fixed assets of different ages first need to be converted into standard efficiency units (known as the quantity of capital services). Next, these units are multiplied by the rental prices (or user costs) which are the unit prices of such services (OECD, 2001, p. 21). Rental prices are the appropriate weights for the construction of volume indexes of capital service inputs. This is the preferred solution. In practice, however, it is difficult to find quantities and prices for capital services and indirect estimation methods of user cost require additional assumptions. Therefore some researchers continue to use the productive capital stock as a proxy for capital services, assuming that capital services are proportional to the productive capital stock. Thus, capital services are measured as the use of a stock of fixed assets during a specified period (e.g. a year). The productive stocks are calculated by cumulating the values of gross fixed capital formation (GFCF) multiplied by their age-efficiency coefficients.

In productivity studies, the capital stock[1] (*K*) can be expressed as the sum of productive investment (*IN*) in the production process. The productive capabilities of each type of investment (fixed assets) should be converted into standard efficiency units.[2]

$$K_t = \phi_0 IN_t + \phi_1 IN_{t-1} + \ldots + \phi_T IN_{t-T}$$

or

$$K_t = \sum_{s=0}^{T} \phi_s IN_{t-s} \qquad (1)$$

where, *T* is the average service life of investment, s is the age of a fixed asset, and ϕ is the productive capability (or efficiency) coefficients of an asset. $\phi = 1$ for a new asset at time t, and $\phi = 0$ when its service life is over. ϕ is also equal to the ratio of the marginal product of currently used assets to the marginal product of a similar new asset (under the condition that the capital- labour ratio remains constant). (Hulten and Wykoff, 1996, p.14).

Taking into account retirement patterns (scrapping patterns) and price indexes (OECD, 2001b, p. 132), the productive capital stock can be written as

$$K_t = \sum_{s=0}^{T} \phi_s \cdot F_s \frac{IN_{t-s}}{p_{t-s,0}} \qquad (2)$$

where $p_{t-s,0}$ is the price index of year $t-s$ relative to year 0, F_s is the retirement rate of assets at age s. [3]

[1] In the remainder of this paper, the term capital stock will be used as shorthand for the productive capital stock, as long we remain within the scope of productivity analysis.

[2] Triplett writes that capital stocks should not be called capital inputs (Triplett, 1998 p. 2). Unless we are explicitly referring to capital flows, we will use the term ‘capital stock’ rather than capital input.

In obtaining volume indices of capital stocks, estimating the efficiency coefficient ϕ is an important step. With a given decay function, the Perpetual Inventory Method estimates the decay in efficiency of capital assets. The volume index of capital services is assumed to be proportionate to the index of the capital stock.

Choosing a proper decay function is a key to this method. An important point worth noting is that the term *depreciation* used in SNA 1993 represents the declining productive capability of fixed assets (in productivity analysis), rather than the allocation of the costs of fixed assets over the successive accounting years (in the business accounts) (SNA-glossary, p.13). The decline of productive capability is different from depreciation in the wealth accounting field (OECD, 2001b, p.53). In order to avoid the confusion surrounding the use of the term depreciation, we use the term *decay of efficiency* in the context of production analysis and the term *economic depreciation* in the context of wealth accounting.

There are five main decay patterns for the loss of efficiency of the capital stock in its contributions to the production process, each of them based on different assumptions: *One-hoss shay, straight-line decay, geometric decay*, *the double declining balance method* (Hulten, 1990) and the *hyperbolic decay pattern*. The decay patterns apply to both capital stocks and capital services.

The *One-hoss-shay* efficiency method

The one-hoss-shay pattern assumes that fixed assets provide constant productive services throughout the whole service life (T) of the asset

$$\phi_s = \begin{cases} 1 & s = 0,1,...T-1 \\ 0 & s \geq T \end{cases} \qquad (3)$$

where s is the age of the fixed asset.

In such an efficiency profile, fixed assets are able to operate as efficiently as new ones, as long as they exist. There is no productivity decay. The typical example of this pattern is the computer. In this pattern, the productive capital stock is equal to the gross capital stock. The one-hoss-shay pattern seems inappropriate for the aggregated capital estimation (Triplett,1997, p.14).

- *Straight-line depreciation*

The straight-line depreciation model assumes that the productive efficiency of an asset decays by an equal amount every year of its service life.

$$\phi_s = \begin{cases} 1-\dfrac{s}{T} & s = 0,1,...T-1 \\ 0 & s \geq T \end{cases} \qquad (4)$$

- *The geometric model*

The geometric assumes that efficiency decay takes place at a constant rate every year.

$$\phi_0 = 1 \qquad (5)$$

$$\phi_s = \phi_{s-1} \cdot (1-\delta) \quad s = 1,...,T-1$$

where δ is the decay rate（Jorgenson, 1990). This pattern is used in Canada.

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3 A further refinement in capital input measurement is to take the mortality function into account. The mortality function refers to the distribution of retirements around the average service life of an asset. Mortality functions are not taken into account in this paper.

However it is not appropriate in the sense that assets will be used infinitely without ever being retired though with very small values in the late stages. In practice, this approach is therefore sometimes substituted by the *double declining balance method.*

- *The double declining balance method*

The double declining balance method is a combination of the geometric model and the straight line method. The double declining method uses a geometric decay rate based on doubling the decay rate for the first service year of an asset as calculated according to the straight-line method. This decay rate is applied to subsequent years. When the efficiency rate calculated using this decay rate drops below the efficiency rate calculated with the straight-line method, the method switches to the straight-line decay rate for the final years.

- The *hyperbolic pattern*.

$$\phi_S = (T - s)/(T - \beta s) \qquad (6)$$

In this pattern, the productive efficiency falls slowly in early periods and more rapidly in later stages (Triplett, 1997, p.14). The Bureau of Labor Statistics (BLS) in the US and the Australian Bureau of Statistics (ABS) use the hyperbolic-efficiency function. As a matter of fact, this pattern is a very suitable pattern for an increasing number of high-tech fixed assets, like computers (or software). Such fixed assets normally don't lose much of their capabilities in the early stages. The values used for the slope coefficient (β) are 0.5 for equipment, and 0.75 for structures. (OECD, 2001a, p.86) .

In determining the shape of the efficiency functions, Jorgenson (1990) and Hulten (1990) use relative marginal products, while Triplett prefers engineering information (Triplett, 1997, p.12).

2.3 The Relationship between Age-Efficiency Profiles and Age-Price Profiles

As stated above, the age-efficiency profile describes the pattern of decline of productive efficiency of assets, while the age-price profile portrays the pattern of changes in asset values. The latter is appropriate for the estimation of the net capital stock and the consumption of fixed assets in national accounts. Age-efficiency and age-price profiles are related, but not identical to each other.

For instance, obsolescence is an important factor in age-price profiles but not in age efficiency profiles. Obsolescence reduces the value of an asset in wealth accounting. It does not affect the amount of capital services provide by the fixed assets in the production process. Thus, the introduction of a newly invented (similar) fixed asset will reduce the value of an existing fixed asset considerably. However, the capital service of the existing asset will remain unchanged.

The pattern of decline over time may also differ. The market value of fixed assets will often decline rapidly in the first years of use, while the productive capability declines much less in the initial period.

Using depreciation figures directly from published yearbooks implicitly denotes a choice for the wealth accounting concept. Unfortunately in practice, depreciation is often used to measure the decay of productive Capacity.

Hulten (1990) and Hulten and Wykoff (1996) discuss the links between productive capability (efficiency) and economic depreciation in wealth accounting - the relationship between ϕ and δ - (see Wu, 2002, p.13; Jorgenson,1973; Hulten, 1990, p.128; and Hulten & Wykoff, 1996, p.14).

One way to estimate efficiency declines is to use the marginal products of assets with different ages or rental prices, if market data are available (Hulten, 1990, p.127; Schreyer, et al. 2003, p.9). Rentals are equal to quantity of capital services multiplied by the unit price of services.

$$\frac{P_{t,s}}{P_{t,0}} = \phi_s, \qquad s = 1,2,...T \tag{7}$$

$P_{t,s}$ is the rental, i.e. the income, from a s-year-old fixed asset at time t. The ratio of $P_{t,s}$ to the rental price of a comparable new machine $P_{t,0}$ indicates the relative marginal productivity of two vintages, which equals the efficiency coefficient (ϕ) of productive capability of assets with age s. However, it is very difficult to obtain the rental prices of certain fixed assets, given that most fixed assets are used by their owners.

Jorgenson (1963, 1990) discusses the use of the concept of 'user cost' instead of rental price.. Under perfect competition, marginal productivity is equal to the rental price. The rental price represents the revenue the fixed asset can obtain in a given year. The value of a fixed asset at year t should be equal to all the income gained in the remaining years of its service life, discounted to the present year. Therefore it has three main determinants: the rental prices of this fixed asset, a discount rate[4] and the scrap value.

Assume the income generated by this fixed asset at time t is $P_{t,s}$. With an interest rate *r*, the value of a fixed asset at age *s* should be

$$V_{t,s} = \sum_{\tau=0}^{\infty} \frac{P_{t+\tau,s+\tau}}{(1+r)^{\tau+1}} \tag{8}$$

where τ is the number of years starting from year t.

Given the productive capability variable ϕ, the value $V_{t,s}$ of a fixed asset at age s can be expressed as a fraction (ϕ_τ) of the value of a new fixed asset.[5]

Thus we get

$$V_{t,s} = \sum_{\tau=0}^{\infty} \frac{\phi_{s+\tau} P_{t+\tau,0}}{(1+r)^{\tau+1}} \tag{9}$$

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4 According to OECD (2001a, p. 16), the discount rate is "often taken as the interest rate on long-term bonds", and also it is also stated that the discount rate in "real terms" is "a nominal rate of interest minus the rate of general inflation" (OECD, 2001a, p. 17).

5 The new vintage doesn't have to be identical to the old one. It can represent a technologically more advanced version of the same type of asset. Thus the efficiency rate (ϕ) also incorporates the influence of technological obsolescence.

The two equations above do not take the scrap value into account. This means they assume that a fixed asset will stay in the capital stock forever without being discarded (T=∞), even though its productive contribution is very small in the far future.

