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New capital estimates for China

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Abstract

Data on physical capital are an indispensable part of economic growth and efficiency studies. In the case of China, economy-wide fixed asset series are usually derived by aggregating gross fixed capital formation (net of depreciation) over time, and sectoral/ownership-specific series by correcting the limited official fixed asset data available. These procedures, to varying degrees, ignore that (i) gross fixed capital formation does not equal investment, (ii) investment does not equal the value of fixed assets newly created through investment, (iii) depreciation is an accounting measure that bears no necessary relation to changes in the production capacity of fixed assets, (iv) official fixed asset data, where available, incorporate significant revaluations in the 1990s, and (v) "net fixed assets" do not measure the contribution of fixed assets to production.

This paper derives economy-wide fixed asset values for 1953–2003, correcting for these shortcomings. It uses both the traditional, cumulative approach and a new, so far unexplored method of combining economy-wide depreciation values and an economy-wide depreciation rate to directly yield economy-wide fixed assets. The derived fixed asset time series are evaluated in a comparison with each other as well as with series in the literature, leading to the recommendation of a specific choice of fixed asset time series.

JEL classification: E22; C80; D24; O47; P23; P24; C43; E10; O40
Keywords: Capital; Investment; National income accounting; Production function estimations; Chinese statistics; Fixed assets; Measurement of economic growth

1. Introduction

Studies of economic growth and inquiries into sector- or ownership-specific efficiency levels require data on physical capital stock. Economy-wide fixed asset time series for China are usually

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derived by aggregating net investment over time. Fixed asset time series for subsets of the economy are usually obtained by correcting the limited official fixed asset data that are available. Yet a closer examination of these procedures reveals major shortcomings.

In the literature, economy-wide capital values are obtained by accumulating gross fixed capital formation less depreciation over time, with all values at constant prices.[1] This ignores that (i) gross fixed capital formation does not equal investment, (ii) investment does not equal the value of fixed assets newly created through investment, and (iii) annual depreciation is an accounting measure that bears no necessary relation to changes in the production capacity of fixed assets. The margins of error due to these three shortcomings appear on the order of approximately −10% to +45% overestimation of investment expenditures, 20% overestimation of effective investment, and up to 500% overestimation of decommissioned fixed assets by applying depreciation rather than scrap rates.

In sectoral analysis, of, for example, industry, where current-price fixed asset data are available for some ownership groups, the significant revaluations of the mid-1990s embedded in the fixed asset data are routinely ignored.[2] This implies that the fixed asset data of the 1990s are price-adjusted twice, once in the official data themselves, and the second time by researchers through the procedures they have adopted to price-"correct" the official data. Some studies, furthermore, rely on the variable "net fixed assets," an accounting artifact that does not reflect the contribution of fixed assets to production.

This paper focuses on economy-wide data. It clarifies the meaning of fixed assets in Chinese statistics and lays out the logical relationships between fixed assets and relevant other variables. The values of these variables are derived. Fixed asset time series are constructed based on two different approaches. The first follows the traditional method of accumulating investment over time. The second relies on the national income (and product) accounts (NIA); economy-wide depreciation in the income approach to the calculation of gross domestic product (GDP) is divided by the economy-wide depreciation rate to directly obtain fixed assets.

The outcome of the two approaches is several economy-wide real fixed asset time series for China. These are evaluated and a recommendation is offered as to which series to choose. In contrast to the fixed asset time series constructed here, those in the literature, apart from being conceptually flawed, tend to exhibit lower long-run growth rates, a different growth pattern in the reform period, and an often implausible relationship to GDP over time.[3]

2. Fixed asset definition

The term "fixed assets" (*guding zichan* [*heji*]) in China's accounting system denotes the sum of (i) net fixed assets (*guding zichan jingzhi*), (ii) corrections to fixed assets (*guding zichan qingli*)

[1] See, for example, Gregory Chow and Li Kui-Wai (2002), Alwyn Young (2003), Wang Yan and Yao Yudong (2003), or Wu Yanrui (2004). Gregory Chow and Li Kui-Wai further include inventory investment, and Wu Yanrui does not precisely specify the investment variable he uses. Gregory Chow (1994) relies on "accumulation," a variable of the earlier used Material Product System that approximately corresponds to gross capital formation, and seems to assume a depreciation rate of zero.

[2] See, for example, Chen Kuan et al. (1988) or Gary Jefferson et al. (1992, 1996, 2000).

[3] This paper improves over an earlier working paper version in that it newly introduces Eqs. (7) and (8) for the construction of the real fixed asset series and explores different options on how to deflate the value of decommissioned fixed assets. It slightly adjusts the linear interpolation of the scrap rates in 1993–2002 (following new considerations on what final scrap rate value is plausible), corrects a previous mistake in one type of series in the NIA approach, and introduces a number of minor refinements. I am grateful for comments from Thomas G. Rawski and critical questions from Zhao Minqiang, Kent.

due to, for example, sale, damage, or the decommissioning of the fixed asset, (iii) fixed assets under construction (*zaijian gongcheng*), and (iv) unresolved net losses on fixed assets (*dai chuli guding zichan jing sunshi*). The first item in this list, net fixed assets, is by far the largest in size; it is officially obtained as the difference between the original value of fixed assets (*guding zichan yuanzhi*) and cumulative depreciation (*leiji zhejiu*).[4]

The balance sheet summary item "fixed assets" does not constitute a measure of the contribution of physical capital to production. The accounts "corrections to fixed assets" and "unresolved net losses on fixed assets" (items ii and iv) capture the counter entries in the double-entry bookkeeping system to changes in such accounts as "original value of fixed assets;" they reflect values of what no longer constitutes fixed assets. "Fixed assets under construction" (item iii) do not yet contribute to production. Net fixed assets (item i), as part of the balance sheet summary item or as independent measure of fixed assets, approximate a hypothetical remaining value of the stock of fixed assets rather than the contribution of fixed assets to production. For example, a machine (say, a computer) that has already been written off in full may still be in use and contribute as much to production as a new machine of the same quality, but its net fixed asset value is zero. Similarly, the fact that the hypothetical remaining value of a machine is 20% of its original purchasing price does not imply that its contribution to production is only 20% of what it was when the machine was bought.[5]

To illustrate further, picture a new factory building that houses ten new machines, and assume linear depreciation by 10% every year for both building and machines. In practice, it is not the case that on the last day of the first year one of the machines turns into dust and 10% of the building caves in, while the remaining walls and ceiling automatically reconfigure themselves to form a new building 90% the size of the original one (or that all machines now run 10% slower than originally and 10% of the rain and wind outside now enter the building). It is not the case that on the last day of the second year a second machine goes out and the building reconfigures itself yet again, etc. Yet this is what the use of the accounting artifact "net fixed assets" in production function estimations implies.

Viewed yet differently, output of a particular period is created by combining the inputs capital and labor (and other inputs). Labor is not adjusted for the *remaining* lifetime of the laborers employed in this period. Why should fixed assets be adjusted for the *remaining* lifetime after this period? Just as the variable labor in production function estimations is a count of the laborers (or their hours worked) during the production period, the appropriate fixed asset measure is a count of the fixed assets used during the production period.

This count is the original value of fixed assets, price-adjusted so that all fixed assets reflect a common price level.[6] Even a machine that is completely written off is included in the

[4] See, for example, Finance Ministry (1999), Vol. 1, p. 438, for the case of industry. The fourth item is a net item, i.e., unresolved losses on fixed assets less gains on fixed assets; this item comes from the account "unresolved losses or gains on fixed assets" (*dai chuli guding zichan sunyi*) (p. 430). Actual data following this breakdown of fixed assets are available for collective-owned township and village enterprises (*xiangzhen jiti qiye*). In 2002, net fixed assets accounted for 90.69% of their fixed assets, corrections to fixed assets for 0.33%, fixed assets under construction for 8.83%, and unresolved net losses on fixed assets for 0.15%. Cumulative depreciation was equivalent to 39.12% of net fixed assets, and the original value of fixed assets was indeed 139.12% of the net fixed asset value. (*TVE Yearbook 2003*, pp. 229f.)

[5] The value of depreciation and, thus, *net* fixed assets, furthermore, is determined by the government (and, where firms have some choice, possibly by tax considerations, competition, the speed of innovation and other factors). It is not clear why government-set depreciation rates should determine the physical contribution of buildings and machinery to the creation of output.

[6] The count could also be the rent that would have to be paid for these capital services if they were leased, in all likelihood corresponding to a *fixed percentage of the original value.*

account "original value of fixed assets," at its purchasing price, 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 date. Only once the machine is decommissioned is there an impact on production; the original value of fixed assets then reduces by the original value of this particular machine.[7]

Two complications of fixed assets measures for China are the following. First, the few data points on fixed assets that are available for specific enterprise groups in specific sectors of China's economy often reflect a total that consists of "productive" (*shengchanyong*) and "non-productive" fixed assets. If the objective is to relate, for example, industrial output to industrial inputs, industrial fixed assets should be free of non-productive components. However, if the objective is to relate economy-wide output to economy-wide inputs, all fixed assets are relevant, including the "non-productive" fixed assets. For example, because GDP includes imputed rent on housing, the non-productive fixed asset housing needs to be included on the input side. The capital–output ratio of housing could be higher than that of machinery in industry, but the mixing of very different production processes is a characteristic of all aggregate production functions.[8]

Second, the 1990s are marked by a series of revaluations. Rapid inflation in the late 1980s and mid-1990s meant that depreciation funds, based on the original value of fixed assets, became too low to replace obsolete fixed assets. In 1993, the government asked state-owned enterprises (SOEs) to revalue all fixed assets purchased before 1991 to market prices (and to raise their depreciation funds correspondingly); enterprises were allowed to spread the revaluation over several years if they could not afford to implement them immediately. Enterprises in other ownership forms were asked to follow suit in the following years.[9] Companies that want to list on the stock market undergo a complete audit (and possibly revaluation) prior to listing. As a result, after 1992 the aggregate stock of fixed assets in a particular ownership group and/or sector reflects an unknown mix of fixed assets valued at original prices and of fixed assets valued at current market prices. In the

[7] An appendix on the concept of fixed assets in production function and growth estimations provides further discussion of the topic. This appendix, as all other appendices mentioned below, is available at http://ihome.ust.hk/~socholz, without the webpage reference being repeated below every time. Appendices also provide detailed data sources, information sometimes too lengthy to fully include in the paper. (The main sources of numerical data throughout are the *Fiscal Yearbook*, *GDP 1952–1995*, *Industrial Yearbook*, *Investment 1950–2000*, *Investment Materials 1950–1985*, *Investment Yearbook*, and the *Statistical Yearbook*).

[8] The output value of (imputed rent on) housing is approximately 2% of the "value" of housing in rural areas, and 4% of the "construction costs" of housing in urban areas (Xu Xianchun, 2000, pp. 51f.). NBS (1997), p. 100, uses 2–4% of the original housing value without distinction between rural and urban areas. For details on the valuation of housing in GDP see Carsten Holz (2004).

[9] The issue of revaluation first arose in 1990. By 1992, a central leading group was handling first trials. The *qingchan hezi* campaign, here translated as revaluation, not only concerns the (positive) revaluation of fixed assets but also clarification of ownership rights, properly cleaning up past losses hidden in balance sheets, accounting for asset stripping, and other issues related to assets. In the early phase, the revaluation of fixed assets appears to have played only a very minor role, but starting in 1993, when the policy was applied to SOEs nationwide, became more prominent. Rural collectives were asked to revalue their fixed assets in 1995, urban collectives in 1996. Several hundred regulations over the years cover or mention revaluation. The key regulations were issued by the State Council in 1993 (SC 3 May 1993, and the implementing instructions SC 14 May 1993). The Finance Ministry five years later, on 21 Sept. 1998, issued a detailed regulation for "day-to-day" use (in contrast to the campaigns of the early and mid-1990s).

construction of an economy-wide fixed asset time series, this is an issue that will have to be addressed.[10]

Economy-wide data on the value of fixed assets in China are not available. Fixed asset data covering some specific parts of the economy are available for some years.[11] These data help identify year-specific depreciation rates and scrap rates to be used in the derivation of economy-wide fixed asset values. They also provide a double-check on constructed fixed asset series.

3. Logical relationships between fixed asset variables and other relevant variables

Fixed asset variables, depreciation, investment, and revaluations are linked through accounting relationships. The derivation of the real original value of fixed assets in the two approaches to the construction of fixed asset time series makes use of these relationships. All equations presented in this and the following section are summarized in Table 1.

3.1. Accounting relationships

Four accounting identities plus one subsidiary equation link fixed asset variables, depreciation, decommissioned fixed assets, and investment. The original value of fixed assets is in the equations abbreviated as "OFA" and the net value of fixed assets as "NFA."

The original value of fixed assets, less cumulative depreciation, equals net fixed assets:

$$\mathrm{OFA}_t - \text{cumulative depreciation}_t = \mathrm{NFA}_t. \quad (1)$$

The identity is confirmed by the published official data on directly reporting industrial enterprises or on SOEs, where occasionally data on all three variables are available. For each particular fixed asset at original value, an enterprise adds to its (cumulative) depreciation account every year until the particular fixed asset has been written off in full (and the net fixed asset value is zero).[12] The fixed asset may be in use, running at 100% of its capacity, for many more years, during all of which there is no further addition to the depreciation account.