If we take into consideration the retirement of fixed assets at the end of their service lives T, then we can get

$$V_{t,s} = \sum_{\tau=0}^{T-s-1} \frac{P_{t+\tau,s+\tau}}{(1+r)^{\tau+1}} + \frac{Scrap\,value}{(1+r)^{T-s}}$$
$$= \frac{P_{t,s}}{1+r} + \frac{P_{t+1,s+1}}{(1+r)^2} + \cdots + \frac{P_{t+(T-s)-1,T}}{(1+r)^{T-s}} + \frac{Scrap\,value}{(1+r)^{T-s}} \qquad (10)$$

The economic depreciation rate equals

$$\delta_{t,s} = 1 - \frac{V_{t,s+1}}{V_{t,s}}. \qquad (11)$$

Thus we have

$$(\delta_{t,s} + r)V_{t,s} = P_{t,s} = \phi_s P_{t,0} \qquad (12)$$

which connects the economic depreciation rate (δ), the value of a fixed asset (V) and the rental price (P). From the above equation, one sees that the economic depreciation rate (δ) and efficiency decay rate (ϕ) are only the same in the geometric pattern. If the depreciation rate is constant over time, we can get $\phi_s = (1-\delta)^s$. (For the derivations see Annex A, see also Wu, 2002, p.13).

In all other decay (or depreciation) functions, δ and ϕ are not the same and cannot be substituted for each other. OECD (2001b, p.58-67) provides examples of the different shapes of age-price profiles and age-efficiency profiles

3 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 the published statistics are not consistent over time.

Basic concepts and variables with regard to fixed assets in China:

The commonly used variables related to capital estimates are the following:

- ***Total Investment in Fixed Assets (TIFA)***. *TIFA* includes the "volume of activities in construction[6] 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.[7] Next, besides productive fixed assets according to the SNA

6 The term "construction" used in Chinese yearbooks is a potential source of confusion. It does not refer to construction activities, or the construction sector, but rather to the creation of fixed assets in general.

7 Compared to the average for the total economy, state-owned units normally have higher proportions of TIFA investment that will not be turned into productive fixed assets (DSIFA, 2002, p.77).

conception, *TIFA* also includes the non-productive part of investment, such as inventories and the residential capital stock.[8]

TIFA data are available from 1950 to present. Between 1950 and 1979, the data only refer to state-owned units. Prior to 1996, TIFA had a coverage of enterprises with investment of more than 50 thousand Yuan per year. However, except for investments in real estate development, rural collective investment and individual investment, the coverage changed to more than 500 thousand Yuan 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 extended coverage of the earlier series. This is not a serious discrepancy and can be disregarded (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 excluded. Hence NIFA is a useful concept according to the SNA framework. One should note that NIFA still includes the non-productive part of investment in fixed assets. NIFA is published in statistical yearbooks of fixed assets investment in China since 1981. From 1952-1980, the NIFA data are only available for investment in basic construction in state-owned units (for an explanation of basic construction see section 4).

-***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). On first sight this ratio could be used to calculate NIFA from the "*Total investment in fixed assets*". However, in practice, it is based on incomparable data. The realization of fixed assets in the current year resulting from the investment undertaken some years ago is expressed as a percentage of the total investment in the current year. Given that it might take quite some years for an investment to result in fixed assets, it is 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 stock of fixed assets valued at their historical acquisition prices. Hence, the OFA of total fixed assets is a cumulated value of assets purchased in different years at different prices. Using historic valuation results in a stock of assets valued at a mixture of prices. Therefore, the OFA data published in statistical yearbooks cannot be used directly to estimate gross capital stocks, However, the difference between OFA in two subsequent years can be used to derive the annual investment figures in the intervening period, as has been done by Chen et al. (1988). (See section 5 of this paper for a more detailed explanation of this method). Data on OFA in industry are available for 1952, 1957 and from 1963 onwards.

[8] Like the stock of infrastructure, the residential capital stock is part of the productive capital stock at the level of the total economy. It is not part of the productive capital stock from the perspective of the industrial sector.

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

$$NFA_t = OFA_t - \sum_{i=0}^{t} depreciation_i \qquad (13)$$

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. It is not clear for which years published NFA data are available.

- ***Accumulation of Fixed Assets (AFA).*** *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 *AFA* 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, see DSIFA, 1997, p.451). Time series of *AFA* are available from 1952 till 1992). Accumulation of fixed assets is also a wealth accounting concept.

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

This section provides an analysis of the different ways in which investment can be broken down into subcategories. The analysis serves as the analytic background for our discussion of existing Chinese capital stock estimates in section five and for our new estimates of regional capital services inputs in industry in section 6.

4.1 Types of TIFA[9]

Total investment in fixed assets (TIFA) includes four types of investment:

1) Investment in basic construction[10]
2) Investment in technical renovation
3) Investment in real estate development
4) Other investment

Investment in basic construction 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

9 There are two different breakdowns of TIFA in Chinese statistics: breakdown into different types of investment (section 4.1) and breakdown into different content categories (section 4.2). The terms type and content have been introduced by us, to avoid confusion between the two breakdowns. They are not found explicitly in Chinese statistical sources. We use the term 'types of investment' to refer to the breakdown into categories such as basic construction, technical renovation, real estate development and other investment. We use the term 'content of investment' to break down investment into substantive categories such as fixed structures, machinery and equipment and other investment. For instance, Chen et al. (1988) distinguish three types of investment and four content categories.

10 In some yearbooks, basic construction is also referred to as *capital construction.*

expanding production capacity or improving project efficiency covering only projects each with a total investment of 500,000 RMB Yuan and over".[11]

Investment in technical renovation 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 investment of 500,000 RMB Yuan and over".[12]

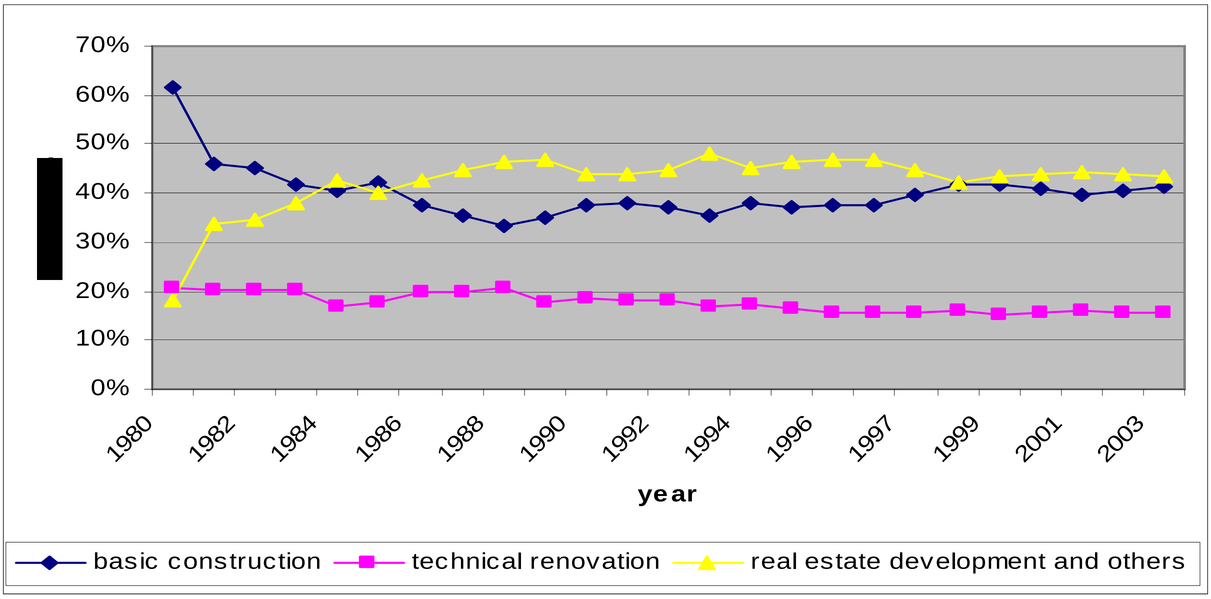
Investment in real estate development refers to "the investment by real estate development companies, commercial building construction companies and other real estate development units of various types of ownership in the construction of buildings, such as residential buildings, factory buildings, warehouses, 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 levelling and other projects of infrastructure. It excludes the activities in pure land transactions" . Unfortunately, the investment types of investment in basic construction and investment in real estate development are not mutually exclusive. Basic construction also includes some investment in non-residential fixed structures.

Other investment in fixed assets
According to China Statistical Yearbook 2000 (p. 234), 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 (*i.e. type 1*) and the plan of innovation (*i.e. type 2)*: (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) Investment in fixed assets by urban collective units. This refers 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.
Thus, other investment is a mixed residual category which includes investment in exploitation of natural resources, investment in infrastructure, investment in non-residential fixed structures as well as other investments which are not included in basic construction or technical renovation.

[11] The definitions for these four categories are from CSY, 2000, pp. 233**.** The coverage was all enterprises with more than 50,000 RMB yuan in investment prior to 1996.
[12] Technical renovation is sometimes also referred to as *innovation* which is not the most appropriate term., or in some publications as *technical updates and transformation*.

Before 1980, the third and fourth types of investment (*real estate development* and *other*) were included in the first two (*basic construction* and *technical renovation*). Data for *real estate development* are available since 1986, data on *other investment* since 1985. The complete breakdown into four types is only available since 1986. For the years between 1980 and 1986, we can reconstruct a residual category of '*real estate plus other investment*' by deducting basic construction and technical renovation from total investment. In Figure 1, we merge the data for real estate development and other after 1986, to get a consistent breakdown into three types – basic construction, technical renovation, real estate development plus other - for the whole period 1980-2003.

Figure 1: Total Investment in Fixed Assets by Type of Investment. Total Economy, 1980-2003



Source: CSY2004, Table 6-4, Table 6-6; CSY2002, Table 6-6, and DSIFA 1997, pp. 20, pp.71.

The share of basic construction in TIFA decreases slightly between 1981 and 1990, while the share of other investment increases substantially. After that the shares remain stable. Real estate development is a special investment category in China, which became more important from the early 1980s onwards. Before the 1980s, housing investment was included in the basic construction category, which was carried out by normal production companies or organizations. In the process of enterprise reform (*zhufang zhidu gaige*), investment in residential fixed structures (i.e. housing) was transferred to real estate companies, for which a separate statistical category was created.

The investment in *real estate development* as published in recent Chinese Statistical Yearbooks mainly consists of four component parts: residential buildings, office buildings, housing for business use, and others. The productive part of real estate development (investment in office buildings and housing for business use) is rather small, as showed in the table below. This implies that most of investment in non-residential fixed structures will still be found in the category 'basic construction'.

Between 1953 and 1980, the officially published time series for basic construction and technical renovation for the total economy only cover the state-owned units (CSY, 2002, Table 6-6; CSY, 2004, Table 6-6 & DSIFA, 1997, p. 20, p.71). They exclude investment by non-state firms, such as e.g. collectively owned enterprises.