Once the fixed asset is decommissioned, the depreciation account, i.e., cumulative depreciation, is written down by the original value of the fixed asset (or by the amount by which the particular fixed asset has been written off so far, with additional entries in other accounts depending on if the fixed asset is sold or discarded). The account "original value of fixed assets" is reduced by the original value of the particular fixed asset.[13]

[10] Yet another issue is capacity utilization. Ideally, in production function estimations only those fixed assets are included which are actually in use. Utilization of the stock of fixed assets is likely to vary over time, such as during the different phases of the business cycle. But the account "original value of fixed assets" covers all operational fixed assets, not only those in use. Given the data limitations, there is no remedy to this problem. (Any other fixed asset measure, such as net fixed assets, is equally affected.) Economy-wide (or sectoral, or ownership group) utilization data are to my knowledge not available. The 1995 industrial census provides some utilization data by industrial sub-sectors.

[11] For details on the availability of fixed asset data see the appendix on fixed asset data.

[12] See, for example, the 1992 accounting regulations for industry in Finance Ministry (1999), Vol. 1, p. 428. Chinese accounting regulations are sector-specific. All references to accounting regulations below refer to industry. Any Western university textbook on accounting will equally well do.

[13] See Finance Ministry (1999), Vol. 1, p. 453.

Table 1
Equations

Accounting relationships (except Eq. (3))

Basic accounting relationship for fixed assets

(1) $\text{OFA}_t - \text{cumulative depreciation}_t = \text{NFA}_t$

Account "original value of fixed assets"

(2) $\text{OFA}_t - \text{OFA}_{t-1} = \text{investment}_t - \text{scrap value}_t + \text{revaluation}_t^{a}$

or:

(2′) $\text{OFA}_t = (1 - \text{scrap rate}_t) * \text{OFA}_{t-1} + \text{investment}_t + \text{revaluation}_t^{a}$

with:

(3) $\text{Scrapvalue}_t = \text{scrap rate}_t * \text{OFA}_{t-1}$ (by choice)

Cumulative depreciation account

(4) $\text{Cumulative depr.}_t = \text{cumulative depr.}_{t-1} + \text{depreciation}_t - \text{scrap value}_t + \alpha * \text{revaluation}_t^{a}$

with:

(5) $\text{Depreciation}_t = \text{depreciation rate}_t * (\text{OFA}_t + \text{OFA}_{t-1})/2$ (by simplifying assumption)

Net fixed assets from Eqs. (1), (2), and (4) *(not relevant for this paper)*

(6) $\text{NFA}_t = \text{NFA}_{t-1} + \text{investment}_t - \text{depreciation}_t + (1-\alpha) * \text{revaluation}_t^{a}$

Construction of the real original value of fixed assets time series

(7) $$\text{ROFA}_t = \text{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\text{investment}_i}{P_i} - \frac{\text{scrap value}_i}{P_{i-k}} \right)$$

(7′) $$\text{ROFA}_t = \text{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\text{investment}_i}{P_i} - \frac{\text{scrap rate}_i * \text{OFA}_{i-1}}{P_{i-k}} \right)$$ (by Eq. (3))

(7″) $$\text{ROFA}_t = \text{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\text{OFA}_i - (1 - \text{scrap rate}_i) * \text{OFA}_{i-1}}{P_i} - \frac{\text{scrap rate}_i * \text{OFA}_{i-1}}{P_{i-k}} \right)$$ (Eqs. (2′) and (3))

(7*) If $k = 0$ $$\text{ROFA}_t = \text{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\text{OFA}_i - \text{OFA}_{i-1}}{P_i} \right)$$ (Eqs. (7) and (2))

(8) Alternatively : $$\text{ROFA}_t = \text{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\text{investment}_i}{P_i} - \frac{\text{investment}_{i-k}}{P_{i-k}} \right)$$ (by simplifying ass.)

(continued on next page)

Table 1 (*continued*)

Eqs. (1)–(5), solved for scrap rate
Depreciation-based scrap rate [from Eqs. (1), (3), (4) *and* (5)*]*
(9) $\text{Scrap rate}_t - (\alpha * \text{revaluation}_t^a / \text{OFA}_{t-1}) = (\text{OFA}_{t-1} - \text{OFA}_t + \text{NFA}_t - \text{NFA}_{t-1} + (\text{depr. rate}_t * (\text{OFA}_t + \text{OFA}_{t-1})/2))/\text{OFA}_{t-1}$
Investment-based scrap rate [from Eq. (2′)*]*
(10) $\text{Scrap rate}_t - (\text{revaluation}_t^a / \text{OFA}_{t-1}) = (\text{investment}_t + \text{OFA}_{t-1} - \text{OFA}_t)/\text{OFA}_{t-1}$

[a] The term "revaluation" is relevant only if official data on the original value of fixed assets or on cumulative depreciation are used, because the official data incorporate revaluations in some years (but not in all years, and not systematically over all years). For an explanation of α see the text.
OFA (ROFA): (Real) original value of fixed assets, i.e., aggregate of the original values of all individual fixed assets, each priced at the price at which it was purchased (at constant prices). NFA: Net fixed assets. Investment: Value of newly increased fixed assets through investment ("effective investment"). Depr.: Depreciation.

The original value of fixed assets changes over time according to the identity

$$\text{OFA}_t - \text{OFA}_{t-1} = \text{investment}_t - \text{scrap value}_t + \text{revaluation}_t, \quad (2)$$

where investment refers to *newly increased fixed assets through investment* rather than to investment expenditures (on which more below). The equation states that the current-period original value of fixed assets equals the previous period's original value of fixed assets, less the original value of decommissioned fixed assets ("scrap value") in this period, plus any increase in the value of fixed assets due to either investment or the revaluation of existing fixed assets.[14]

Eq. (2) differs significantly from the literature. For example, Gary Jefferson et al. (2000), p. 808, in sectoral analysis define net investment (at current prices) as "$\text{OPF}_t - \text{OPF}_{t-1}$ + depreciation allowance," where OPF denotes the year-end value of productive fixed assets at original cost. The use of depreciation instead of scrap values is logically incorrect and the omission of revaluations problematic in the mid-1990s.[15] The authors report that "a completely unexpected outcome is the dramatic TFP [total factor productivity] decline of

[14] The term "scrap value" is used here to denote the original purchasing price of the fixed asset that is decommissioned (which is needed for Eq. (2) to be correct); it does not denote some residual market or book value. If this definition of "scrap value" was misleading, another label could be used.With data on scrap values not published—the *aggregate* scrap value is not a variable of relevance in the accounting system—an immediate check of the equation via data is not possible. The accounting regulations describe Eq. (2) with all three right-hand side variables in text form (Finance Ministry (1999), Vol. 1, p. 428). At the enterprise rather than economy-wide level, the equation should be expanded to include such items as leased equipment and equipment received without compensatory payment.

[15] In their equation, depreciation allowance comes with a negative sign, which I take to be a typo and corrected here. The same equation (with all variables in constant prices) can be found in Gary Jefferson et al. (1992, 1996), but with the correct sign for the depreciation allowance. With depreciation rates typically exceeding scrap rates and revaluations inflating net investment, the resulting growth rates in the mid-1990s are likely to be too high. Chen Kuan et al. (1988), p. 244, provide an equation in which current-year "fixed assets at original costs" equal previous-year fixed assets at original cost plus investment. This is incorrect in that the value of decommissioned fixed assets needs to be subtracted for the equation to hold (apart from the fact that revaluations are ignored).

7.96% in the shareholding sector during 1993–1996" (p. 798). The revaluations of fixed assets occurring in this period *inflate* their "net investment" measure which is then price corrected (unawares of the fact that their fixed asset series incorporates revaluations) and summed to yield capital; this causes an artificial rise in capital relative to output, which in turn lowers TFP growth.

It is unclear whether Gregory Chow and Kui-Wai Li (2002), Wang Yan and Yao Yudong (2003), Alwyn Young (2003), and Wu Yanrui (2004) regard the economy-wide fixed asset values they derive as original or net fixed asset values. If the first, then they erroneously use the depreciation rate instead of the scrap rate and use an inappropriate investment measure of gross fixed capital formation or accumulation (on which more below). If they regard their fixed asset values as net fixed asset values, then comments presented further below apply.

Eq. (2) can also be written as

$$\mathrm{OFA}_t = (1 - \text{ scrap rate}_t)^*\mathrm{OFA}_{t-1} + \text{investment}_t + \text{revaluation}_t \qquad (2')$$

if the scrap rate is defined as

$$\text{scrap value}_t = \text{ scrap rate}_t^*\mathrm{OFA}_{t-1}. \qquad (3)$$

This choice of specification for the scrap rate relates the original value of decommissioned fixed assets in a particular year to the original value of fixed assets in the previous year. The original value of fixed assets is the sum of the original values of a large number of fixed assets which have been purchased at different periods of time, each valued at the then current price level. Every year some fixed assets are scrapped; some of these may be 50 years old and others 10; furthermore, the average lifetime of fixed assets may change over time.[16]

The depreciation account, i.e., cumulative depreciation (abbreviated as "cum. depr.") changes according to the identity

$$\text{Cum. depr.}_t = \text{ cum. depr.}_{t-1} + \text{depreciation}_t - \text{ scrap value}_t + \alpha^*\text{revaluation}_t. \qquad (4)$$

Current-year depreciation adds to cumulative depreciation, while the removal of a fixed asset means the depreciation account is reduced by the *original value* of the particular fixed asset.[17]

If fixed assets are revalued, the original value of fixed assets changes by the full amount of revaluation. For example, if a fixed asset was originally purchased for 200 yuan RMB and is now revalued by 100 yuan RMB, it reaches a new "original" value of 300 yuan RMB. The depreciation account needs to change proportional to the value that has already been written off, therefore the factor α in the equation. If so far 50 yuan RMB have been written off, i.e., one quarter of the original purchasing price, the revaluation by 100 yuan RMB needs to be written off immediately by one quarter, i.e., $\alpha = 0.25$. The depreciation account after the revaluation shows 50+25 yuan RMB for this particular fixed asset. The remainder of 75 yuan RMB enters the account of unresolved *net* losses (here: gains) on fixed assets.[18]

[16] Theoretically, the scrap rate could also be defined as the ratio of *real* scrap values to *real* original values of fixed assets. But in order to obtain a measure of current-period real original fixed assets, the real scrap value would have to be known first. (I.e., construction of a real scrap rate is not feasible.)

[17] See Finance Ministry (1999), Vol. 1, pp. 428, 453. If the fixed asset has not yet been fully depreciated, the account "cumulative depreciation" is only reduced by the value that has already been depreciated, and other accounts pick up the difference to the full original value. The equation abstracts from such special cases.

[18] See a circular by the Finance Ministry on 21 Sept. 1992 for these procedures.

Every year, depreciation is incurred either on the average annual or end-year original value of fixed assets:

$$\text{Depreciation}_t = \text{depreciation rate}_t{}^*(\text{OFA}_t + \text{OFA}_{t-1})/2, \text{ or} \tag{5}$$

$$\text{Depreciation}_t = \text{depreciation rate}_t{}^*\text{OFA} \quad \text{for an individual fixed asset.} \tag{5'}$$

The accounting regulations require linear depreciation based on government-determined depreciation periods. Depreciation periods in industry as of 1992 range from 4 years (computers) to 55 years (dams with electricity generation). For each individual fixed asset, Eq. (5′) is to be used to calculate depreciation; the annual depreciation rate is one divided by the depreciation period. Depreciation is accumulated on a monthly basis, where the monthly depreciation rate is one-twelfth the annual depreciation rate.[19] When the depreciation period of a particular fixed asset has ended but the fixed asset is still in use, the depreciation rate for this particular fixed asset turns zero. Below, when deriving economy-wide depreciation, Eq. (5) is used.[20]

Eqs. (1), (2) and (4) together imply a transition identity for net fixed assets:

$$\text{NFA}_t = \text{NFA}_{t-1} + \text{investment}_t - \text{depreciation}_t + (1-\alpha)^*\text{revaluation}_t. \tag{6}$$

This is not an independent equation and it is not needed below. In the accounting regulations, net fixed assets is defined as the original value of fixed assets less cumulative depreciation (Eq. (1)). However, Eq. (6) has been used in the literature on sectoral fixed assets by, for example, Chen Kuan et al. (1988) and Jefferson et al. (1992, 1996), with the revaluation term ignored throughout.[21] As argued above, net fixed assets is not an appropriate measure of fixed asset values for production function estimations.

If Gregory Chow and Kui-Wai Li (2002), Wang Yan and Yao Yudong (2003), Alwyn Young (2003), or Wu Yanrui (2004) regard the economy-wide fixed asset values they derive as net fixed

[19] See Finance Ministry (1999), Vol. 1, pp. 409f., with two dozen asset-specific depreciation periods on p. 416. The original value of fixed assets in Eq. (5′) does not have a time subscript because the original value of *one* particular fixed asset is constant over time. If the depreciation rate also stays constant for this particular fixed asset, as is likely, then its time subscript can also be omitted. For the depreciation value (left-hand side variable), time runs from the period when the fixed asset is purchased until it has been fully depreciated.

[20] Monthly investment data show that, consistently over the years, approximately two-thirds or more of all investment occurs in the second half of the year, and approximately two-fifths to one-half in the last quarter of the year. This implies that a more appropriate average annual value weighs previous year end-year fixed asset values with a factor of 2, compared to current-year end-year fixed asset values with a factor of 1. For simplicity, and following that part of the literature which makes the effort to obtain average annual values, the arithmetic means of previous and current year end-year values are used here ("midyear" values). An *aggregate* depreciation rate can de facto only be obtained as *residual* of Eq. (5) (or an aggregate Eq. (5′)); it is unclear how the published (through 1992/1993/1998) official depreciation rates presented below were derived.

[21] Chen Kuan et al. (1988) and Gary Jefferson et al. (1992) in sectoral analysis set current-year "fixed assets at net value" equal to previous-year fixed assets at net value plus investment, less depreciation and less the book value of assets decommissioned. This is incorrect in that the decommissioning of fixed assets does not affect net fixed assets as long as the fixed asset has been fully written off by the time of decommissioning; once a fixed asset has been fully depreciated, that fixed asset does not exist in the "net fixed asset" category any longer. The first authors subsequently regard decommissioned assets as small in value and ignore them; the second set these values equal to zero since they do not have data. Gary Jefferson et al. (1992, 1996) obtain investment values using Eq. (2) where they omit the scrap value term (and revaluation) on the right-hand side. Gary Jefferson et al. (1992) calculate the depreciation rate as "total depreciation fund" divided by (presumably current) end-year original fixed assets; presumably the "total depreciation fund" (correctly) refers to current-year depreciation and not to the cumulative depreciation account.

asset values, then, beyond using an inappropriate fixed asset measure and an inappropriate investment measure, they calculate depreciation incorrectly in that it is obtained by applying depreciation rates to net fixed assets rather than to the original value of fixed assets not yet fully depreciated.

3.2. Deriving aggregate real fixed assets at constant prices

A shortcoming of the accounting item "original value of fixed assets" in the context of production function estimations is that it mixes different fixed assets, each of which is valued at the price at which it was originally purchased (except when fixed assets are revalued), and each of which is later decommissioned at that value/price. This is different from a nominal fixed asset time series, in which *all* individual fixed assets are priced at the current-year price level, or from a real series, in which *all* individual fixed assets are priced at one and the same given price level at all times.

Economy-wide, a real fixed asset time series follows from a first year real value of fixed assets to which is added, cumulatively in each following year $i=\ldots t$, real investment less the real value of decommissioned fixed assets. Real investment is current-period nominal (effective) investment divided by the current-period price level. Assuming the decommissioned fixed assets of a given year were all purchased at the same point of time k years earlier (i.e., the price level of k years earlier is the relevant one for deflating), the real original value of fixed assets (ROFA), in which all individual fixed assets are priced at the same price level, is:

$$\mathrm{ROFA}_t = \mathrm{ROFA}_O + \sum_{i=1}^{t}\left(\frac{\mathrm{investment}_i}{P_i} - \frac{\mathrm{scrap\ value}_i}{P_{i-k}}\right), \text{ or} \tag{7}$$

$$\mathrm{ROFA}_t = \mathrm{ROFA}_O + \sum_{i=1}^{t}\left(\frac{\mathrm{investment}_i}{P_i} - \frac{\mathrm{scrap\ rate}_i{*}\mathrm{OFA}_{i-1}}{P_{i-k}}\right), \text{ or} \tag{7'}$$

$$\mathrm{ROFA}_t = \mathrm{ROFA}_O + \sum_{i=1}^{t}\left(\frac{\mathrm{OFA}_i - (1-\mathrm{scrap\ rate}_i){*}\mathrm{OFA}_{i-1}}{P_i} - \frac{\mathrm{scrap\ rate}_i{*}\mathrm{OFA}_{i-1}}{P_{i-k}}\right), \tag{7''}$$

where P denotes the price level and k the average number of years between purchase and decommissioning of fixed assets. Eq. (7′) incorporates Eq. (3), and Eq. (7″) incorporates Eqs. (2′) and (3); revaluations (in Eq. (2')) are irrelevant in the new construction of a real fixed asset series.

Making explicit that all fixed assets decommissioned in the current period are assumed to have been purchased (constituted investment) in one and the same earlier period yields

$$\mathrm{ROFA}_t = \mathrm{ROFA}_O + \sum_{i=1}^{t}\left(\frac{\mathrm{investment}_i}{P_i} - \frac{\mathrm{investment}_{i-k}}{P_{i-k}}\right). \tag{8}$$

Values on up to seven variables are needed to calculate the real original value of fixed asset series: (i) the real original value of fixed assets in the first year, (ii) the investment in fixed assets price index (or deflator), (iii) investment, (iv) the time lag of the investment deflator for the scrap

value, and scrap values. Scrap values are obtained via Eq. (3) using (v) scrap rates and the (vi) original values of fixed assets, where the scrap rate depends on (vii) the depreciation rate (as explained below). Investment, depreciation rates, and scrap rates (items iii, vii, and v) are derived in the following section.

A deflator for investment in fixed assets (item ii) is only available since 1991. For the earlier years the implicit deflator of gross fixed capital formation is used; in the overlapping years after 1990 it differs only marginally from the price index of investment in fixed assets and beats all other available official price indices.[22] The combined gross fixed capital formation deflator and investment in fixed assets price index is reported in the last two columns of Table 3 below. While investment is an annual value, the deflator series reflects end-year values. In the following, no attempt is made to bridge the time discrepancy because the quality of the underlying data and the unequal distribution of investment over the course of a year make further manipulations seem excessive.

The first year's *real* original value of fixed assets (item i) is set equal to the first year's original value of fixed assets deflated in full at first year's price level. The first year's original value of fixed assets is obtained using the perpetual inventory method: the 1953 (effective) investment value is multiplied by $(1+g)/g$, where g denotes the average annual growth rate of 1953–1998 in decimal form (0.05 for a 5% growth rate). Depending on how the investment series is constructed, g is measured either in nominal or real terms; given that the deflator in 1953–1998 is near-flat, the choice makes no noticeable difference (the choice is specified in the notes to Table 5 below). No scrap rates are applied to pre-1953 values. The first year's value of fixed assets is relatively small compared to that of later years, so that the particular choice of assumptions underlying its derivation has virtually no impact on later year values. Original values of fixed assets for other years (item vi) can be obtained via Eq. (2′).

What is the appropriate average number of years (k) between purchase and decommissioning of a fixed asset (item iv)? If all fixed assets decommissioned in the current year had been bought in the same one earlier year, then the current-year scrap value should equal the (effective) investment value of that particular earlier year, which implies a measure of k. An approximate equivalence is established below.

A simplification for deflating decommissioned fixed assets is to assume the relevant price level to be the current-period one. Incorporating Eq. (2) into Eq. (7) then yields

$$\mathrm{ROFA}_t = \mathrm{ROFA}_O + \sum_{i=1}^{t} \left(\frac{\mathrm{OFA}_i - \mathrm{OFA}_{i-1}}{P_i} \right). \tag{7*}$$

This simplified procedure (Eq. (7*)) tends to deflate the nominal value of decommissioned fixed assets too much, i.e., underestimates the real value of decommissioned fixed assets, and therefore overestimates the real increase in fixed assets.

4. Key variables

Data on three variables needed below for the construction of the real fixed asset time series have to be derived or in part constructed: investment, depreciation rates, and scrap rates.

[22] For a full discussion of the two deflators and alternatives see the appendix on the selection of the investment in fixed asset deflator.

4.1. Choice of investment data

The investment measure in all equations is the newly increased value of fixed assets through investment (*xinzeng guding zichan*), here labeled "effective investment." The use of the measure investment (expenditures) is incorrect because not all investment expenditures lead to increases in fixed assets. This could be due to a number of reasons, including waste or time lags between when money is being spent and when the completed fixed assets are ready for use.[23] Official statistics explicitly provide annual investment and effective investment data, as well as the (presumably residual) "transfer rates," i.e., the ratio of effective investment to investment expenditures.

A complication of investment expenditures and effective investment is that they are unlikely to cover all investment across the economy. First, the data coverage changed over time. For example, investment by certain ownership groups has to be of a particular size before it is included in the statistics; this size criterion was raised in 1997. Or, prior to 1999, urban private and individual-owned non-real-estate investment is not included in the statistics. Second, some types of investment appear to be excluded from the statistics until today. For example, non-real-estate investment of a value below 500,000 yuan RMB is not included in the statistics except if by state-owned units, rural collective-owned enterprises, or individuals. Investment data of the early reform period and pre-reform period may have an even more limited coverage than the recent data.[24]

An alternative is to use the component "gross fixed capital formation" in the expenditure approach to the calculation of GDP. Because GDP is a comprehensive measure of economy-wide production activities, gross fixed capital formation could be a comprehensive measure of investment. However, the definitions of gross fixed capital formation and investment differ. According to the *GDP Manual 2001*, pp. 92–95, 106f., gross fixed capital formation in the expenditure approach to the calculation of GDP comprises (i) "total society investment in fixed assets" (this is economy-wide investment), (ii) value-added created in the sale of real estate, (iii) fixed assets created in the prospecting for mineral resources (*kuangcang kantan*, valued at 75% of costs), and (iv) fixed assets created in the improvement of land (unless already included in total investment of society), less three items. The three items to be subtracted are (a) the purchase of old structures (*jianzhuwu*), old equipment (*shebei*), and land, (b) other items in "other costs" (*qita feiyong*) which do not constitute fixed asset investment, and (c) investment in afforestation, unless these numbers are very small and not easy to obtain, in which case they can be ignored.[25]

[23] Government fees and the costs of feasibility studies, environmental impact studies, etc., all constitute investment expenditures but do not necessarily turn into fixed assets. Regarding the time lag, suppose investment expenditures last year were \$100 and are \$200 this year, and suppose it takes one year to complete an investment. Then the increase in the value of fixed assets this year, if based on investment expenditures, is \$200, when actually it is only \$100. For example, in the case of the Three Gorges project, investment occurred over many years, but the newly created fixed asset entered production only in the final year(s).

[24] For details on the shortcomings of the investment data see the appendix on investment data.

[25] For the three items to be deducted, they must have been included in one of the four components of gross fixed capital formation in the first place. This is possibly total society investment in fixed assets, but the source refers to total society investment in fixed assets only for item b ("other items in other costs"). The source provides further details on components (i) and (ii). Investment in fixed assets by the definition of fixed assets in the accounting system excludes the value of land because land is an intangible asset (a separate asset category). However, the investment statistics of the NBS need not necessarily adhere to accounting definitions. If the purchase of old structures, old equipment, and land were included in the investment statistics, they are likely to have been of rather minor size before the 1990s. The "effective investment" data used here to derive fixed asset values should net out these purchases at all times.

Data on economy-wide investment ("total society investment in fixed assets") are available since 1980. Fig. 1 shows that in 1980 gross fixed capital formation exceeded economy-wide investment by 44.69%. This difference diminished rapidly in the following years and by 1986 gross fixed capital formation was approximately equal to economy-wide investment. In order to make a conclusive comparison, one would need data on the other items comprised in gross fixed capital formation besides economy-wide investment; a priori, relative to economy-wide investment, they are unlikely to be large.

Does this imply that official investment data underestimate actual investment in the years prior to 1986? If the gross fixed capital formation values are wrong on the scale the 1980 data suggest, this would question the official expenditure approach GDP, and, because that value is highly similar to that for production approach GDP, the official Chinese GDP data.[26] However, gross fixed capital formation through the mid-1980s may not be what it seems. These data were constructed retrospectively by manipulating data from the Material Product System to fit into the newly adopted System of National Accounts (with the variable gross fixed capital formation). Lacking clear definitions of the early data, the possibility cannot be ruled out that early gross fixed capital formation might include some inventory investment or consumption. I.e., Fig. 1 can be interpreted as evidence for the early 1980s of underestimated investment or of overestimated gross fixed capital formation, or of both.

In the literature, Wang Yan and Yao Yudong (2003), Alwyn Young (2003), and presumably Wu Yanrui (2004) use gross fixed capital formation as a proxy for investment. Gregory Chow and Kui-Wai Li (2002) use gross capital formation (including inventories) since 1978 and a similar measure limited to the five material production sectors prior to 1978.[27] These authors seem unaware of the other items included in gross fixed capital formation; one may not want one's fixed asset series to include value-added created in the sale of real estate (second item in gross fixed capital formation). They further ignore the fact that only approximately three-quarters of all investment expenditures translate into effective investment.

Data on economy-wide effective investment are available for the years 1981 through 2003; alternatively, they can be approximated for all years by applying an estimated transfer rate to gross fixed capital formation.[28] Separate data on effective investment of state-owned units (SOUs) are available for the years 1981 through 2003; the difference of the economy-wide and SOU effective investment series in 1981 through 2003 yields a non-SOU series. (For the data see Table 2).

For the years prior to 1981, SOU effective investment can be reliably estimated from two exhaustive components of SOU investment, for the significantly larger of which effective

[26] In 1980, gross fixed capital formation accounted for 28.96% of expenditure approach GDP. A 44.69% overestimate of gross fixed capital formation implies a 12.94% overestimate of expenditure approach GDP. In 1980 expenditure approach GDP was equal to 100.74% of production approach GDP. (*Statistical Yearbook 2004*, pp. 53, 65f).