Table 2: Breakdown of Investment in Real Estate Development

Total Economy 1997-2003		Percentage shares of				Productive Investment (%)
	Total investment (100 mill. yuan)	residential buildings (1)	office buildings (2)	houses for business (3)	other use (4)	Col. 2 +3 as % of total (5)
1997	**3178.37**	48.4	12.2	13.4	25.9	25.6
1998	**3614.23**	57.6	12.0	13.2	17.2	25.2
1999	**4103.20**	64.3	8.3	11.8	15.6	20.1
2000	**4984.05**	66.5	6.0	11.6	15.9	17.6
2001	**6344.11**	66.5	4.9	11.9	16.8	16.8
2002	**7790.92**	67.1	4.9	12.0	16.0	16.9
2003	**10153.80**	66.7	5.0	12.8	15.4	17.8

Source: CSY 2004, Table 6-44

4.2 Breakdown of TIFA by Content of Investment[9]

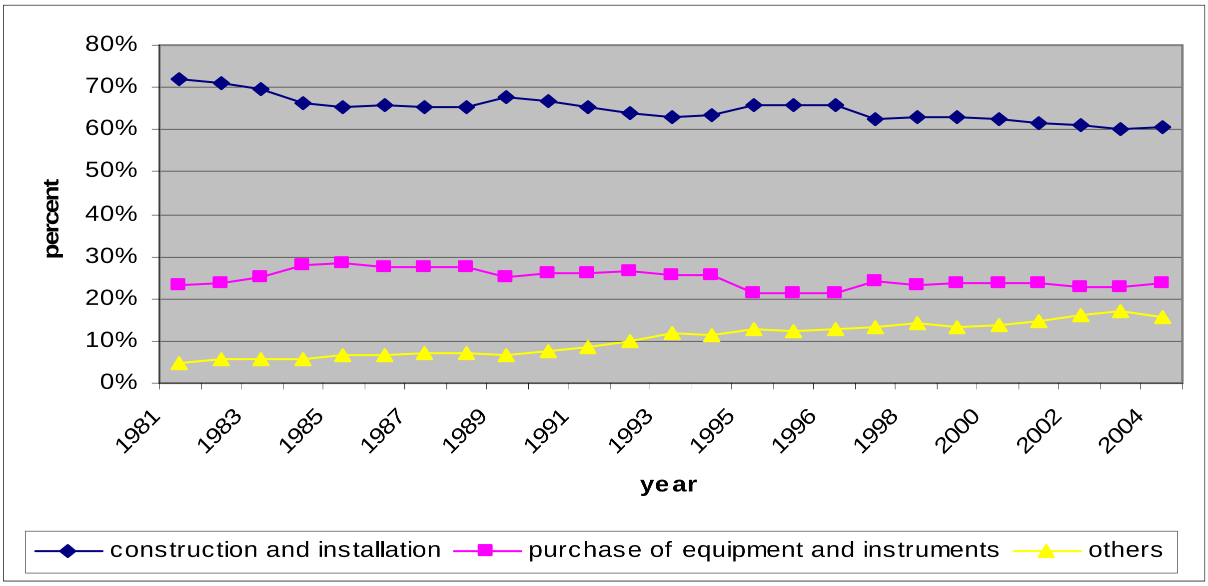
By content, all categories of total investment (TIFA) can be classified into three categories:

1) Investment in Fixed Structures, referred to as '*construction and installation*' [13]
2) Investment in Machinery and Equipment, referred to as the '*purchase of equipment and instruments*' [14]
3) Other investment.

[13] *Construction and installation* represents various investments in houses, buildings and foundations etc. It has a different meaning from the term *basic construction* discussed in section 4.1. According to CSY, 2000, p. 235 'Construction and installation' 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 investment in machinery and equipment

[14] Purchase of equipment and instruments refers to the total value of equipment, tools, and vessels purchased or self-produced which meet the 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, 2000, p. 235).

Figure 2: Total Investment in Fixed Assets, by Content. Total Economy,1981-2004



Source: DSIFA 1997, pp. 26-27, and CSY 2005, Table 6-2.

The share of construction and installation in TIFA decreased by more than 10 percentage points from 1981 to 2004 from around 70 to 60 percent. The share of other investment increased from less than 5 percent to more than 15 percent.

We are not only interested in the aggregate proportions of the three content categories in TIFA. We are also interested in the proportions within each of the four types of investment distinguished in section 4.1. In the published yearbooks, only two of the types of investment - basic construction and technical renovation – are broken down by content. There is no breakdown for real estate development or other investment. Table 3 indicates what breakdown is available in the published sources and how some of the gaps in the data can be filled.

Table 3: Breakdown of Investment Types by Content Categories

		Type of investment				
		Basic construction (1)	Technical renovation (2)	Real estate development (3)	Other (4)	**Total (5)**
Content of investment	Construction and installation	Published	Published	Assumption that all real estate development belongs to construction and installation	Calculated as residual	Published
	Purchase of equipment and instruments	Published	Published		Calculated as residual	Published
	Other expenses	Published	Published		Calculated as residual	Published
	Total	Published	Published	Published	Published	Published

This method has been applied in table 4. In each content category, the residual is calculated by deducting the published categories from the content totals. The residuals equal investment type 'other investment'. Column XIV represents the sum of those three residuals. The figures in this column exactly equal the published data for the fourth type category, *other investment* (from CSY, 2004, Table 6-6). Hence, our method provides us with a reliable breakdown of the type category *other investment* by content of investment (columns V, IX and XIII of table 4, see also column (4) of table 3).

We may safely assume that investment in real estate development can be classified fully as construction and installation, since it involves only housing or office construction. As we know the totals for each content category (see figure 2), we can thus subtract basic construction (col 1), technical renovation (col 2) and real estate development (col 3) from total investment within each content category. The residual equals 'other investment' as indicated in column 4. Thus, we can derive a full crosstabulation of types of investment and content categories of investment.

Table 4 provides us with the shares of the three content categories within the other investment type category. Figures 3, 4 and 5 present the breakdown of the different investment types by the three content categories. No separate figure is included for real estate development as this only consists of construction and installation investment.

The most detailed published data are available for *basic construction*, for which the series can be traced back to 1950. A breakdown for *technical renovation* is available since 1980. For *other investment* we have estimated the breakdown for the period since 1985.

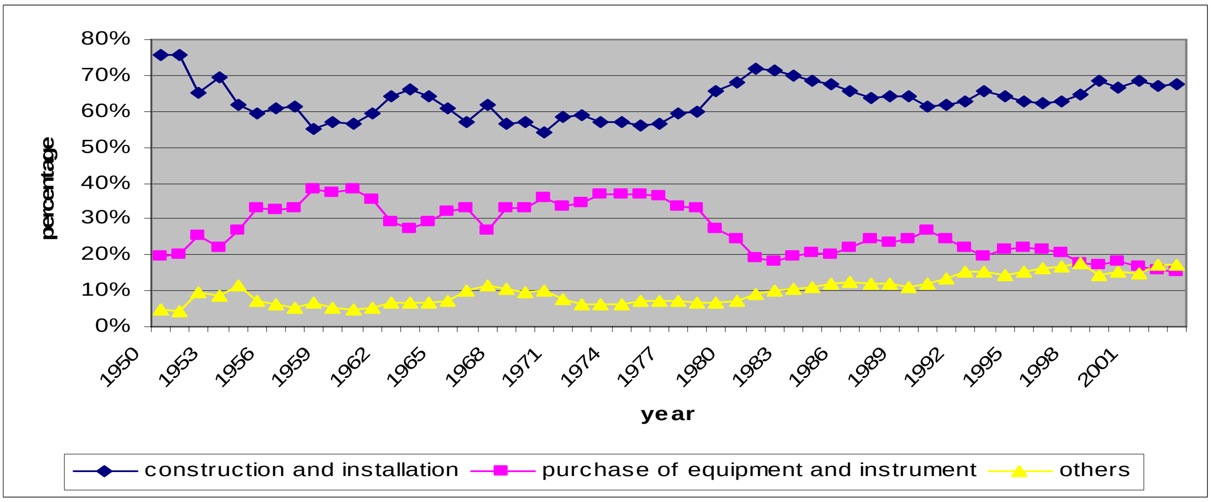
Table 4: Content of Investment by Type of Investment

	Construction and Installation					Purchase of Machinery and equipment				Other Investment				sum of 3 residuals
	Total (I)	from BC (II)	from TR (III)	total RE (IV)	residual 1 (V)	Total (VI)	from BC (VII)	from TR (VIII)	residual 2 (IX)	Total (X)	from BC (XI)	from TR (XII)	residual 3 (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); XIV=(V)+(IX)+(XIII).

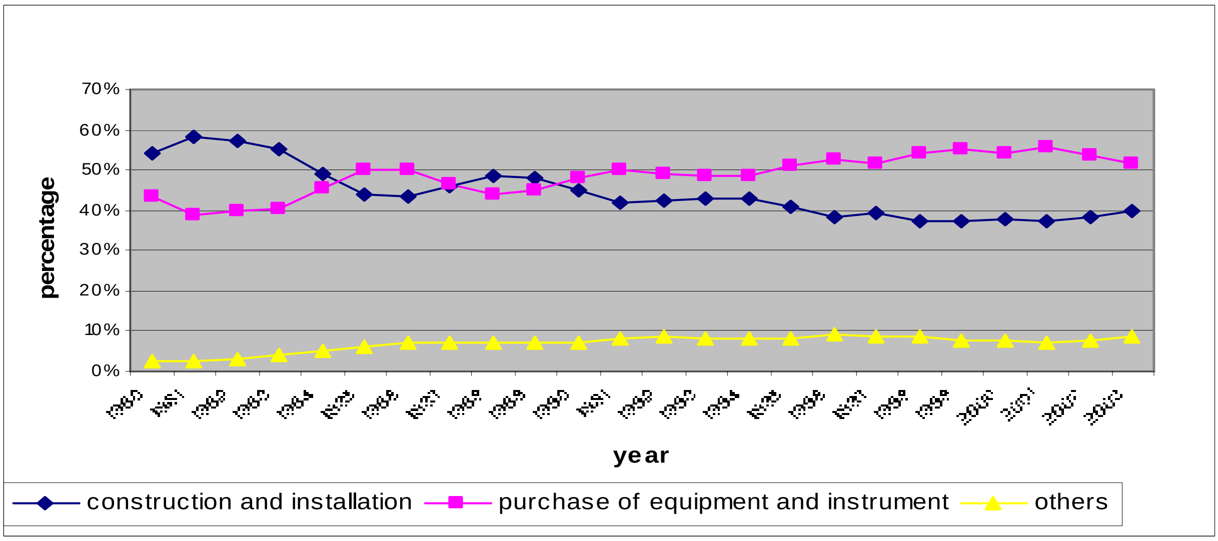
Source: DSIFA, 2002, p.288; CSY, 2005, p.186; CSY, 2004, Table 6-8 and Table 6-21.