[27] The measure used by Gregory Chow and Kui-Wai Li (2002) for the years prior to 1978 is accumulation in the Material Product System, as a component of the Material Product System's national income variable for the five material production sectors. Accumulation is also used by Gregory Chow (1994). For details, see the appendix on Gregory Chow and Chow/Li.

[28] The *estimated* economy-wide (and below also non-SOU) transfer rate is based on a regression of economy-wide (below non-SOU) transfer rates in 1981–1992 on a constant, SOU transfer rates, and the ratio of non-SOE to SOE industrial gross output value (available through 1992 only); with values on the right-hand side variables available for the years prior to 1981, the economy-wide (and non-SOU) transfer rates prior to 1981 can be estimated. For a discussion of transfer rates see the appendix on investment data.

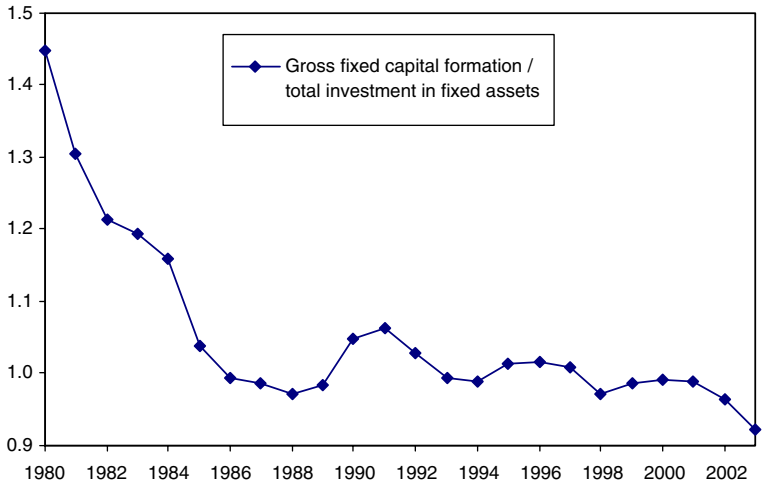

Fig. 1. Gross fixed capital formation vs. total investment in fixed assets. Sources: Gross fixed capital formation: *GDP 1952–1995*, p. 50, *Statistical Yearbook 2004*, p. 66; total investment in fixed assets: *Investment 1950–2000*, p. 15, *Statistical Yearbook 2004*, p. 188.

investment data are also directly available, and the latter's annual transfer rates can then be applied to the smaller investment component.[29]

Lacking investment and effective investment data for non-SOUs in the years prior to 1981, effective investment data for non-SOUs are estimated using five different methods. All bypass the potentially questionable pre-1986 non-SOU investment data, the first three methods by backward estimating non-SOU effective investment values from 1986 or 1986–2000 data.

The first method regresses the ratio of non-SOU to SOU effective investment in the years 1986 through 2000 on a constant and time (year). The trend line is rather stable and when extended to the years prior to 1986 yields positive ratios back to 1967. Multiplying these ratios for the years 1967 through 1985 by SOU effective investment yields non-SOU effective investment.[30]

The second method relies on the average annual real growth rate of non-SOU effective investment during the period 1986 through 2000. Applying this real growth rate subsequently to the value of 1986 and then of earlier years allows the backward creation of a time series of non-SOU effective investment in 1986 prices; each year's value is translated into nominal terms in a second step.

The third method extends the 1986 value of non-SOU effective investment back in time to 1949 based on the real growth rate of non-SOE industrial gross output value (and then translates the pre-1986 values into nominal terms). This assumes that the ratio of gross output value to capital of

[29] For details on the construction of pre-1981 values see the appendix on investment data.

[30] This assumes that SOU effective investment (and thereby investment) values prior to 1986 are rather reliable and the "culprit," if any, for the difference between gross fixed capital formation and investment (Fig. 1) is the non-SOUs. Effective investment values would also have been available for 2001–2003; 2000 seemed a good year to end the regression because then the effective investment data are all from one source.

Table 2
Summary table on effective investment and transfer rates

	Effective investment (b yuan RMB, at current prices)								Transfer rates		
	Economy-wide		SOUs	Non-SOUs: method (for details see text)					Econ.-wide	SOU	Non-SOU
	GFCF	Official		Official	1	2	3	4	5			
'53[a]	*54.98*		*40.605*			*15.00*	*0.50*	*15.16*	*14.34*			
1953	*9.92*		*7.508*			*1.64*	*0.25*	*2.24*	*2.41*	*0.8602*	*0.8198*	*0.9432*
1954	*12.06*		*8.347*			*1.82*	*0.40*	*3.60*	*3.71*	*0.8556*	*0.8130*	*0.9427*
1955	*13.01*		*9.067*			*1.96*	*0.58*	*3.87*	*3.94*	*0.8940*	*0.8616*	*0.9623*
1956	*17.92*		*12.130*			*2.19*	*1.67*	*5.52*	*5.79*	*0.8162*	*0.7542*	*0.9386*
1957	*17.88*		*14.131*			*2.36*	*1.99*	*3.59*	*3.75*	*0.9561*	*0.9344*	*1.0040*
1958	*26.83*		*20.869*			*2.66*	*1.76*	*4.97*	*5.96*	*0.8057*	*0.7478*	*0.9210*
1959	*33.25*		*25.474*			*3.23*	*2.74*	*6.11*	*7.77*	*0.7631*	*0.6922*	*0.9024*
1960	*35.90*		*28.655*			*3.61*	*2.49*	*5.07*	*7.25*	*0.7590*	*0.6879*	*0.8989*
1961	*18.29*		*11.622*			*3.98*	*1.85*	*6.59*	*6.67*	*0.8035*	*0.7447*	*0.9206*
1962	*14.69*		*6.898*			*4.80*	*1.76*	*8.23*	*7.79*	*0.8389*	*0.7903*	*0.9370*
1963	*18.53*		*9.559*			*5.65*	*1.75*	*9.33*	*8.97*	*0.8607*	*0.8194*	*0.9454*
1964	*25.17*		*13.729*			*6.21*	*2.01*	*11.79*	*11.44*	*0.8669*	*0.8276*	*0.9481*
1965	*33.26*		*20.299*			*6.73*	*2.33*	*13.12*	*12.96*	*0.9501*	*0.9359*	*0.9848*
1966	*31.39*		*17.938*			*7.41*	*2.73*	*13.75*	*13.45*	*0.7716*	*0.7040*	*0.9048*
1967	*20.06*		*9.498*		*0.18*	*8.35*	*2.78*	*11.40*	*10.56*	*0.6198*	*0.5060*	*0.8384*
1968	*17.52*		*6.958*		*0.36*	*9.05*	*2.56*	*12.22*	*10.56*	*0.5837*	*0.4590*	*0.8222*
1969	*25.87*		*13.013*		*1.08*	*9.92*	*3.27*	*13.52*	*12.86*	*0.6359*	*0.5270*	*0.8454*
1970	*40.02*		*24.029*		*2.76*	*11.13*	*4.76*	*15.82*	*15.99*	*0.7332*	*0.6528*	*0.8898*
1971	*39.21*		*22.713*		*3.33*	*12.63*	*6.28*	*15.86*	*16.50*	*0.6503*	*0.5443*	*0.8543*
1972	*41.07*		*22.979*		*4.10*	*14.35*	*7.29*	*17.99*	*18.09*	*0.6602*	*0.5566*	*0.8597*
1973	*50.56*		*30.097*		*6.32*	*16.13*	*8.44*	*20.50*	*20.46*	*0.7609*	*0.6870*	*0.9056*
1974	*53.90*		*29.348*		*7.10*	*18.12*	*9.36*	*25.33*	*24.55*	*0.7205*	*0.6336*	*0.8891*
1975	*63.86*		*34.840*		*9.53*	*20.59*	*11.77*	*29.93*	*29.02*	*0.7255*	*0.6393*	*0.8926*

1976	*59.53*		*30.871*		*9.43*	*23.26*	*13.90*	*29.98*	*28.66*	*0.6882*	*0.5892*	*0.8789*
1977	*71.53*		*39.166*		*13.21*	*26.50*	*17.14*	*33.51*	*32.36*	*0.7851*	*0.7143*	*0.9237*
1978	*86.66*		*49.694*		*18.34*	*29.91*	*19.05*	*37.80*	*36.97*	*0.8070*	*0.7431*	*0.9328*
1979	*101.15*		*58.519*		*23.45*	*34.29*	*20.37*	*43.56*	*42.63*	*0.8786*	*0.8367*	*0.9640*
1980	*108.98*		*57.275*		*24.77*	*39.67*	*25.62*	*53.98*	*51.70*	*0.8268*	*0.7679*	*0.9436*
1981	*107.51*	82.453	54.862	27.591	*25.47*	*45.94*	*28.96*	*55.04*	*52.64*	0.8580	0.8219	0.9401
1982	*120.45*	99.247	63.129	36.118	*31.32*	*52.75*	*32.34*	*60.77*	*57.32*	0.8066	0.7468	0.9379
1983	*141.88*	118.723	72.574	46.149	*38.31*	*60.67*	*38.41*	*73.07*	*69.30*	0.8302	0.7624	0.9652
1984	*172.91*	149.096	87.469	61.627	*48.95*	*70.85*	*53.93*	*89.48*	*85.44*	0.8134	0.7380	0.9514
1985	*202.50*	195.003	116.467	78.536	*68.88*	*85.23*	*79.77*	*87.44*	*86.03*	0.7668	0.6930	0.9104
1986	*261.44*	263.352	161.569	101.783	101.78	101.78	101.78	*99.57*	*99.88*	0.8439	0.7770	0.9776
1987	*306.01*	310.073	179.497	130.576	130.58	130.58	130.58	*125.74*	*126.51*	0.8178	0.7330	0.9723
1988	*370.46*	380.864	212.910	167.954	167.95	167.95	167.95	*155.38*	*157.55*	0.8012	0.7050	0.9687
1989	*369.76*	375.843	216.793	159.050	159.05	159.05	159.05	*151.96*	*152.97*	0.8522	0.7720	0.9927
1990	*418.55*	399.534	246.369	153.165	153.17	153.17	153.17	*174.68*	*172.18*	0.8845	0.8250	1.0006
1991	*493.70*	464.980	280.020	184.960	184.96	184.96	184.96	*218.94*	*213.68*	0.8311	0.7540	0.9835
1992	*643.77*	625.437	376.111	249.326	249.33	249.33	249.33	*272.21*	*267.66*	0.7740	0.6840	0.9659
1993	*921.31*	927.863	498.539	429.324	429.32	429.32	429.32	*421.62*	*422.77*	0.7098	0.6290	0.8342
1994	*1178.16*	1191.150	610.603	580.547	580.55	580.55	580.55	*566.02*	*567.56*	0.6989	0.6351	0.7817
1995	*1472.57*	1452.172	738.986	713.186	713.19	713.19	713.19	*735.17*	*733.58*	0.7254	0.6781	0.7819
1996	*1877.63*	1848.499	907.953	940.546	940.55	940.55	940.55	*971.74*	*969.68*	0.8046	0.7531	0.8615
1997	*2088.36*	2070.671	1042.060	1028.611	1028.61	1028.61	1028.61	*1047.11*	*1046.30*	0.8302	0.7960	0.8681
1998	*2201.15*	2262.919	1147.131	1115.788	1115.79	1115.79	1115.79	*1049.42*	*1054.02*	0.7966	0.7464	0.8559
1999	*2432.12*	2463.409	1225.269	1238.140	1238.14	1238.14	1238.14	*1204.38*	*1206.85*	0.8251	0.7683	0.8903
2000	*2660.25*	2684.219	1292.463	1391.756	1391.76	1391.76	1391.76	*1366.83*	*1367.79*	0.8154	0.7831	0.8479
2001	*2788.18*	2818.488	1251.263	1567.225	1567.23	1567.23	1567.23	*1535.24*	*1536.91*	0.7574	0.7107	0.7993
2002	*3112.97*	3230.420	1301.440	1928.980	1928.98	1928.98	1928.98	*1805.07*	*1811.53*	0.7426	0.6894	0.7834
2003	*3483.75*	3773.201	1383.042	2390.159	2390.16	2390.16	2390.16	*2089.66*	*2100.70*	0.6790	0.6385	0.7049

Values in italics are estimated values. GFCF: gross fixed capital formation times estimated economy-wide transfer rate. Non-SOU values, methods 4 and 5, and GFCF values (unless otherwise noted), for years after 1986 are in the remainder of the paper replaced by official values. For details see the appendix on investment data.

[a] Values in line "'53*" are obtained using perpetual inventory method (sum 49–53 for non-SOUs, method 3).

Table 3
Fixed asset depreciation rates and deflator

	Depreciation rates of fixed assets (in %)							Deflator of fixed assets[a]	
	State-owned enterprises:				Dir. rep.	Economy-wide			
	Total[b] (budget.)	Industry[b] (budget.)	Industry[c]	Industry[d] (prov.)	Industry[e]	5 prov.[f]	Approximated	Prev. y. = 100	2000 = 100
1953	2.9	3.7						98.8	26.71
1954	3.1	4.1						99.4	26.55
1955	3.3	4.2						95.7	25.41
1956	3.3	4.1						99.7	25.34
1957	3.1	3.7						95.7	24.26
1958	[3.3]	[3.9]						100.3	24.35
1959	[3.5]	[4.2]						108.4	26.38
1960	3.7	4.4						99.7	26.30
1961	3.4	4.1						98.2	25.82
1962	3.2	3.6						107.4	27.72
1963	3.1	3.7						104.8	29.06
1964	3.2	3.8						97.9	28.46
1965	3.2	3.8						96.7	27.52
1966	3.3	3.9						98.1	26.99
1967	3.0	3.6						100.3	27.08
1968	3.0	3.6						96.6	26.15
1969	3.1	3.7						97.7	25.55
1970	3.2	3.8						100.0	25.54
1971	3.2	3.8						101.1	25.82
1972	3.5	4.0						101.3	26.14
1973	3.4	3.9						100.1	26.17
1974	3.5	3.9						100.1	26.20
1975	3.6	4.0						101.2	26.52
1976	3.6	4.0						100.7	26.70
1977	3.7	4.1						101.5	27.10
1978	3.7	4.1					3.7	100.6	27.25
1979	3.7	4.2					3.8	102.2	27.83
1980	4.1	4.2					3.8	103.1	28.69
1981	4.1	4.3					3.9	103.2	29.60
1982	4.1	4.3					3.9	102.3	30.28
1983	4.2	4.4					4.0	102.5	31.03
1984	4.4	4.6					4.1	104.0	32.29
1985	4.7	5.0	4.41		4.76		4.4	107.2	34.60
1986	4.9	5.1	4.46		4.89		4.5	106.4	36.82
1987	4.9	5.2	4.50		4.90		4.5	105.3	38.75
1988	5.0	5.3	4.61				4.6	113.5	43.99
1989	5.0	5.3	4.59		5.05		4.6	108.5	47.73
1990	4.8	5.1	4.43		4.90		4.4	105.5	50.35
1991	5.5	(5.6) 5.5	4.59	(4.48)	5.04		4.6	109.5	55.13
1992	5.5	(5.8) 5.7		4.67			4.7	115.3	63.56
1993	[6.6]	(6.5) 6.6		5.50			5.5	126.6	80.47
1994	[6.5]	(6.5)		5.94			5.9	110.4	88.84
1995	[6.3]	(6.3)		5.78			5.8	105.9	94.08
1996	[5.7]	(5.7)		5.03			5.0	104.0	97.84
1997	[5.1]	(5.1)		4.78			4.8	101.7	99.51
1998	[5.8]	(5.8)		4.20			4.2	99.8	99.31
1999		[6.0]		4.44			4.5	99.6	98.91
2000		[6.1]		4.52		4.96	4.7	101.1	100.00
2001		[6.4]	5.14	(5.12)	5.47		5.2	100.4	100.40
2002		[6.3]	5.04		5.48		5.1	100.2	100.60
2003		[6.5]	5.40		5.87		5.4	102.2	102.81

Note(s) to Table 3:

All depreciation rates are calculated ones except those in the first two data columns (figures not in parentheses or brackets); calculations are based on data for depreciation and the midyear original value of fixed assets (sum of previous year end-year value plus current year end-year value, divided by two), except in the case of the 5 provinces in 2000, where only end-year original values of fixed assets are available (for the five) and used. In as far as some fixed assets in the category "original value of fixed assets" may already have been fully depreciated and their depreciation rate is zero, relating aggregate depreciation to the aggregate "original value of fixed assets" yields a depreciation rate that is lower than the true average depreciation rate (the one that applies across those individual fixed assets which are not yet fully depreciated). The calculated one is the appropriate one in the context here; see footnote 34.

Sources:

Basic depreciation rates of all budgetary SOEs and of industrial budgetary SOEs: *Statistical Yearbook 1990*, p. 30; *1995*, p. 29; *Fiscal Yearbook 1993*, p. 685; provincial data on industrial budgetary SOEs: *Fiscal Yearbook 1999*, pp. 487, 489.

Third and fifth data column: depreciation: *Industrial Yearbook 1986*, p. 21; *Statistical Yearbook 1987*, pp. 310, 314; *1988*, pp. 376, 377; *1989*, p. 324; *1990*, p. 421; *1991*, p. 401; *1992*, p. 413; *Industrial Yearbook 2002*, p. 61; *2003*, p. 61; *2004*, p. 57; original value of fixed assets: *Statistical Yearbook 1993*, p. 430; *Industrial Yearbook 1993*, p. 65; *2004*, pp. 25f.

Fourth data column: depreciation and original value of fixed assets: individual provincial yearbooks of individual years (all provinces were checked); missing original values of fixed asset data for Xinjiang in 1999 and 2000 are from the *Statistical Yearbook 2000*, p. 431; *2001*, p. 427.

Sixth data column: provincial original fixed asset data are from provincial statistical yearbooks of *Anhui 2002*, pp. 78f., *Henan 2002*, pp. 58–61, *Hebei 2002*, pp. 202f., *Shaanxi 2002*, pp. 55–57, and *Shanghai 2004*, p. 47; depreciation data are from the national income accounts in the *Statistical Yearbook 2001*, p. 60.

Last two data columns (fixed asset deflator): for 1953–1990 calculated from nominal data and real growth rates of gross fixed capital formation in *GDP 1952–1995*, pp. 50, 51; investment in fixed assets price index for the years since 1991 from the *Statistical Yearbook 2004*, p. 323.

[a] The investment in fixed asset deflator is the implicit deflator of gross fixed capital formation in the years 1953 through 1990, and the since 1991 available investment in fixed assets price index.

[b] These published rates presumably cover budgetary SOEs only. The source lists "basic depreciation rates" (*jiben zhejiu lu*) in the categories total, industry, railway, communications, commerce, and grain.

The depreciation rates in curved parentheses, in the case of industry, are derived from provincial-level original values of fixed assets and provincial-level depreciation rates; provincial-level end-year original values of fixed assets are used as weights in the derivation of the nationwide depreciation rate. (Depreciation rates and original values of fixed assets are in the same section of the *Fiscal Yearbook 1999* (pp. 487, 489), separated only by one page of net fixed assets, in similar tables with the same coverage across provinces and years.) Provincial original values of fixed assets do not cover central enterprises located in a particular province, except in 1998, when the sum across provinces equals the national total (in the *Fiscal Yearbook 1999*, p. 481). The sum of original values of fixed assets across provinces is approximately half the nationwide value in 1991 through 1997.

The depreciation rates in square brackets are assumed. The depreciation rate of budgetary SOEs after 1992 is assumed to follow that of budgetary industrial SOEs, and that of budgetary industrial SOEs after 1998 is taken to follow the trends in the industry depreciation rates available according to other definitions.

[c] Current-year depreciation divided by the current-year midyear original value of fixed assets. The enterprise coverage is all industrial SOEs (since 1998 including state-controlled enterprises).

[d] Same as in c, but depreciation and original value of fixed asset data are for individual provinces (from provincial statistical yearbooks); the depreciation rate reported is the weighted mean across those provinces for which the data are available (weighted by the midyear original value of fixed assets). The number of provinces on which data are available in 1992 through 2000 is 8, 6, 7, 8, 9, 10, 8, 8, 7. The ten provinces in 1997 are Beijing, Jilin, Anhui, Hubei, Hunan, Tibet, Shaanxi, Gansu, Qinghai, and Xinjiang; fewer provinces in other years are a subset of these ten. For 1991 and 2001, data on all provinces are available, but only those of the ten provinces are used. The 1998 through 2000 SOE coverage is not clear for all provinces; different provinces switched from "SOEs" to "SOEs and state-controlled enterprises" in different years.

[e] Same as in c, but the coverage is all directly reporting industrial enterprises.

[f] Unweighted mean across five provinces: current-year economy-wide depreciation in the provincial national income accounts divided by end-year original value of fixed assets in the provincial economy-wide balance sheet. Since the denominator contains end-year rather than midyear values, this depreciation rate is an underestimate. The five provinces for which fixed asset values are available in the provincial statistical yearbooks (out of all provinces) are Anhui (with a depreciation rate of 6.37%), Henan (4.36%), Hebei (5.17%), Shaanxi (4.86%), and Shanghai (4.05%). Only for Shaanxi is a 1999 original value of fixed assets available, implying a ratio of year 2000 depreciation to midyear original value of fixed assets of 5.29% instead of 4.86%.

non-SOUs is constant over time, and that output of *non-industrial* non-SOUs grows at the same rate over time as that of *industrial* non-SOUs. The advantage over the previous two methods is that historical growth rates rather than later (post-1985) or SOU growth rates are used.[31]

The fourth method obtains non-SOU investment for the years prior to 1986 as the difference of economy-wide gross fixed capital formation and SOU investment; these pre-1986 non-SOU investment values are turned into effective investment using an estimated non-SOU transfer rate. The fifth method for the years prior to 1986 uses the difference of effective gross fixed capital formation (based on an estimated economy-wide transfer rate) and effective SOU investment. Table 2 reports the values of all series.

4.2. Depreciation rates

Economy-wide depreciation rates are not published. The following depreciation rates are available or can be calculated (Table 3). (i) Depreciation rates of budgetary SOEs and of budgetary SOEs in some economic sectors, such as industry, have been published for the years 1953–1957 and 1960–1992/93 (first and second data columns in the table); in terms of fixed assets, budgetary SOEs account for approximately four-fifths of all SOEs.[32] For budgetary SOEs in industry, depreciation rates can also be calculated from limited provincial data on depreciation and fixed assets for 1991–1998 (in the second data column, in parentheses). (ii) Depreciation rates of all industrial SOEs as well as of all directly reporting industrial enterprises (third and fifth data columns) can be calculated for some years.[33] In years when nationwide data for industrial SOEs are not available, their depreciation rates can be approximated through calculations based on provincial-level data available for some provinces (fourth data column). (iii) An economy-wide value based on end-year (rather than midyear) fixed assets can be calculated for five provinces in 2000 (sixth data column). All calculated depreciation rates except in the last instance use midyear fixed asset values.

Various depreciation rates are used in the following section. The seventh data column in Table 3 also reports approximate economy-wide depreciation rates for the years 1978–2003, the years for which the NIA provide economy-wide depreciation data; combining the two series yields a capital series in the NIA approach. These approximate depreciation rates are constructed based on the observed patterns between the different series in Table 3, following closely the

[31] The gross output value series starts in 1949 and the cumulative 1953 value is the sum of the 1949–1953 values; aggregate 1949 through 1952 non-SOU effective investment is approximately equal to only 1% of 1980 non-SOU effective investment (in real terms), which renders any attempt to approximate pre-1949 effective non-SOU investment pointless. An appendix on the ratio of gross output value to capital of non-SOUs elaborates further on the plausibility of these assumptions and shows that the same method would work well for SOUs.

[32] Budgetary SOEs refers to those SOEs included in the budget; for further details see the appendix on fixed asset data. The table in the *Statistical Yearbook* reporting these depreciation rates does not come with any note to the effect that they are only applicable to budgetary SOEs. However, the depreciation rate table immediately follows two tables on original and net fixed asset values which also do not carry such a note but only cover budgetary SOEs as indicated by identical data in the *Fiscal Yearbook*. (Except for one further table, on fixed-quota working capital, all other tables in this *Statistical Yearbook* section are not related to fixed assets).

[33] "Directly reporting industrial enterprises" prior to 1998 denotes industrial enterprises with independent accounting system at township level and above, and since 1998 all industrial SOEs plus industrial non-SOEs with independent accounting system and annual sales revenue in excess of 5 m yuan RMB; these enterprises report regularly and directly to the statistical authority.

calculated ones of industrial SOEs.[34] In the years 1978–1984 when calculated industrial SOE depreciation rates are not available, the reference rates are the official depreciation rates for budgetary SOEs and budgetary industrial SOEs (considering their relationship with calculated rates for *all* industrial SOEs in 1985–1991). Minor adjustments are made in later years to take into consideration the approximate economy-wide value of 2000.

4.3. Scrap rates

In the absence of data on scrap values, the scrap value of this period relative to the original value of fixed assets in the previous period, i.e., the scrap rate, is estimated from data available on *subsets* of the economy. Two procedures are possible.

First, combining Eqs. (1), (3), (4) and (5) yields a "depreciation-based" scrap rate as

$$\begin{aligned}\text{scrap rate}_t - (\alpha * \text{revaluation}_t/\text{OFA}_{t-1}) = (\text{OFA}_{t-1} - \text{OFA}_t + \text{NFA}_t - \text{NFA}_{t-1} \\ + (\ \text{depr.rate}_t * (\text{OFA}_t + \text{OFA}_{t-1})/2))/\text{OFA}_{t-1}.\end{aligned} \tag{9}$$

Data on the three time series original values of fixed assets, net fixed assets, and depreciation rates are available for three subsets of the economy: budgetary SOEs and all industrial SOEs in the years 1953–1998/1953–2003, and SOUs in 1953–1998 (approximate values).[35]

Second, an "investment-based" scrap rate follows from Eq. (2′) as

$$\text{scrap rate}_t - (\text{revaluation}_t/\text{OFA}_{t-1}) = (\text{investment}_t + \text{OFA}_{t-1} - \text{OFA}_t)/\text{OFA}_{t-1}. \tag{10}$$

Effective investment data are available or can be constructed for industrial SOEs for all years in the period 1953–2003 except 1966–1974, and for SOUs are available for all years.