Figure 3: Total Investment in Basic Construction, by Content Category, 1950-2003



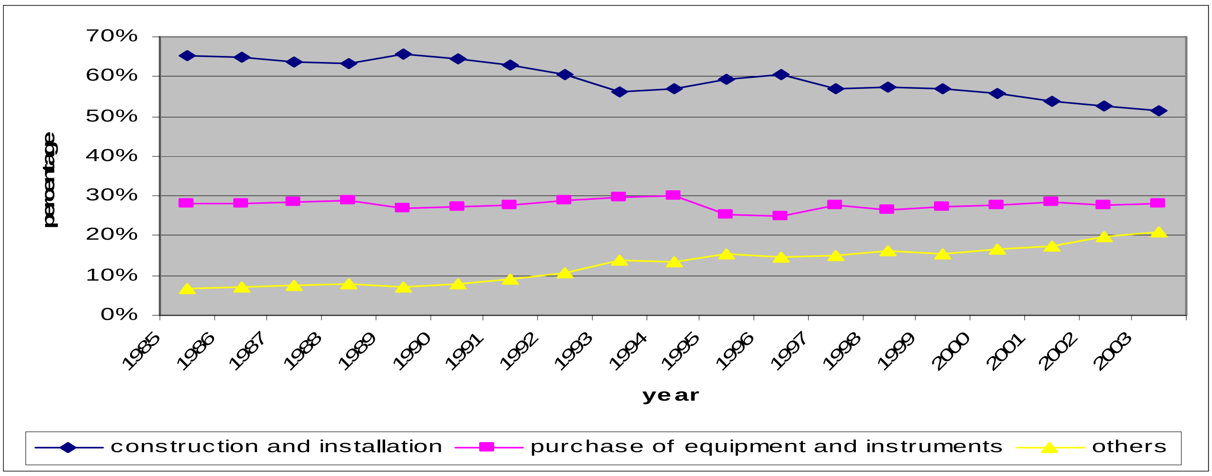
Sources: DSIFA, 1997, pp.97; and CSY 2004, Table 6-8.

Figure 4: Total Investment in Technical Renovation, by Content Category, 1980-2003



Sources: DSIFA, 1997, PP. 249; and CSY 2004, Table 6-21.

Figure 5: Other investment by Content Category, 1985-2003



Sources: DSIFA, 2002, pp. 28; CSY 2005, pp.186; and own calculations.

The decline in the aggregate share of fixed structures (construction and installation) since 1981, as documented in figure 2, primarily takes place in the technical renovation and other investment types. In basic construction, there is not all that much change in the share of fixed structures.

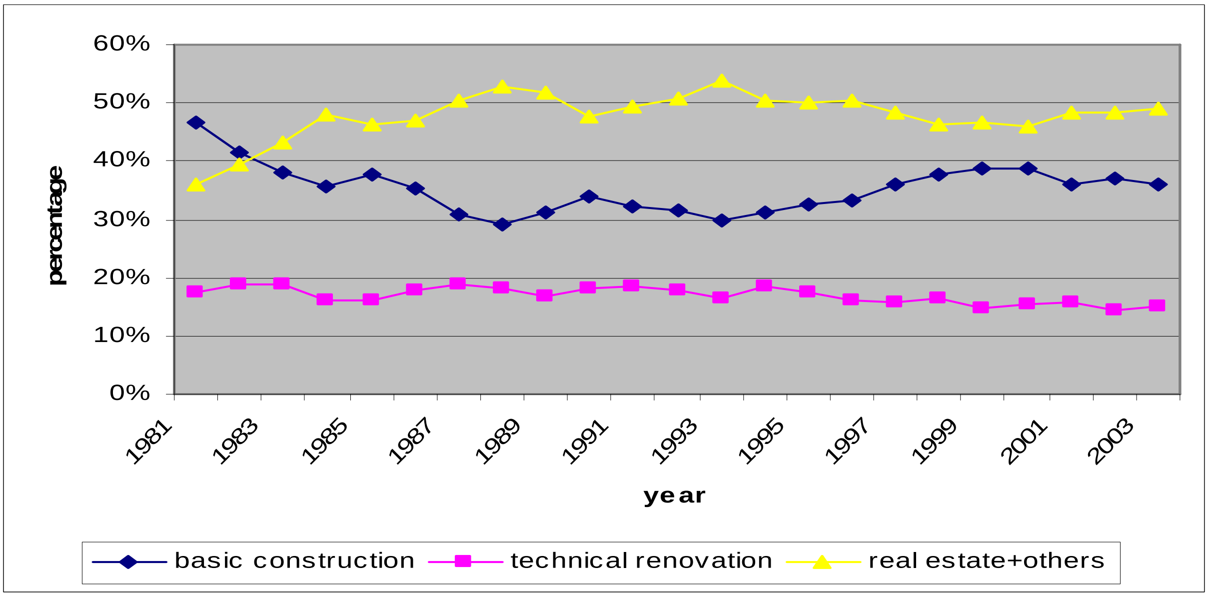
For machinery and equipment (purchase of equipment and instruments), the main changes are found in basic construction and technical renovation. In basic construction the share of machinery and equipment declines after 1980, in technical renovation it increases. On balance this results in the more or less stable share of machinery and equipment in figure 2.

This analysis of types and content categories will be useful, when we try to break down investment by content in section 6.

4.3 Newly Increased Fixed Assets (NIFA)

As indicated in the section 3, total investment in fixed assets (TIFA) is broader than the real investment in the formation of the capital stock. The more appropriate concept is newly increased fixed assets (NIFA). NIFA shares the same type classification as TIFA, i.e. basic construction, technical renovation, real estate development and others.

Figure 6: Structure of Newly Increased Fixed Assets, 1981-2003



Source: DSIFA, 1997, p. 62; DSIFA, 2002, p. 77; CSY2004, Table 6-14, 15, and 23.

5 Discussion of Chinese Capital Estimates in the Literature

In this section, we discuss literature on Chinese capital input estimates in the light of the theoretical, empirical and conceptual issues discussed in paragraphs 2, 3 and 4.

5.1 Productive Capital versus Wealth Accounting.

In section 2.1, we discussed the differences between the concepts of "productive capital services" and "productive capital stock" used in productivity analysis and the concept of "wealth capital stock" used in wealth accounting (OECD, 2001a, p. 53).

One of the shortcomings of many earlier estimates of Chinese capital inputs is that they tend to use wealth accounting capital stock concepts and apply them in TFP analysis, for which they are not really appropriate (Chow, 1993; Hsueh and Li, 1999, Wu, 2000; Jefferson et al., 2000; Wang and Yao, 2003; Holz, 2006). Wu (2004) constructed Chinese regional capital stock 1953-2000, by introducing a "backcasting approach" to substitute the use of initial value of capital stock, but his general framework is still that of wealth and accounting.

Huang et al. (2002) are among the few researchers who give explicit consideration to difference between depreciation and the efficiency decline of fixed assets (called 'replacement' in their paper). Sun and Ren (2007) estimate the flow of capital service using capital service prices, and construct the capital input indexes by industries in China (1980-2000). This is one of the most consistent efforts to create a capital input indexes for China which are consistent with the SNA framework. Compared to the present paper less attention is paid to nature and coverage of the investment data and there are no attempts to estimate the capital inputs at a regional level

5.2 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).[15] For instance, Hsueh and Li (1999), Wang and Yao (2003) and Huang, Ren and Liu (2002) use TIFA to construct the gross capital stock, which would overestimate the final size of the capital stock. Our preferred concept is NIFA.

- *Accumulation of fixed assets (AFA) versus NIFA*

The data on accumulation of fixed assets consist of fixed assets and circulating funds. The accumulation of fixed assets excluding circulating funds is the part needed for estimating the capital stock (see Chow, 1993, p. 816-817). In principle, the productive part of accumulation of fixed assets is equal to the productive part of investment in newly increased fixed assets (NIFA) minus depreciation. 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 (for instance, used by Chow, 1993, 1994), 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.

[15] 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.

Table 5: Comparison of Newly Increase Fixed Assets and Accumulation of Fixed Assets

	Accumulation of Fixed Assets (AFA)		**Newly Increased Fixed Assets (NIFA)**		Rate of depreciation and major repair
	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 %
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: AFA is from CSY1992, P.40; and CSY1993, p.43; and NIFA is from CISFA, 1950-1995, p.10.

According to the concepts discussed in CISFA1950-1995 (page 451), the difference between productive NIFA (col. 4) and the accumulation of fixed assets (col 2) should be equal to basic depreciation and the major repair fund in fixed assets in that year.. The comparison of accumulation (col.2) and productive NIFA(col.4) shows that the depreciation and major repair as a percentage of fixed assets is greater in later years than in earlier ones. Though we cannot disentangle major repairs and depreciation, Chow does not seem to have used a zero depreciation rate. However, the increase in the rate of depreciation may suggest that Chows investment figures for the early years are underestimated and for the later years overestimated.

OFA versus NIFA

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 in the current year.[16] Direct NIFA data are not yet published prior to 1981. Chen et al. estimate newly increased fixed assets in each year by IN(t)= OFA(t) - OFA(t-1).[17] The same method is used by Jefferson et al. (1992, p.261, equation A4; 1996, p.174; 2000). A problem with the Chen et al. estimates is that they do not discard assets at the end of their life times.

5.3 *Is the Neglect of Scrap Values a Problem?*

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 negligible proportion of the total capital stock. Disregarding scrap values simplifies the capital calculations, but may introduce a bias in the estimates.

[16] Chen et al. (1988) use the term "newly-commissioned fixed assets" which has the same meaning as NIFA.

[17] 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.

The equation used by Chen et al. (1988) disregards scrap values. Scrap values are also neglected in the publications of Jefferson et al. (1992, p.261, equation A4;1996, p.174; 2000). Like Chen et al., these authors obtain investment through deducting the original value of fixed assets (OFA) in year *t*-1 from OFA of year *t*, disregarding scrap values.

In theory, the difference of original value of fixed assets in two continuous years, is equal to the NIFA minus the scrap value in that year, i.e. $OFA_t - OFA_{t-1} = NIFA_t - Scrap_t$. We can get scrap values 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. In this section, we 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, the scrap value 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

$$K_t^G = OFA_0 + \sum_{i=1}^{t}(IN_i - scrap_i) \tag{14}$$

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 assets 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 the scrap value should be deflated to a price at T (service life of fixed assets) years earlier than i. Then we have

$$K_t^G = OFA_0 + \sum_{i=1}^{t}\left(\frac{IN_i}{p_i} - \frac{scrap_i}{p_{i-T}}\right) \tag{15}$$

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

$$IN_t - scrap_t = OFA_t - OFA_{t-1} \tag{16}$$

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.

$$K_t^G = OFA_0 + \sum_{i=1}^{t}(IN_i - scrap_i) = OFA_0 + \sum_{i=1}^{t}((OFA_t - OFA_{t-1} + scrap_t) - scrap_t) \tag{17}$$

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

$$K_t^G = OFA_0 + \sum_{i=1}^{t}\left(\frac{OFA_i - OFA_{i-1}}{p_i} + scrap_i\left(\frac{1}{p_i} - \frac{1}{p_{i-T}}\right)\right) \tag{18}$$

The last item on the right hand of above equation shows the effect of the 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, which is $\frac{1}{p_i} - \frac{1}{p_{i-T}}$ =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 less of a problem than 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 the 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.