Comparing the three depreciation-based scrap rates in the overlapping years for which more than one time series is available reveals them to move closely in step; the same is true, separately, for the two investment-based scrap rates.[36] Two complete scrap rate series to be retained and examined in the following are (i) a depreciation-based one which consists of the values of

[34] For an explicit identification of patterns see an appendix on the derivation of the approximate economy-wide depreciation rates. The *calculated* depreciation rate (depreciation divided by the midyear original value of fixed assets) is lower than the true average depreciation rate because the calculation relates 'depreciation on those fixed assets not yet fully depreciated' to 'all fixed assets (including those already fully depreciated).' This is necessitated by the fact that the value of fixed assets already fully depreciated is unknown. The resulting depreciation rate is appropriate in the context here because this depreciation rate, calculated from a subset of the economy, is in the NIA approach related to economy-wide depreciation in order to derive the economy-wide original value of fixed assets (by design and as desired including those already fully depreciated).

[35] Ideally, the depreciation rates used in Eq. (9) are "calculated" ones because they are paired with the original value of all fixed assets (including those already fully depreciated but not yet decommissioned). (Also see previous note.) But for the years 1953–1984 no calculated depreciation rates are available. Combining reported official rates for some years with calculated ones for other years would involve a statistical break. Adjusting all reported official rates downward is an option, but the earlier the year, the more arbitrary would be the adjustment. Given the way the depreciation rate enters Eq. (9), the impact of using reported official rather than (unavailable) calculated rates is likely to be minor. The result of no adjustment is that the scrap rate is biased upward.

[36] For data on all individual scrap rate series and the data on which they are based, including charts and tables, see the appendix on scrap rates.

budgetary SOEs in 1953–1992 and of industrial SOEs in 1993–2003, and (ii) an investment-based scrap rate series which consists of the values of SOUs in 1966–1974, and of those of industrial SOEs otherwise (1953–1965, 1975–2003).[37]

Both series exhibit a severe statistical break in 1998 in that the coverage of fixed asset values in 1998 changes from SOEs to "SOEs and state-controlled enterprises;" the investment data continue to cover SOEs (only). The depreciation-based scrap rate series continues in 1999 with consistent data for the new enterprise coverage, while the investment-based scrap rate series in 1998 and all years thereafter reflects an inconsistent combination of investment and fixed asset data (implying underestimation of the scrap rate).

Table 4 reports the two scrap rate series. The scrap rates through the mid-1990s are rather low with the depreciation-based scrap rate around zero to 1%, and the investment-based scrap rate covering a wide range of values, often negative ones. Eq. (10) clarifies the meaning of a negative investment-based scrap rate: if the original values of fixed assets are correct (which is plausible for these subsets), a negative scrap rate implies a positive revaluation and/or underestimation of effective investment. In the case of depreciation-based scrap rates, Eq. (9), the likely culprits for (the very few) negative scrap rates are either revaluation or poor depreciation rate data.

In all likelihood, revaluations did not occur prior to 1993. The frequently negative investment-based scrap rates (Eq. (10)) then suggest that the official effective investment values are too small. The implication for the construction of a constant-price economy-wide fixed asset series from data on effective investment is that the investment-based scrap rates are the most appropriate because, given the way they have been derived, they incorporate an adjustment factor to compensate for underestimated official effective investment.[38]

In the years after 1992, in particular in the mid-1990s, revaluations of unknown and most likely positive size occurred.[39] This biases both scrap rates downward. Both series suggest large positive revaluations in 1994 and 1995. But for the purpose of constructing an economy-wide original value of fixed asset series from investment values and scrap rates (Eq. (2′)), needed in Eq. (7), scrap rates should only capture the value of decommissioned fixed assets (and the degree to which investment is underestimated).

The solution for the years after 1992 is the following. First, by the year 2000 revaluations are likely to be small, occurring if at all only in the process of changes to the organizational form of

[37] Are these scrap rates representative of economy-wide scrap rates? In 1992, industrial SOEs accounted for slightly below one-half of SOU original fixed asset values, and SOUs for about two-thirds of the economy-wide total. The years with overlapping scrap rates suggest that industrial SOEs can proxy for all SOU. One may suspect that rural collective-owned enterprises renew their machinery *less* frequently than SOUs and industrial SOEs, or that, on the other hand, foreign-owned and domestic private enterprises renew their machinery *more* frequently than SOUs or industrial SOEs (but because the latter have developed rapidly only in the second half of the reform period, very little decommissioning may as yet have happened). If use of the scrap rates derived here was to lead to biased results in economy-wide circumstances, the sign of that bias is ambiguous. Given the relatively small ratio of non-SOU to SOU fixed asset values throughout most years, any bias is likely to be small.

[38] Using these scrap values/rates derived from a subset of the economy (SOUs or industrial SOE) when constructing *economy-wide* fixed assets (following Eq. (2′)) assumes that the economy-wide adjustment factor is the same as that of the subset (and that the published fixed asset values for the subset of the economy are correct). In the case of *non-SOUs*, effective investment could be even more severely underreported in the official data, in which case even greater compensation would be necessary. Also see the appendix on scrap rates for the implications of negative investment-based scrap rates for depreciation rates.

[39] The objective of the official revaluations is to obtain an original value of fixed assets at *current* prices. Revaluations, however, could also incorporate downward revisions due to, for example, asset stripping. To judge from the instructions requesting the revaluations, upward adjustments appear to be the rule.

Table 4
Scrap rates and fixed asset lifetimes

	Scrap rates based on				Deflator relevant for scrap value[b]		Decommission effective investment value(s) of year(s)
	Depreciation		Investment		B-C.4	B-C.3	
		Altern.[a]		Altern.[a]			
1953	−0.0259		−0.0227		1953		–
1954	−0.0158		−0.0653		1953		–
1955	0.0020		0.0401		1953		–
1956	−0.0053		0.0801		1953		–
1957	0.0067		0.0693		1953		–
1958	0.0016		0.0993		1953		–
1959	−0.0104		0.0363		1953		–
1960	0.0050		0.0338		1953		–
1961	−0.0024		−0.0124		1953		–
1962	0.0146		−0.0197		1953		–
1963	0.0073		0.0160		1953		–
1964	0.0079		0.0074		1953		–
1965	0.0160		0.0129		1953		–
1966	0.0125		0.0116		1953		–
1967	0.0078		−0.0037		1953		–
1968	0.0140		−0.0060		1953		–
1969	0.0103		0.0002		1953		–
1970	0.0018		−0.0245		1953		–
1971	−0.0064		−0.1051		1953		1/55 * 1953 ROFA
1972	0.0087		−0.0406		1953		2/55 * 1953 ROFA
1973	0.0080		−0.0261		1953		3/55 * 1953 ROFA
1974	0.0073		−0.0222		1953		4/55 * 1953 ROFA
1975	0.0067		−0.0162		1953		5/55 * 1953 ROFA
1976	0.0090		−0.0092		1953		6/55 * 1953 ROFA
1977	0.0084		−0.0144		1953		7/55 * 1953 ROFA
1978	0.0083		−0.0140		1953		8/55 * 1953 ROFA
1979	0.0036		0.0043		1953		9/55 * 1953 ROFA
1980	0.0089		0.0055		1953		10/55 * 1953 ROFA
1981	0.0097		0.0028		1954		See on left
1982	0.0126		0.0016		1955		See on left
1983	0.0152		0.0055		1956		See on left
1984	0.0194		0.0168		1957		See on left
1985	0.0180		−0.0296		1958		See on left
1986	0.0184		0.0189		1959		See on left
1987	0.0172		0.0146		1960		See on left
1988	0.0131		0.0130		1961+1/2 1962	1961+1962	See on left
1989	0.0105		−0.0151		1/2 1962+1963	1963+1964	See on left
1990	0.0171		−0.0008		1964+1965	1965+1966	See on left
1991	0.0144		−0.0304		1966+1967	1967, 1968, 1969	See on left
1992	0.0130	0.0130	−0.0166	−0.0166	1968+1969	1970+1971	See on left
1993	0.0046	0.0141	−0.0734	−0.0128	1970+1971	1972+1973	See on left
1994	−0.0151	0.0152	−0.0801	−0.0091	1972+1973	1974+1975	See on left
1995	−0.0198	0.0163	−0.2062	−0.0053	1974+1975	1976+1977	See on left
1996	0.0172	0.0173	−0.0047	−0.0015	1976+1977	1978+1979	See on left
1997	0.0090	0.0184	0.0104	0.0023	1978+1979	1980+1981	See on left
1998	−0.0395	0.0195	−0.1578	0.0061	1980+1981	1982+1983	See on left
1999	0.0439	0.0206	−0.0356	0.0099	1982+1983	1984+1/2 1985	See on left
2000	0.0211	0.0217	−0.0106	0.0136	1984+1/2 1985	1/2 1985+1986	See on left

(continued on next page)

Table 4 (*continued*)

	Scrap rates based on				Deflator relevant for scrap value[b]		Decommission effective investment value(s) of year(s)
	Depreciation		Investment		B-C.4	B-C.3	
		Altern.[a]		Altern.[a]			
2001	0.0222	0.0228	−0.0223	0.0174	1/2 1985+1986	1987+1/3 1988	See on left
2002	0.0391	0.0239	0.0077	0.0212	1987+1/2 1988	2/3 1988+1/2 1989	See on left
2003	0.0324	0.0250	−0.0272	0.0250	1/2 1988+1989	1/2 1989+1990	See on left

Further details are in the appendices on scrap rates and on the lifetime of new fixed assets.

[a] The revaluations starting after 1992 necessitate a switch to the alternative series in 1993. For details on the subsets of the economy from which scrap rates were derived, and for a statistical break in 1998 and the inconsistency of investment-based scrap rates after 1997 see the text.

[b] Deflator average of years when more than one year is listed; effective investment as sum of years.

individual enterprises. The depreciation-based scrap rates of 2000–2003, thus, are likely to be accurate.[40] Connecting the reliable 1992 and an approximate 2003 depreciation-based scrap rate of 2.5% through linear interpolation yields alternative depreciation-based scrap rates for 1993–2003 (also reported in Table 4).[41] Second, by 2003 the official investment data should be highly complete, which implies that the investment- and the depreciation-based scrap rates should be near-identical. Consequently, the 2003 investment-based scrap rate is assumed to be identical to the approximate depreciation-based scrap rate, and investment-based scrap rates for the years 1993 through 2002 are obtained through linear interpolation.[42]

5. Cumulative investment approach to the calculation of fixed asset values

With a variety of different effective investment series and two scrap rate series, a choice needs to be made which series to use to derive economy-wide real original fixed assets.

5.1. Choice of effective investment series

The results of different choices of investment and scrap rate series are in the following compared for 1992. The year 1992 is chosen for three reasons. First, for a few "benchmark" years SOU fixed asset values can alternatively be constructed from dispersed sectoral SOU

[40] The original 1992 depreciation-based scrap rate in Table 2 is that of budgetary SOEs, in later years it is that of industrial SOEs. The cross-over is needed due to limited data availability for each group individually. In 1992, the two values for budgetary SOEs and industrial SOEs are 0.0130 and 0.0144 which seem reasonably close to allow the cross-over from a 1992 budgetary SOE scrap rate to a 2003 industrial SOE scrap rate. (There is a similarly close match between the two series in earlier years. The 1993 values, presumably already incorporating some revaluation, for the two ownership groups are 0.0048 and 0.0046. For the complete, individual time series see the appendix on scrap rates).

[41] The most recent scrap rates (Eq. (9)) are based on various fixed asset values which all incorporate past revaluations. As long as no revaluation occurs in the current year, past revaluations do not affect the resulting scrap rate (a simple simulation shows that the scrap rate is the same as if no revaluation had happened). The calculated depreciation-based scrap rate of 2003 is 3.24%, which appears too high given past trends, too high in comparison to the year 2000 and 2001 values, and too high in comparison to the average values of 1996 or 1997–2002. Furthermore, the scrap rate series is, if anything, biased upward (Footnote 35). The average of 2000–2003 is 2.87% which led to the adoption of a 2.5% scrap rate for 2003 as basis for the linear interpolations 1993–2002.

[42] The original investment-based 2003 scrap rate in Table 2 cannot be identical to the depreciation-based one because of the statistical break and inconsistent investment-based scrap rates since 1998.

fixed asset data; the 1992 value is likely to be more accurate than that of other years thanks to the 1993 tertiary sector census (covering 1991 and 1992). Second, the later the year chosen, the greater the likelihood that investment data are complete. Third, due to the unknown amount of revaluations that occurred starting in 1993, 1992 is likely to be the last year with a benchmark value that is meaningful for a comparison.

Line "B" in Table 5 reports SOU original fixed asset values for 1992 based on three scrap rate scenarios: a scrap rate of zero, depreciation-based scrap rates, and investment-based scrap rates. The original values are 2736.093b, 2483.093b, and 2876.617b yuan RMB; the last and highest value exceeds the lowest by 15.85%. The values using investment-based scrap rates are higher than those using depreciation-based scrap rates because investment-based scrap rates are often negative, potentially compensating for underreported investment.

An alternative to the cumulative investment approach is to sum up dispersed fixed asset values available for SOUs in different sectors of the economy. The 1992 SOU benchmark original value thus derived, of 3076.845b yuan RMB (reported in line A of Table 5), is 6.96% larger than the highest original value obtained via the cumulative method, the one in the case of investment-based scrap rates.[43] The small size of the discrepancy would appear to justify the use of investment-based scrap rates in the cumulative approach.

Lines C.1 through C.6 of Table 5 report the non-SOU fixed asset values. The underlying non-SOU effective investment data of lines C.1 through C.5 *prior to 1986* are derived following the five methods as explained above: C.1 uses the trend of the ratio of non-SOU to SOU effective investment in 1986–2000, C.2 the average annual real growth rate of non-SOU effective investment in 1986–2000, C.3.a/b the real/nominal growth rates of non-SOU industrial gross output value, C.4 the difference of gross fixed capital formation and SOU investment turned into non-SOU effective investment, and C.5 the difference of effective gross fixed capital formation and SOU effective investment. Between 1986 and 1992, non-SOU effective investment is the difference of official economy-wide and SOU effective investment. Method C.6 subtracts the benchmark SOU fixed asset value (A) from economy-wide fixed asset values (based on effective gross fixed capital formation prior to 1986, D).

Taking the case of original values with investment-based scrap rates, the six methods yield values from 1533.473b yuan RMB to 2085.003b yuan RMB. The first three methods yield values towards the lower end of the range of values, the latter three methods towards the higher end. Switching to depreciation-based scrap rates or a scrap rate of 0% does not change this pattern.[44]

[43] The 1992 SOU fixed asset value of 3076.845b yuan RMB comprises the SOU original values of fixed assets in four exhaustive sectors of the economy: (i) agriculture (limited to budgetary SOEs): 70.31b yuan RMB (*Statistical Yearbook 1998*, p. 35); (ii, iii) industry and construction (all SOEs): 1566.978b and 68.44b yuan RMB (*Statistical Yearbook 1993*, pp. 419, 562); (iv) tertiary sector (all SOUs except those in agricultural services with fixed assets of 10.62b yuan RMB, which in all likelihood are already included in agriculture): 1371.117b yuan RMB (*Tertiary Sector Census 1993*, pp. 618–629 and 1749–1759). For further details see the appendix on fixed asset data; this appendix also provides SOU fixed asset values for other years (1980, 1981, 1982, 1991, 1995, 2000), as well as a comparison of these fixed asset values of other years with data obtained via the cumulative investment approach.

[44] The switch to depreciation-based scrap rates or a scrap rate of 0% causes one significant change. The value of the non-SOU residual where the SOU benchmark value (line A) is subtracted from the economy-wide value (D) now becomes the smallest value (C.6). This is due to the fact that investment-based scrap rates, by potentially compensating for underreported investment, yield the highest fixed asset values. When the unchanged SOU benchmark value is subtracted from a lower economy-wide value (when other scrap rates are used), the resulting non-SOU value is correspondingly smaller.

Table 5
Estimates of 1992 original value of fixed assets (end-year, in b yuan RMB)

Scrap rate:	0%	Depr.-based	Inv.-based
A. Benchmark estimate for SOUs	3076.845	3076.845	3076.845
B. SOUs: sum of effective investment (i.e., of newly increased fixed assets)[a]	2736.093	2483.093	2876.617
C. Non-SOUs: sum of effective investment values, which are obtained by/as			
(1) Extending the ratio of effective investment by non-SOUs to SOUs in 1986–2000 backwards to 1953 using regression line (and then applying the ratio to the SOU values of the pre-1986 years); actual values for years since 1986[b]	1483.684	1395.264	1533.473
(2) Applying the average annual real growth rate of effective investment of non-SOUs in 1986–2000 to the 1986 value and successively back to 1953; actual values for years since 1986[a, c]	1803.766	1654.006	1885.026
(3) Applying the annual growth rates (1954–1986) of non-SOU *industrial* gross output value to the 1986 non-SOUs effective investment value and successively back; actual values for years since 1986[d]			
(a) Based on annual real growth rates	1557.362	1453.905	1617.597
(b) Based on annual nominal growth rates	1621.033	1505.216	1687.330
(4) Annual non-SOU investment (gross fixed capital formation less SOU inv.) turned into effective investment using the non-SOU transfer rate (estimated through 1980);[a] non-SOU effective investment since 1986	1984.722	1799.999	2085.003
(5) Difference of economy-wide value (D) and SOU value in B[e]	1962.284	1780.618	2061.975
(6) Difference of economy-wide value (D) and SOU benchmark value in A	1621.532	1186.866	1861.747
D. Economy-wide: sum of gross fixed capital formation, where annual values are translated into effective investment through the estimated economy-wide transfer rate;[a, e] economy-wide effective investment since 1986	4698.377	4263.711	4938.592

In the cases C.4-6 and D other transfer rates for the years prior to 1981 were also explored, with no significant impact on results.
Sources (see appendices on investment data, scrap rates, and fixed asset data for detailed sources and more data): Benchmark estimate for SOUs: see text and footnote 43. Effective investment (newly increased fixed assets): see Table 2. Gross fixed capital formation, nominal and real: *GDP 1952–1995*, pp. 50f. Transfer rates: see Table 2. Scrap rates: see Table 4.

[a] First-year effective investment values are augmented using the perpetual inventory method. I.e., 1953 effective investment data are multiplied by "$(1+g)/g$," where g is the average annual growth rate of nominal (real in line C.2) effective investment between 1953 and 1958 in decimal form. It makes little difference if nominal or real growth rates are used since the deflator shows little variation in the mid-1950s; pre-1953 annual scrap rates are assumed to be zero. This derived 1953 original value of fixed assets is deflated in full at the 1953 price level since deflators for earlier years are not available. (The use of a 5-year growth rate follows Alwyn Young's (2003) practice).

[b] The regression line in C.1 is ratio = −62.4947 + 0.0318 * year (both coefficients are significant at below 0.005% level). The values start in 1967, the first year with a positive ratio.

[c] The average annual real growth rate in C.2 is 12.24%.

[d] Growth rates in C.3 are year-specific. For example, dividing the 1986 value of non-SOU effective investment by one plus the 1986 real growth rate of non-SOU gross output value yields an estimate of 1985 effective investment; applying the 1985 growth rate to this value yields a 1984 estimate of effective investment, etc. Gross output values go back to 1949; the sum of the 1949–1953 values is treated as 1953 value.

[e] One might expect the data in C.4 and in C.5 to be identical but they are not, for two reasons. First, non-SOU and economy-wide transfer rates are independent series. Second, pre-1953 values were estimated using the perpetual inventory method and the average annual growth rates of 1953–1958; these average annual growth rates differ across ownership categories. (Year-specific scrap rates further affect the outcome).

The close match of the SOU fixed asset benchmark value (line A) with the fixed asset value of SOUs derived from cumulative effective investment with *investment-based scrap rates* (B) suggests that SOU effective investment data cannot be far off, if at all. Among the investment data, those of SOUs are probably the best because SOUs by default take part in the regular reporting system and their investment in 1992 required government approval.

But if the effective investment values of SOUs were of good quality, most burden of any underestimate of total investment prior to 1986 would be carried by non-SOUs. The first three methods for calculating non-SOU effective investment all bypass the question of how accurate non-SOU investment data of 1980–1985 and earlier years are by starting the regressive calculations from the presumably reliable 1986 effective investment value.[45] In other words, by construction, the first three methods are unlikely to underestimate non-SOU investment. The third method (version a) appears best in that it does not rely on taking trends or growth rates established in the period 1986–2000 to the earlier years, but uses historical year-specific real growth rates of a related variable to establish the effective investment values of earlier years. The resulting 1992 fixed asset value (in line C.3.a) is between those obtained using the first two derivation methods for non-SOU effective investment. Given the good match in the SOU benchmark comparison, *investment-based scrap rates* are in the following used with method 3 (always 3a) for constructing non-SOU effective investment.

The sixth method is only feasible for 1992. The fourth and fifth method yield near-identical fixed asset values. Continuing with the fourth method as an alternative to the third, these non-SOU effective investment values are best combined with depreciation-based scrap rates. Gross fixed capital formation values which underlie this method through 1985 are likely to capture all investment (and perhaps more); the use of investment-based scrap rates, which compensate for any underreported investment, would exaggerate non-SOU investment.[46] The original 1992 non-SOU fixed asset value resulting from the fourth method with *depreciation-based* scrap rates is 1799.999b yuan RMB (line C.4), eleven percent higher than the 1617.597b yuan RMB obtained using the third method and investment-based scrap rates (line C.3.a).

5.2. Real original fixed asset series with scrap values deflated at current-year prices

The validity of methods C.3 and C.4 can be further explored in economy-wide time series comparisons. Fig. 2 charts the annual growth rates of six different *real*, economy-wide (sum SOU and non-SOU) midyear original value of fixed asset series when all scrap values are deflated *at current-year prices*. The six fixed asset series, ordered by what scrap rates they use, are:

(1) scrap rate of 0%; SOU effective investment values as in line B of Table 5, fourth method for non-SOU effective investment (C.4);
(2) scrap rate of 1%, B-C.4;
(3) depreciation-based scrap rates, B-C.4;
(4) depreciation-based scrap rates, economy-wide effective investment D;

[45] With non-SOUs accounting for more than one-third of investment in 1986 (and one-half by 2000), the close match starting 1986 in the comparison of economy-wide investment and gross fixed capital formation (Fig. 1) does not allow for large inaccuracies in the data on non-SOUs (or on gross fixed capital formation).

[46] An additional issue is that non-SOU investment is subjected to the non-SOU transfer rate to obtain effective non-SOU investment; if the residual non-SOU investment in this scenario captures underreported SOU investment, that SOU investment is subjected to a higher transfer rate than it should be (the non-SOU transfer rate is above that of SOUs).

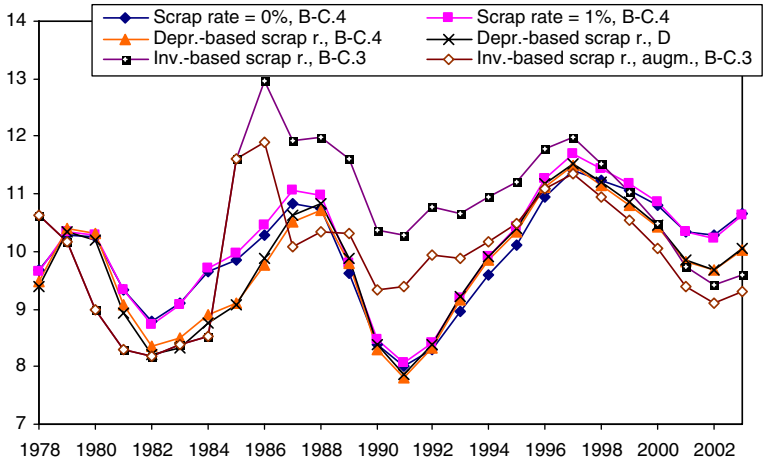

Fig. 2. Growth rates of economy-wide real fixed asset values I. Growth rates are annual real growth rates in percent. The deflator for scrap values is the *current-period* one. All fixed asset values are midyear values obtained as arithmetic mean of previous- and current-year values. Underlying end-year fixed asset values are derived based on Eq. (7*). Scrap rate refers to type of scrap rate used in deriving the *original value of fixed assets*. Letters/numbers refer to methods used to derive SOU and non-SOU effective investment (see Table 5).

(5) investment-based scrap rates, B-C.3;
(6) investment-based scrap rates, B-C.3, with effective investment augmented in each year through 1986 by that factor of 1.174394 which raises the 1992 cumulative SOU original fixed asset value with investment-based scrap rates (B) to the SOU 1992 benchmark value of original fixed assets (A).

The constant long-run scrap rate scenarios of 0% and 1% are included as a rough, constant approximation of (and alternative to) the investment-based and depreciation-based scrap rates.

Fig. 2 focuses on the reform period because the fixed asset series are almost identical in the pre-reform period. In terms of annual growth rates, three couples, each of two series that move closely in line, emerge: the two series with constant scrap rates, the two series with depreciation-based scrap rates, and the two series with investment-based scrap rates (identical by construction through 1985, and then with only difference the higher base in the augmented case). The first two couples are rarely more than half a percentage point apart, and never more than about one percentage point. This implies that the series with constant scrap rates do not provide a significant alternative to the series with depreciation-based scrap rates.[47] The two series with investment-based scrap rates exhibit higher growth rates than those with depreciation-based scrap rates starting in 1985 due to a lower base; the effect gradually erodes with the use of official effective investment data for all series starting 1986.

A scenario with a constant scrap rate such as of 1% is desirable only if one distrusts the annual variation in derived scrap rates or the applicability of scrap rates derived from a subset

[47] If the constant scrap rate series used effective investment values of non-SOUs derived using method C.3 (rather than C.4), the resulting growth rates shift uniformly upwards by up to one percentage point except in 1985–1992, when the difference reaches a maximum 3.5 percentage points, but the pattern over time remains the same. With the early non-SOU effective investment data likely to be underestimates, the base is lower than when non-SOU values derived using method C.4 are used, and the growth rates are consequently higher.

of the economy to the whole economy (a variation would be to impose a deterministic long-term positive trend). Of the two scenarios with depreciation-based scrap rates, the series "B-C.4" with a depreciation-based scrap rate is retained in the following.[48] (Applying depreciation-based scrap rates to effective gross fixed capital formation in *all* years, omitted in the chart, would yield yet another near-identical series.) In the case of the two fixed asset series with investment-based scrap rates, the assumptions of a constant augmentation factor for *all* years prior to 1986 and of perfect accuracy of the 1992 SOU benchmark value appear precarious. The non-augmented "B-C.3" series with an investment-based scrap rate is retained in the following. The two most plausible series chosen here are the same as in the previous section.