5.4 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 use of a gross capital stock 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 choice 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 the concept of depreciation from wealth accounting with the concept of 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. But, this observation is mainly based on a business account concept of depreciation. 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.

5.5 *Non-Productive Fixed Investment*

It is important to distinguish between productive and non-productive investment. Within industry and manufacturing, the non-productive part of fixed assets in industry includes the residential housing stock, but also other non-productive investment such as investment in infrastructure. According to most China statistical yearbooks, the non-productive part of gross investment is 30% of all TIFA in the total economy, while the residential part accounts for little more than 10% of TIFA. If we only exclude investment in the residential capital stock from the total investment in fixed assets in industry, this will result in overestimation of the productive capital stock in industry.

To create a series of NIFA in industry, Chow et al. (1988) and Wu and Xu (2002) use original fixed assets (OFA) data from the published yearbooks (see discussion in Wu and Xu, 2002, p.16).

$$NIFA_t = OFA_t - OFA_{t-1} \tag{19}$$

Using OFA to create NIFA, following Chen et al. (1988), solves a practical problem of the lack of direct data on industrial investment in fixed assets prior to 1981.[18] In estimating the productive (or efficient) NIFA, Chen et al. (1988) deduct the residential housing part from total NIFA. However, this is not an adequate solution because, the non-productive part of capital stock includes a variety of other non-productive assets along with the residential housing stock.

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

Holz includes non-productive fixed assets in the total capital stock in his "economy-wide output" analysis. (Holz, 2006, p.145). For the total economy, this is less problematic than for the industrial sector. From the perspective of the total economy, investment in residential fixed structures and investment in infrastructure are productive investments.

Non-productive fixed assets, as part of consumption material, are the infrastructures in residential buildings, schools, hospital and other welfare structures.[19]

5.6 *Types of Investment*

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.*[20] 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) distinguish only three categories: basic construction, technical renovation and miscellaneous. In figure 2, we have made estimates for basic construction, technical renovation and other (including real estate development).

[18] As explained in section 5.3, this method ignores scrap values. But we have argued that that scrap values are negligible and can be neglected in estimating investment.
[19] See also from http://old.ynce.gov.cn/content.asp?ARTID=5575&COLID=174 .
[20] 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.

5.7 Breakdown of Investment in Fixed assets into Different Content Categories.

Different kinds of fixed assets are not homogeneous. For reasons of simplicity, some studies (Jefferson et al., 2000; Chow and Li, 2002), only consider one aggregate type of investment. 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 different types of fixed assets have different price deflators and the different service lives.

Chen et al. (1988) decompose newly increased fixed assets into four content categories: non-residential construction, equipment, housing and others. The proportions of these categories within industry are not known. The authors use 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 concept of non-productive assets is broader than that of residential housing alone.

5.8 Revaluation Problems.

After 1993, many fixed assets have been revalued. As a result, the original value of fixed assets (OFA) 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 (called investment in their paper) by deducting the original values of assets (OFA) in two successive years. However, this method cannot be directly used from the 1990s onward because the large revaluations of fixed assets in the enterprises will result in overestimation of the annual investment figures.

6 New Estimates of Capital Service Inputs in China (Total Economy, Industry and Manufacturing)

6.1 Introduction

In this section, we explain the choices we made in constructing indexes of capital service inputs in the Chinese economy, the industrial sector and the manufacturing sector, in the light of the theoretical, empirical and conceptual discussions in the previous sections. To estimate capital services in productivity analysis, we need the following data: investment series (or gross fixed capital formation), the service lives of fixed assets, decay coefficients, an estimate of the initial capital stock and price indexes.[21] We estimate the gross capital stock from the accumulated investment series and an initial capital stock, according to the Perpetual Inventory Method. We take age-efficiency patterns into account. The resulting capital stock series is used as a proxy for the index of capital service inputs.

[21] When the scrap value is taken into account, one also needs information about retirement patterns (mortality functions) around the average service life. As explained in section 5.3 of this paper, the scrap value as percentage of investment is very low. We will disregard it..

6.2 Investment Series

6.2.1 Newly increased fixed assets (NIFA)

As explained in section 2 of this paper, newly increased fixed assets (NIFA) is the investment variable that is consistent with the SNA. Data on newly increased fixed assets in the total economy are published for the period 1981-present. Prior to 1981, we only have NIFA data on basic construction for the state-owned sector.

a. NIFA 1981-present, total economy

NIFA data are published from 1981 onwards. Using the proportions from TIFA, these can be broken down by different types of investment. From 1981 onwards, the statistical yearbooks provide data on two types: basic construction and technical renovation in NIFA. From 1986, data are provided for all four types: basic construction, technical renovation, real estate development and other.

Between 1981 and 1986, the difference between total NIFA and basic construction and technical renovation equals real estate development plus other investment. Thus, from 1981 onwards, we can reconstruct series of NIFA for three types of investment:1. basic construction, 2. technical renovation, 3. real estate development and other investment (see figure 6 in section 4.3)

b. *Reconstructing NIFA 1953-1980, total economy*

From 1953-1980, the only data we have are on NIFA-basic construction in state-owned units (NIFA-BAC-SOU). In this period *real estate development* was included in the basic construction figures. For TIFA, we do have data on both basic construction and technical renovation (CSY, 2004, Table 6-6; DSIFA, 1997, p. 20 and p. 71). We can reconstruct total NIFA by applying the proportions of basic construction and technical renovation from TIFA. Thus we derive estimates for total NIFA in SOUs.

c. Coverage adjustments State-owned units – total economy 1953-1980

The NIFA estimates under (b) refer only to state-owned units. Thus we have to make a coverage adjustment to get an estimate for the total economy, 1953-1990..

Using available information about the original value fixed assets (OFA) in the industrial sector, we calculate the ratios of non-SOU/SOU OFA in industry (ratio-a) for the period 1953-1999. From 1980 to 1996, we have time series of TIFA in state-owned units as well as for the total economy including non-state owned units. Thus we can calculate the ratio of non-SOU/SOU TIFA for all years between 1980 and 1996 (ratio-b). We can compare the ratios a and b for the overlapping years 1980-1996. Ratio-b was twice ratio-a in 1980. It increases to four times ratio a by 1985, due to the decline of the share of the state owned sector.

Considering that the industrial structure in China didn't change much before 1980, we therefore rely on the 1980 ratio of 2 to 1 to adjust the earlier OFA based ratios of non-SOU/SOU upwards. These adjusted ratios are used to make the coverage adjustment non-state owned state-owned NIFA from 1953-1980.

d. Change in coverage in 1997

Prior to 1997, the published TIFA and NIFA series include investment of sums of 50 thousand yuan or more. After 1997, the 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 1953-1996 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.

The result of steps a, b, c and d is a time series of NIFA investment in the total economy from 1953 till 2003.

6.2.2 Productive NIFA (P-NIFA) in the total economy

To be consistent with SNA concepts, the non-productive part (e.g. residential housing and other non-productive investment) has to be deducted from NIFA. 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 shares of productive investment in those four groups respectively, and then summed. This method requires detailed information on shares of productive investment in each of the categories. For instance, it is known that the productive ratio in real estate development is very low, about 17%-26% during 1997-2003. However, the shares for the other investment types of NIFA are not known.

(2) The ratio of productive to total investment for total NIFA is applied to each of the investment types. The share of productive investment to total investment is published once every five years from 1953 to 1995 (DSIFA 1997, pp.98). After 1995, we use the 1995 ratio.

This results in a time series of P-NIFA in the total economy from 1953 to 2003.

6.2.3 Productive NIFA in industry (P-NIFA-Industry) and manufacturing (P-NIFA manufacturing)

The next step is to construct a series of P-NIFA in the industrial sector and the manufacturing sector

In section 5.5 we have explained that the method used by Chen et. al. (1988) and Wu and Xu (2002) will tend to overestimate productive investment, because it only deducts housing investment from total NIFA.

Our procedure is to derive productive NIFA in industry from the time series of productive NIFA in the total economy. This is done as follows:

a. For the period 1985-2003, we calculate the ratio of capital investment in industry (investment in NIFA-basic construction plus NIFA technical renovation) to capital investment in the total economy (investment in NIFA-basic construction plus NIFA technical renovation).[22]
b. We apply this ratio to P-NIFA in the total economy and thus derive an estimate of productive NIFA in the industrial sector for the period 1985-2003.[23]
c. We compare the P-NIFA-industry series with the series of NIFA derived by deducting OFA(t-1) from OFA(t) for the period 1985-2003. The difference between the two series provides an estimate

[22] Given that there are no NIFA data for the category ‘ *other’* , which is actually only a small part in productive - NIFA, our calculation is mainly based on the two major categories: investment in NIFA-basic construction and NIFA -technical renovation.

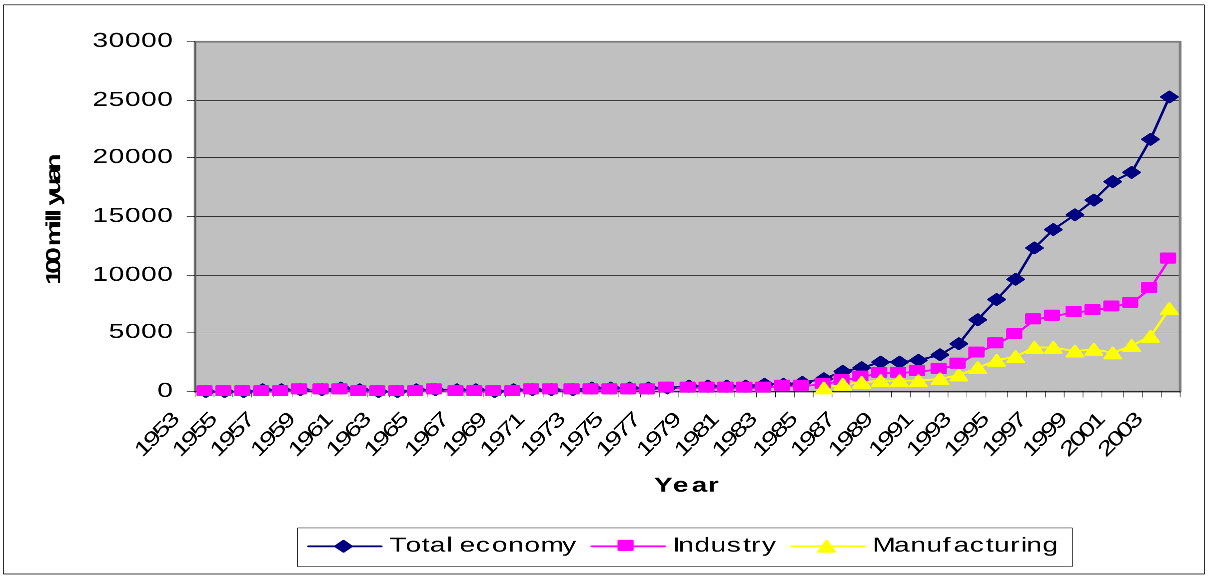
[23] An alternative would be to apply the ratio NIFA-industry/NIFA-total for investment in basic construction + technical renovation to NIFA-total. But, this would lead to biased results because real estate development (non-productive) has a rather big share in NIFA total.

of non-productive investment. The average share of non-productive investment for the whole period is 12.6 %.[24]

d. We apply this ratio to the NIFA-industry data estimate from OFA for the period 1953-1984. This gives us an estimate of P-NIFA in industry between 1953 and1984.

For Manufacturing , we use the same method as for P-NIFA in industry. After obtaining productive NIFA for the total economy, we apply the ratio of investment in manufacturing to total investment for NIFA in the categories basic construction plus technical renovation. However in the case of manufacturing, we can only estimate productive NIFA from 1985 onwards. The OFA data used to estimate NIFA in industry for the earlier years, are not available for the manufacturing sector.

Figure 7: Productive Newly Increased Fixed Assets in Total Economy, Industry and Manufacturing, 1953-2003



Note: at current prices. The coverage is 500 thousand yuan and above.
Sources: Various China Statistical Yearbooks; DSIFA 1997 and 2002; and our own calculations.

6.2.4 Breakdown of productive investment in industry into non-residential fixed structures, machinery and equipment and other.

We want to break down the productive NIFA data in industry into three content categories: non-residential fixed structures, machinery and equipment and other investment. Direct information for this is not available.

As explained in section 4.2, we do have data on TIFA in the total economy for three content categories of investment in fixed assets: construction and installation, purchase of equipment and instruments, and other investment (see figure 2). Proportions from TIFA from the total economy can be used to make a breakdown of productive NIFA in industry into three content categories.

In order to do this, we first have to make an adjustment for investment in residential fixed structures. These are productive from the perspective of the total economy, but non-productive from the perspective of the industrial sector.

[24] This confirms that the use of an average ratio of residential to total fixed assets of 8.2% in Chen et al (1988) results in an overestimation of the real productive NIFA in industry.

In the total economy, we start by excluding real estate development which consists mainly of non-productive investment. We also disregard the less important type 'other' which does not contribute much to P-NIFA. We focus on the main types: basic construction and technical renovation. For the years 1981-2003, each of these can be broken down by content into *construction and installation, purchase of equipment and instruments and others,* (CSY 1996-2004, see also figures 3 and 4). In addition, we have data on investment in residential construction in both basic construction and technical renovation. We use this information to calculate the shares of non-residential fixed structures (FS), machinery and equipment (ME) and other (OT) in TIFA as follows:

$$\text{FS share in TIFA} = \frac{(BCFS - BCresidential) + (TRFS - TRresidential)}{BC - BCresidential + TR - TRresidential} \quad (20)$$

$$\text{ME share in TIFA} = \frac{BCME + TRME}{BC - BCresidential + TR - TRresidential} \quad (21)$$

$$\text{Other share in TIFA} = \frac{BCOT + TROT}{BC - BCresidential + TR - TRresidential} \quad (22)$$

Unfortunately, from CSY 2005 onwards, the TIFA and the NIFA data are only available for urban investment, so we cannot extend our series beyond 2003. The results of this exercise are reproduced in table 6. These proportions are subsequently applied to the NIFA data for industry.

Table 6: Proportions of Investment Categories in TIFA (%) (Total economy, 1981-2003)

Year	Non-residential construction and installation	Machinery and equipment	Others	Year	Non-residential construction and installation	Machinery and equipment	Others
1981	59.2	33.6	7.1	**1993**	52.9	32.0	15.0
1982	58.9	33.4	7.8	**1994**	52.7	32.7	14.6
1983	56.9	35.3	7.7	**1995**	55.2	27.9	16.9
1984	55.0	37.2	7.8	**1996**	52.3	30.9	16.8
1985	53.3	37.8	8.9	**1997**	52.2	29.7	18.2
1986	54.7	36.4	8.9	**1998**	51.5	30.9	17.6
1987	53.8	36.5	9.7	**1999**	51.1	30.7	18.1
1988	53.6	36.6	9.8	**2000**	50.4	30.7	18.9
1989	56.0	34.7	9.3	**2001**	49.7	29.4	20.9
1990	55.0	34.8	10.2	**2002**	48.5	29.5	22.0
1991	53.4	35.0	11.6	**2003**	49.2	30.3	20.5
1992	54.2	33.4	12.4	**2004**	52.3	30.9	16.8

Note: Proportions are calculated from Basic construction and Technical renovation after the deduction of residential housing investment. The residential housing construction data are only available from 1981-2000, we apply the average residential ratio in TIFA (1996-2000) to 2001-2004. Sources: From Statistics on Investment in Fixed Assets of China, 1950-2000, p.30, and China Statistical Yearbooks, 2005**,** p.186.

We apply the proportions of table 6 to P-NIFA in industry. This results in time series of investment in machinery and equipment, non-residential fixed structures and other assets in industry for the period 1981-2003.

We apply the average of the proportions 1981-2003, to break down P-NIFA for the earlier period 1953-1980. The same procedure is followed for manufacturing.

6.3 Price Deflators

Price indices also play an important role in measuring the value of fixed assets at constant prices, given that NIFA is available at acquisition prices. We apply specific price indexes for each of the three categories: construction and installation, purchase of machinery and equipment, and other investment for the period 1992-2004. For the period 1953-1991, we have used the aggregate price index for fixed assets, as specific deflators for the three investment categories were not available.

6.4 Initial Capital Stock

To assess the initial or benchmark 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. Such series are unavailable. Therefore, we need to estimate the initial capital stock by proxy methods (e.g. Huang et al., 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 (ICORs) for this purpose (Osada, 1994). The assumption underlying these procedures is that the capital-output ratio is sufficiently stable, so that incremental capital output ratios approximate the average capital-output ratios.

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

$$V_0 = IN_0 \cdot \frac{g+1}{g+d} \qquad (23)$$

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

In the literature, various estimates of the benchmark capital stock have been made. Based on Chow (1993, p. 822 and 823), Chow and Li (2002) estimate the initial stock in the total economy at 221.3 billion yuan at the end of 1952, reaching 1411.2 billion yuan by the end of 1978, Wang and Yao (2003) at 175 billion yuan. Chen et al. (1988) have a 14.88 billion initial capital stock in industry in 1952.[25] Jefferson, Rawski and Zheng (1992) estimate a net value of productive fixed assets in industry in 1980 of 228.59 billion yuan (at 1980 prices).[26]

[25] The original cost of fixed assets of independent accounting units within state-sector industry is taken as the initial industrial capital stock.

[26] Jefferson et al. (1992) estimate the net value of productive fixed assets at end of 1979 through the net value of fixed assets and the ratio of productive to total fixed assets (i.e. NFA*productive ratio).

Applying the ICVAR method proposed by Timmer, we average the ICVARS for 1952 to 1957 and use these to calculate the initial capital stock. We find a capital stock in 1952 of 84.3 billion yuan (at 1952 prices) in the total economy and a capital stock of 19.9 billion yuan (at 1952 prices) in industry. This is much lower than Chow and Li and Wang and Yao, but in the same ballpark as Chen et al.

Due to the lack of data in manufacturing in the early years, we construct a capital stock series for manufacturing from 1986 onwards, with an initial capital stock at 407,8 billion yuan in 1986 (at 1952 prices).

6.5 *Service Lives*

Service lives are 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[27], which is so far the most informative 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 a service life of 7 years for this category.

On fixed assets in industry, there is a widely used document, Regulation of Industrial Enterprises[28], published by the Financial Department of China and valid since 1993. With the data from this source, we find an average service life of 14 years for machinery and equipment, 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 dates from 1984. The later set of estimates are more appropriate for recent years, mainly because there are more product innovations in the market and obsolescence rates are increasing especially in high-tech sectors related to computing and the internet (OECD, 2001a, p.50).

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

6.6 *Age-Efficiency Patterns*

As explained in section 2.3 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. In this paper, we apply hyperbolic decay functions as proposed by Bureau of Labour Statistics and the Australian Bureau of Statistics to derive the efficiency of fixed assets in Chinese total economy, industry and manufacturing. The hyperbolic age-efficiency function used by BLS and ABS 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 a value of 0.5 for equipment and of 0.75 for structures.

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

The age efficiency function is used to derive the efficiency coefficients for the NIFA of each year and to express the productive capability of investments in standardised efficiency units. PIM is applied to efficiency adjusted investment series.

6.7 Estimates of the Capital Stock: Summary

We can summarise our procedures for construction a capital stock for the industrial sector as follows:

1. We construct a time series for investment for the total economy for the period 1953-2003, using the concept of Newly Increased Fixed Assets (NIFA). Data on total NIFA are published from 1980 onwards. From 1953 to 1980, there are published data on NIFA in *basic construction* in state owned enterprises. We use proportions of total investment to investment in basic construction from TIFA to adjust the published NIFA series upwards to arrive at an estimate of total investment in state-owned units..
2. The NIFA series for the total economy are adjusted for changes in coverage in 1980 and 1997.
3. We derive estimates of productive NIFA (P-NIFA) in the total economy from the NIFA series in 2.
4. We apply the ratio of investment in industry to investment in the total economy to P-NIFA in the total economy. For this, we use investment ratios in the combined categories basic construction and technical renovation. This gives us a series of productive NIFA in the industrial sector.
5. Applying ratios of investment in machinery and equipment, non-residential fixed structures, and other assets from TIFA for the total economy, we decompose productive NIFA in industry into these three categories since 1981. We apply the average of the content proportions 1981-2003, to break down P-NIFA for the earlier period 1953-1980.
6. The investment in the three categories is deflated using appropriate deflators.
7. An estimate of the initial capital stock is estimated for industry for 1952, using incremental capital value added ratios.
8. Investments are standardised for productive efficiency using a hyperbolic decay function.
9. We apply a PIM with appropriate service lives for the three asset categories, resulting in a efficiency standardised capital stock series. For the period 1952-1989, we assume a service life of 30 years for construction, 16 years for machinery and equipment, and 7 years for other assets. From 1990 onward, we use service lives of 27 years for construction, 14 years for machinery and equipment, and 6 years for other assets.
10. The capital stock series are used as a proxy for the index of capital service inputs

The same procedures have been applied for manufacturing. Here we estimate an initial stock for 1985. Data to construct productive NIFA in manufacturing prior to this year are not available.

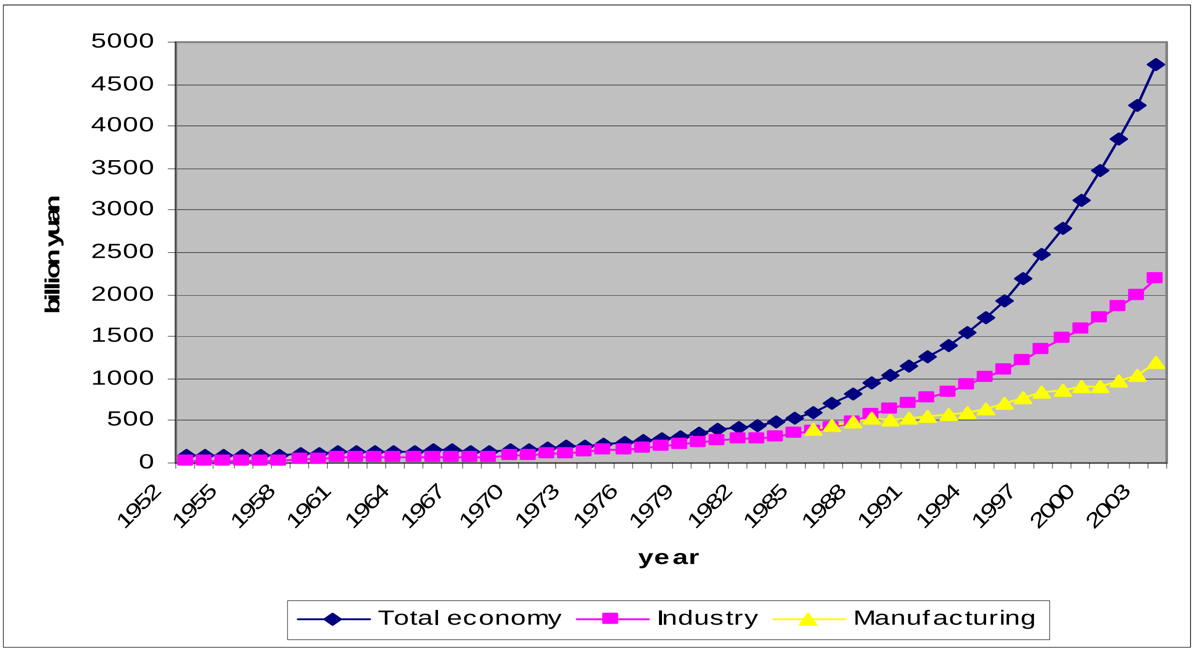
The final results are reproduced in table 7 and figure 8.

Table 7: Productive NIFA and estimated productive capital stock (100 million yuan)

	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

Table 7 Sources: 1) P-NIFA in total economy from DSIFA, 1997, p.62; DSIFA, 2002, p.77; and productive ratio from DSIFA, 1997, p.98. 2) P-NIFA in industry (1953-1984) is from the (CIESY04-p.25, CIESY95-p.53) after applying a (calculated) industry productive ratio; the P-NIFA in industry (1985-2003) is derived from P-NIFA-total 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).

Figure 8: Estimates of the Capital Stock in Total Economy, Industry and Manufacturing, 1952-2003 (at 1952 prices)



Source: table 7

7 Regional Capital Input Estimates, 1978-2003

The regional capital input estimates for 30 Chinese regions are derived from the aggregate national estimates of productive NIFA (P-NIFA) in industry and manufacturing discussed in section 6.2.3 (see table 7 and figure 8). Regional shares in investment are used to calculate P-NIFA at regional levels. The procedures for estimating regional capital inputs can be summarised as follows:

1. Estimating regional series of Productive NIFA, 1953-1980.

   There are published regional data on TIFA in basic construction (BC) from 1953 to 1980. Regional shares in TIFA-BC in the total economy are applied to the aggregate national series on P-NIFA in industry. This provides us with regional estimates of P-NIFA in industry, 1953-1980. The reason for using total economy regional shares, rather than regional shares in industrial investment, is that data on the latter are not available. As can be seen in figure 8, prior to 1980 industrial investment accounts for most of aggregate investment, so there is no major bias involved.

2. Estimating regional series of Productive NIFA, 1980-1994.

   There are published regional data on TIFA in basic construction (BC) and technical renovation (TC) in the total economy from 1980 till 1994. Regional shares in TIFA-BC + TIFA (TC) are applied to break down the aggregate series on P-NIFA in industry, by region. This provides us with regional estimates of P-NIFA in industry, 1980-1994.

   The P-NIFA series in manufacturing start in 1985. Regional shares in TIFA-BC + TIFA (TC) are applied to breakdown the aggregate series of P-NIFA in industry. This provides us with regional estimates of P-NIFA in manufacturing, 1985-1994.

   As in step 2, the use of regional shares in total investment, rather than industrial investment to breakdown the series is a second best solution. Data on regional industrial investment is not available.
3. Estimating regional series of Productive NIFA, 1995-2003.

   There are published regional data on NIFA in basic construction (BC) and technical renovation (TC) from 1995 to 2003 in both industry and manufacturing. Regional shares in NIFA-BC + NIFA-TC in industry are applied to the aggregate national series on P-NIFA in industry; regional shares in manufacturing are applied to P-NIFA in manufacturing. This results in regional series of productive NIFA in both industry and manufacturing, 1995-2003.
4. As in the estimates for the national economy, we apply regional content proportions from TIFA for the total regional economy to break down regional P-NIFA into three content categories non-residential construction and installation, purchase of equipment and instruments and other investment. At the regional level the breakdown of TIFA into content categories and the information on residential fixed structures is only available from 1995 to 2003 (CSY 1996-2004). For the years prior to 1995 (industry 1978-1995 and manufacturing 1985-1995), we apply the average content proportions for the period 1995-1999. From CSY 2005 onwards, the TIFA and the NIFA data are only available for urban investment, so we cannot extend our series beyond 2003.
5. Regional Investment in the three categories is deflated using the national deflators for the three categories, as described in section 6.
6. Estimates of the initial regional capital stocks in industry are made for 1953, using incremental value added ratios. Estimates of the initial regional capital stocks in manufacturing are made for 1985, applying the same methodology.
7. The regional investment series are adjusted for efficiency decay, using the hyperbolic efficiency decay function.
8. We apply a PIM with appropriate service lives for the three asset categories, resulting in a efficiency standardised regional capital stock series.
9. The capital stock series are used as a proxy for the index of regional capital service inputs.

See Table 8 provides the resulting regional time series for capital stocks in manufacturing. Table 9 provides the same information on industry by region**.**[29] [30]

[29] In table 9, we only report the regional capital input estimates for industry from 1978 onwards.

[30] There are small discrepancies between the national totals in table 9 and the aggregate data in table 7. This is due to the fact that we applied regional proportions in the calculations.

Table 8: Estimated Productive Capital Stock in Manufacturing by Region, 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total	***4117.68***	***4494.76***	***4902.02***	***5341.83***	***5075.76***	***5335.56***	***5599.34***	***5840.19***	***6027.10***	***6571.40***	***7130.37***	***7792.40***	***8387.69***	***8798.66***	***9102.56***	***9139.68***	***9786.57***	***10600.80***	***11989.81***
Beijing	208.09	228.88	252.65	276.56	250.27	264.55	275.75	285.44	291.24	342.13	345.27	375.17	383.31	385.77	378.77	351.07	364.73	367.85	370.07
Tianjin	110.63	123.22	134.13	144.29	135.11	140.77	149.81	156.60	155.85	168.05	201.84	218.72	229.21	248.88	268.12	278.88	295.38	309.04	321.97
Hebei	166.92	181.26	196.53	214.54	206.52	216.62	225.04	234.39	240.48	260.67	296.62	337.23	378.51	410.17	464.09	480.57	517.09	560.80	654.57
Shanxi	139.40	155.57	169.63	181.64	171.04	180.23	189.68	195.40	195.72	202.56	203.88	205.81	207.52	204.77	195.03	190.61	202.64	243.37	286.78
Inner	75.74	83.35	90.06	96.85	90.67	96.41	103.72	112.24	120.14	130.19	148.16	150.73	153.98	152.96	148.07	138.57	145.01	170.52	213.96
Liaoning	299.18	326.66	358.52	392.83	377.17	393.61	410.24	421.94	430.22	458.21	504.17	555.09	596.02	614.68	593.07	594.19	622.82	650.17	719.26
Jilin	89.00	97.32	106.67	117.95	112.47	117.35	122.57	127.57	132.60	142.80	154.29	213.04	247.66	277.42	289.41	295.23	312.75	337.18	378.26
Heilongjiang	174.02	191.31	209.53	227.86	217.24	227.06	234.80	239.18	237.87	249.34	256.99	268.32	275.34	278.77	276.45	265.63	285.23	296.69	329.05
Shanghai	293.25	317.60	346.73	380.93	364.98	383.21	398.12	406.29	420.28	469.39	515.52	566.22	634.13	666.77	749.50	764.20	803.38	823.09	888.23
Jiangsu	205.91	226.02	249.98	275.36	262.38	272.66	284.23	298.56	308.66	331.48	387.77	437.79	484.16	529.06	553.03	579.49	664.17	749.88	887.38
Zhejiang	109.80	120.21	131.19	142.49	136.18	142.75	149.27	156.71	165.00	183.43	202.45	227.66	258.03	281.10	306.86	315.81	358.95	415.02	493.95
Anhui	104.48	116.21	126.56	136.63	129.76	135.51	140.84	146.44	148.08	157.69	178.00	206.89	227.89	233.17	247.75	251.62	271.38	293.21	336.83
Fujian	89.28	97.65	107.01	115.74	109.98	115.52	121.19	126.78	132.74	147.03	155.42	165.11	178.78	189.58	201.05	223.47	243.88	277.13	313.47
Jiangxi	68.59	75.21	81.17	87.60	83.38	87.96	92.32	95.92	98.57	106.50	117.97	124.21	136.78	140.66	141.30	142.75	147.11	156.56	184.48
Shandong	227.27	246.55	268.86	297.28	283.46	297.50	312.11	326.98	336.50	362.72	400.90	439.08	477.98	519.16	567.88	581.85	649.72	762.86	971.78
Henan	141.47	155.03	167.82	184.16	176.44	184.78	195.93	204.83	211.34	232.29	258.61	293.92	342.18	356.90	371.40	370.35	398.91	450.94	509.64
Hubei	143.70	158.09	173.26	189.78	178.97	187.31	194.90	203.92	211.94	234.75	259.63	343.18	393.44	436.50	456.45	466.60	505.10	540.28	605.15
Hunan	106.19	116.44	126.89	138.11	131.35	137.80	145.28	154.37	159.03	171.82	188.77	206.58	229.03	232.90	230.33	233.70	254.85	273.72	315.37
Guangdong	358.39	391.89	422.21	458.57	434.30	459.15	484.66	515.94	545.20	612.85	631.26	669.47	703.05	768.40	799.21	803.87	847.14	945.44	1031.75
Guangxi	69.59	76.70	84.22	93.21	89.09	92.43	96.40	101.87	109.91	122.63	152.72	159.68	164.46	167.05	166.07	168.64	175.98	181.55	210.07
Hainan	25.79	24.97	24.05	26.55	26.95	30.84	34.40	38.82	46.32	56.23	63.96	74.41	82.43	84.92	81.52	77.07	75.64	73.74	75.90
Sichuan	227.72	247.20	269.30	291.79	278.69	293.86	309.83	322.56	328.60	351.15	384.90	406.09	437.07	449.96	452.28	449.68	479.16	520.10	610.17
Guizhou	52.30	57.34	62.06	67.13	63.91	67.30	70.54	73.21	73.76	77.92	82.52	86.20	91.72	94.32	105.26	108.46	119.60	125.85	136.11
Yunnan	71.36	78.30	84.80	92.17	87.25	91.89	98.05	104.40	111.80	123.96	147.49	168.50	188.17	203.11	208.62	207.62	216.64	224.51	228.73
Tibet	9.55	10.50	11.18	11.88	11.09	11.87	12.89	13.66	14.18	15.25	14.72	14.46	13.60	12.64	11.27	9.81	9.49	9.07	9.03
Shaanxi	103.30	112.75	122.76	132.84	126.95	133.52	138.56	140.66	142.25	149.28	158.10	168.07	168.71	176.78	184.22	179.90	194.74	215.70	243.36
Gansu	69.57	75.79	82.72	90.09	85.40	89.93	93.71	95.66	93.77	96.85	103.02	112.64	120.34	123.15	138.86	141.39	153.41	158.10	189.86
Qinghai	30.01	33.65	37.14	40.67	38.44	39.71	40.68	40.83	40.41	41.39	41.07	40.63	40.80	41.04	38.85	35.80	36.18	37.06	38.82
Ningxia	25.84	28.72	31.60	33.55	31.51	33.06	34.60	35.60	35.34	36.97	38.10	38.74	40.01	39.07	39.19	43.17	54.36	57.83	64.89
Xinjiang	86.93	93.44	99.59	107.10	101.24	108.80	116.47	126.12	134.28	146.73	165.85	172.71	182.63	187.46	183.70	180.28	183.85	189.58	200.81
Not classified	234.43	246.95	273.21	295.69	283.57	301.61	322.75	337.30	355.02	389.14	370.40	346.07	320.79	291.58	254.96	209.38	197.30	183.96	170.11

Note: at 100 mill yuan, 1952 constant price. Chongqing is included in Sichuan. Sources: authors' estimates.

Table 9: Estimated Productive Capital Stock in Industry by Region

	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	***2233***	***2420***	***2591***	***2786***	***2995***	***3226***	***3461***	***3736***	***4291***	***4985***	***5739***	***6384***	***7042***	***7748***	***8498***	***9272***	***10161***	***11158***	***12324***	***13604***	***14878***	***16138***	***17402***	***18653***	***20141***	***22203***
Beijing	84	93	104	114	122	133	145	161	192	230	270	302	335	364	394	425	508	521	555	581	610	641	667	711	711	721
Tianjin	52	60	67	75	84	94	102	113	131	149	166	182	197	219	239	251	271	322	354	377	413	454	478	510	540	573
Hebei	107	119	129	139	149	161	170	179	199	224	254	279	304	329	359	388	420	476	546	607	670	772	843	929	982	1084
Shanxi	74	80	86	91	98	106	119	132	155	178	198	219	240	263	282	297	310	331	347	384	420	434	474	506	624	685
Inner	37	43	47	51	56	63	71	78	88	99	110	121	133	149	168	188	204	242	257	267	292	334	332	339	384	481
Liaoning	145	154	165	180	193	206	220	238	281	336	396	449	494	544	591	641	689	750	824	897	970	991	1043	1093	1138	1220
Jilin	59	64	69	74	79	85	89	94	106	121	140	153	165	179	194	212	228	247	312	354	396	422	456	494	534	585
Heilongjiang	104	112	122	135	148	162	174	184	209	239	269	294	319	342	363	381	399	430	458	509	571	615	663	724	782	853
Shanghai	67	76	88	104	123	143	164	185	226	281	344	397	448	496	540	600	683	747	838	935	1013	1222	1315	1349	1351	1410
Jiangsu	66	76	85	94	104	116	129	144	176	219	265	299	329	365	408	450	489	566	641	709	800	896	999	1106	1231	1408
Zhejiang	35	40	44	50	57	63	70	78	94	114	135	154	172	191	214	241	272	308	350	417	470	525	581	694	828	915
Anhui	60	64	68	73	78	84	90	98	115	132	150	165	180	196	214	229	245	275	329	378	393	421	464	490	519	565
Fujian	31	34	38	42	46	51	57	64	77	94	110	125	140	156	174	194	218	236	256	298	338	379	422	459	506	543
Jiangxi	41	44	47	50	54	59	65	69	78	89	99	110	121	132	144	156	169	186	198	226	238	247	263	270	285	331
Shandong	96	106	116	126	138	150	161	175	205	245	295	332	370	411	457	500	545	613	681	791	879	975	1106	1232	1399	1702
Henan	97	104	109	118	126	134	143	152	171	192	218	241	261	288	314	340	373	432	502	593	659	706	740	809	890	984
Hubei	138	147	155	164	171	178	185	193	210	233	259	275	294	313	338	364	399	426	518	582	663	716	764	810	863	1011
Hunan	74	79	84	89	95	101	107	114	128	145	163	178	194	213	236	256	276	298	328	362	379	403	432	457	480	543
Guangdong	90	98	106	120	138	157	180	213	269	328	401	459	526	598	685	778	892	975	1079	1155	1271	1346	1437	1499	1656	1770
Guangxi	45	48	51	54	57	60	63	67	77	90	105	116	125	136	151	171	192	232	248	259	270	283	326	339	348	389
Hainan	2	2	2	1	2	2	3	3	4	4	5	14	23	32	43	58	75	90	103	112	116	118	120	118	116	120
Sichuan	163	171	178	186	194	204	213	226	253	290	328	364	401	442	482	517	553	608	647	709	826	889	941	986	1058	1163
Guizhou	54	57	59	62	63	65	67	70	76	83	90	98	105	113	121	127	132	147	165	175	183	215	244	264	284	308
Yunnan	60	64	68	71	76	80	84	89	98	108	119	128	139	152	168	187	205	236	270	295	324	345	358	387	420	441
Tibet	6	7	7	7	8	8	10	12	13	14	15	16	18	20	22	24	26	28	28	28	27	28	30	30	31	32
Shaanxi	88	92	97	101	106	110	114	119	131	147	163	178	194	208	220	234	245	255	276	292	315	351	374	405	443	497
Gansu	67	70	72	74	76	78	81	84	91	102	113	122	132	142	150	154	159	166	180	205	220	243	268	294	311	355
Qinghai	25	30	32	34	36	38	41	43	47	52	58	61	64	67	69	71	72	76	84	98	105	113	116	126	131	130
Ningxia	17	19	20	20	21	22	23	25	29	34	38	41	45	49	53	55	58	60	64	77	82	84	94	109	119	134
Xinjiang	43	49	55	61	67	73	78	84	94	104	117	130	147	165	189	211	231	271	298	341	374	402	466	511	551	607
Not classified	205	217	222	225	231	237	242	251	267	309	346	384	425	474	517	570	624	607	588	592	592	569	588	604	628	644

Note: at 100 mill yuan, 1952 constant price. Chongqing is included in Sichuan. Source: authors' estimates.

Annex A: Relationships between Rental Price and Value of Fixed Assets

Value of a s-year-old fixed asset at time t should equal to all the profits gained by this fixed asset in the following service years deflated into the present value of t. Assuming r is the discount rate, $P_{t,s}$ is the rental price at year t aged s, value of fixed can be expressed as

$$V_{t,s} = \frac{P_{t,s}}{1+r} + \frac{P_{t+1,s+1}}{(1+r)^2} + \cdots + \frac{P_{t+(T-s)-1,T}}{(1+r)^{T-s}} + \frac{Scrap}{(1+r)^{T-s}} \tag{1}$$

The last term on right hand in equation (1) is the deflated crap value of this certain fixed assets when it is discarded at the end of its service life (year T).

Accordingly, after one year in use, its value will be

$$V_{t+1,s+1} = \frac{P_{t+1,s+1}}{1+r} + \frac{P_{t+2,s+2}}{(1+r)^2} + \cdots + \frac{P_{t+(T-s)-1,T}}{(1+r)^{T-s-1}} + \frac{Scrap}{(1+r)^{T-s-1}} \tag{2}$$

(1)-(2)*(1/(1+r))

$$V_{t,s} - V_{t+1,s+1} \cdot \frac{1}{1+r} = \frac{P_{t,s}}{1+r} \tag{3}$$

then we have

$$V_{t,s} + r \cdot V_{t,s} - V_{t+1,s+1} = P_{t,s} \tag{4}$$

If $\delta_{t,s}$ is assumed as the depreciation rate of this s-year-old fixed asset at time t is

$$\delta_{t,s} = \frac{V_{t,s} - V_{t+1,s+1}}{V_{t,s}} \tag{5}$$

Then equation (4) can produce

$$V_{t,s} \cdot (\delta_{t,s} + r) = P_{t,s} \tag{6}$$

If we apply the efficiency rate ϕ_s to substitute the $P_{t,s}$, furthermore, we will get

$$V_{t,s} \cdot (\delta_{t,s} + r) = \phi_s \cdot P_{t,0} \tag{7}$$

For a s+1 year-old fixed asset, we can get

$$V_{t,s+1} \cdot (\delta_{t,s} + r) = \phi_{s+1} \cdot P_{t,0} \tag{8}$$

If we assume that depreciation rate keeps constant, dividing (8) by (7), we have

$$1 - \delta = \frac{\phi_{s+1}}{\phi_s} \tag{9}$$

Thus the depreciation rate and the productive efficiency can be connected. (See also, Hulten, 1990 and OECD, 2001a,p.87)

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