5.3. Real original fixed asset series with scrap values deflated at lagged prices

The above comparisons of real fixed asset series assumed that the scrap values can be deflated using the current-period deflator. But the proper deflator, as indicated in Eq. (7), is the deflator of the period in which the fixed assets decommissioned in this period were originally purchased. An improvement over using the current-period deflator is possible under the assumption that all fixed assets decommissioned in the current period were purchased in one and the same earlier year. In that case, the current-year scrap value should equal the (effective) investment of a particular earlier year. The equivalence can be established either through visual year-by-year comparisons, or by calculating in simulations the average lifetime that results from a specific (say, 5-year average) scrap rate combined with the specific average annual investment growth rate (of the same period). Both techniques yield near-identical results.

Table 4, for each current year, reports the corresponding earlier year, i.e., the year whose deflator is appropriate to deflate the current period scrap value or whose (real) effective investment is being decommissioned in this period. Two different series are reported for the years since 1988, differing in the method used to derive the original values of fixed assets: (i) non-SOU effective investment from method 4 (and SOU effective investment, B-C.4), combined with depreciation-based scrap rates; (ii) non-SOU effective investment from method 3 (B-C.3), combined with investment-based scrap rates. In either case, the resulting original value of fixed assets is multiplied by the depreciation-based scrap rate to obtain the scrap value for which a matching earlier-period effective investment value is then found. The match identifies the corresponding earlier year.[49]

The result is four midyear real original value of fixed asset time series (Table 6). Two series rely on a lagged deflator to deflate the scrap value, with the lag identified in Table 4. The first relies on Eq. (7′) with effective investment values "B-C.4," depreciation-based scrap rates, and

[48] The economy-wide calculation for the years prior to 1986 requires *economy-wide* estimated transfer rates (rather than only for non-SOUs), which makes it slightly less preferable.

[49] For details on the derivation of these values, including the detailed data, see the appendix on the lifetime of new fixed assets. The basic procedure is to create an original value of fixed asset series from Eq. (2′) using the effective investment data and the two scrap rate series in a first step, to then calculate the scrap value from Eq. (3) using depreciation-based scrap rates in all instances, and to finally compare this scrap value to effective investment of earlier periods in an attempt to match the two values. In using Eq. (8), the scrap value through 1970 is zero. (Gregory Chow (1994), working with depreciation rates, appears to assume a 0% depreciation rate for this whole period 1952–1985.) The 1953 fixed assets are decommissioned over the period 1971–1980 such that the transition to the 1981 scrap value (effective investment of 1954) is smooth.

Table 6
Economy-wide midyear fixed asset values b yuan RMB (year 2000 prices for real series)

	Original value of fixed assets [Eq. (2′)] (all values end-year)		Midyear real original value of fixed assets [equation], with						
			Scrap value deflated using deflator of				Real effective inv. less lagged		
			Current period [Eq. (7*)]		Earlier period [Eqs. (7′) and (7″)]		Real effective investment [Eq. (8)]		
	B-C.4	B-C.3	B-C.4	B-C.3	B-C.4	B-C.3 [a]	B-C.4 [a]	B-C.3	GFCF
1953 [b]	55.763	41.106	208.754	153.883	208.754	153.883	208.754	153.883	205.707
1954	68.594	52.541	232.920	175.419	232.910	175.412	231.262	170.365	228.412
1955	81.401	60.081	282.284	211.792	282.276	211.787	279.232	205.831	276.710
1956	99.479	69.072	343.150	244.367	343.111	244.339	339.510	252.044	337.669
1957	116.534	80.408	413.965	285.467	414.009	285.495	410.848	312.494	409.880
1958	142.180	95.053	501.779	338.905	501.984	339.044	500.432	392.182	501.828
1959	175.238	119.814	617.093	415.905	617.299	416.045	613.340	492.119	619.934
1960	208.087	146.911	742.191	514.343	742.388	514.478	737.307	604.808	751.196
1961	226.791	162.207	840.863	595.478	841.053	595.608	836.686	690.116	854.867
1962	238.617	174.062	898.412	646.481	898.346	646.427	899.228	731.818	916.778
1963	255.765	182.589	949.246	682.535	948.692	682.128	959.005	766.889	975.157
1964	279.274	196.983	1020.051	722.493	1019.003	721.730	1036.337	813.994	1051.256
1965	308.216	217.080	1113.938	784.296	1112.412	783.194	1141.892	882.758	1155.908
1966	336.043	235.240	1218.082	854.458	1216.237	853.131	1261.326	962.174	1274.502
1967	354.331	248.386	1303.412	912.380	1301.428	910.956	1358.635	1023.142	1369.706
1968	368.559	259.391	1364.389	957.698	1362.540	956.368	1433.899	1064.004	1440.260
1969	391.291	275.612	1436.088	1010.491	1434.763	1009.530	1522.511	1114.070	1524.409
1970	430.436	311.158	1557.209	1111.824	1556.271	1111.134	1652.466	1202.299	1653.401
1971	471.764	372.842	1713.883	1300.878	1712.826	1300.102	1803.297	1313.399	1805.824
1972	508.619	418.231	1864.418	1507.161	1863.350	1506.388	1950.682	1423.237	1954.712
1973	555.134	467.700	2023.785	1688.495	2023.045	1687.986	2116.233	1547.775	2120.521
1974	605.762	516.789	2209.277	1876.695	2208.843	1876.441	2303.968	1685.494	2306.892
1975	666.466	571.763	2420.330	2074.008	2420.098	2073.925	2513.342	1834.636	2513.309

1976	721.316	621.790	2637.490	2271.334	2637.319	2271.303	2728.545	1990.955	2724.622
1977	787.948	687.048	2863.161	2485.439	2862.834	2485.274	2951.947	2160.504	2943.788
1978	868.865	765.383	3134.603	2749.608	3133.875	2749.094	3218.142	2369.558	3206.756
1979	967.775	840.958	3460.781	3029.126	3459.573	3028.191	3529.803	2613.642	3515.701
1980	1070.376	919.233	3817.289	3301.316	3814.726	3299.201	3871.029	2873.257	3851.811
1981	1169.872	1000.469	4164.166	3574.954	4158.465	3570.133	4209.093	3128.834	4181.927
1982	1279.051	1094.352	4512.491	3867.181	4500.112	3856.642	4551.328	3392.570	4514.087
1983	1405.271	1199.352	4896.129	4191.373	4872.068	4170.840	4930.279	3682.805	4880.594
1984	1554.950	1320.600	5331.283	4548.309	5286.228	4509.843	5367.609	4020.141	5304.729
1985	1730.793	1555.919	5817.141	5076.077	5741.034	5011.181	5846.655	4442.957	5773.127
1986	1962.287	1789.857	6385.573	5733.765	6275.272	5638.978	6385.989	4984.182	6302.644
1987	2238.605	2073.833	7056.434	6417.825	6908.399	6288.846	7019.695	5629.166	6921.222
1988	2590.173	2427.713	7812.492	7186.390	7621.757	7018.756	7739.578	6361.146	7620.143
1989	2938.845	2840.187	8577.313	8020.676	8345.487	7815.603	8471.122	7098.920	8334.735
1990	3288.152	3241.888	9289.486	8851.721	8998.804	8588.201	9109.951	7762.917	8987.982
1991	3705.728	3805.474	10,015.124	9761.820	9639.910	9410.839	9725.600	8429.281	9651.571
1992	4283.091	4494.215	10,848.018	10,814.752	10,372.934	10,359.869	10,453.382	9157.750	10,426.389
1993	5150.707	5479.828	11,841.268	11,968.931	11,231.128	11,375.183	11,280.540	9982.218	11,266.801
1994	6263.774	6720.652	13,006.798	13,279.680	12,211.459	12,493.555	12,199.681	10,935.863	12,172.879
1995	7614.141	8208.309	14,350.900	14,768.648	13,311.250	13,726.718	13,240.339	12,028.548	13,220.155
1996	9330.562	10,069.079	15,945.671	16,510.146	14,589.010	15,137.472	14,482.181	13,289.316	14,495.528
1997	11,229.180	12,116.691	17,776.785	18,489.890	16,016.177	16,706.232	15,875.245	14,720.460	15,920.152
1998	13,272.758	14,306.001	19,759.682	20,621.025	17,507.293	18,345.289	17,331.554	16,277.745	17,365.466
1999	15,462.396	16,628.352	21,895.441	22,897.243	19,069.082	20,057.549	18,897.358	17,965.145	18,904.145
2000	17,810.774	19,085.677	24,176.492	25,299.854	20,702.022	21,843.143	20,624.173	19,692.380	20,622.193
2001	20,222.940	21,571.501	26,551.958	27,766.477	22,376.779	23,663.315	22,443.660	21,394.392	22,425.476
2002	22,969.898	24,344.281	29,118.513	30,382.547	24,226.060	25,643.625	24,331.444	23,373.819	24,254.546
2003	26,168.851	27,508.875	32,039.488	33,299.647	26,452.055	27,932.401	26,545.341	25,735.261	26,292.737
2003 [b]			33,595.187	34,838.637	27,669.337	29,152.280	27,770.151	26,976.571	27,389.065
Average annual growth rate (in %)									
1954–2003		10.57	10.59	10.14	10.90	10.16	10.78	10.17	
1954–1999		10.62	10.65	10.28	11.11	10.28	10.91	10.31	
1978–1999		9.70	9.71	8.98	9.93	8.80	10.13	8.82	

GFCF: gross fixed capital formation. B, C.3, C.4: see Table 5.

[a] Preferred series.

[b] End-year values.

original values of fixed assets derived with depreciation-based scrap rates.[50] The second relies on Eq. (7″) with depreciation-based scrap rates and with original values of fixed assets derived using effective investment values "B-C.3" and investment-based scrap rates. Depreciation-based scrap rates are applied in Eq. (7″) because the original fixed asset values have already been corrected for potentially underestimated investment (were constructed using investment-based scrap rates); using investment-based scrap rates in Eq. (7″) would imply underestimating effective investment and scrap values.[51]

Two further series follow from Eq. (8) with lagged real effective investment as real scrap value. One uses effective investment values "B-C.4," the other "B-C.3." In the case of "B-C.3," the effective investment values of the early years are presumably underestimates.[52]

Figs. 3 and 4 chart the resulting four real fixed asset series in growth rate form for all years and in a close-up for the reform period only. All four series move in step. The two series with underlying effective investment "B-C.4" are always very close. The second couple of series with underlying effective investment "B-C.3" is close to the first couple with three exceptions. In 1956–1959, the second couple shows either higher or lower growth rates; in the years since 1985 the second couple experiences higher growth rates, declining over time (because of the lower pre-reform values but then official effective investment values for all *four* series starting 1986); in the second couple, the series with deflated scrap values shows higher growth in 1971–1974.[53] In levels, the four series start with two end-53 values which are one-third apart, but end with rather similar end-03 values (Table 6).

Fig. 4 and Table 6 also include the accumulation of effective real gross fixed capital formation in *all years* less *lagged* effective real gross fixed capital formation (Eq. (8), with as lag the B-C.4 lag in Table 4).[54] The values closely track those of the B-C.4 series.

[50] For example, taking the case of non-SOU effective investment values obtained via method C.4, the 1953 economy-wide effective investment value is 55.765b yuan RMB (40.605+15.16 in Table 2), which translates into 208.779b yuan RMB once the year 2000 constant prices (Table 3, 0.2671) are applied; see the 1953 real original value of fixed assets for the scenario B-C.4 in Table 6 of 208.754b yuan RMB (using more decimals for the deflator). To obtain the 1954 real original value of fixed assets, economy-wide effective investment of 11.947b yuan RMB (8.347+3.60 in Table 2) deflated by 0.2655 (Table 3), i.e., 44.998b yuan RMB, is added, and a scrap value of negative 0.0158 (Table 4) times 55.763b yuan RMB (Table 6, first column) deflated by 0.2671 (Table 3), i.e., negative 3.299b yuan RMB is subtracted; the year 1953 real original value of fixed assets of 208.754b yuan RMB plus 44.998b yuan RMB less negative 3.299b yuan RMB yields the 1954 end-year real original value of fixed assets of 257.051b yuan RMB, which implies a midyear 1954 real original value of fixed assets of 232.903b yuan RMB (compare 232.920b yuan RMB in Table 6). (The end-year values are provided in the appendix on fixed asset data.) The 1954 original value of fixed assets (Table 6, first column) of 68.594b yuan RMB equals the 1953 value of 55.763b yuan RMB, plus effective investment of 11.947b yuan RMB, less the negative scrap value of 0.881b yuan RMB (negative 0.0158 times 55.763 above).

[51] Eq. (7′) is not used with "B-C.3" to avoid the potentially underestimated effective investment values in this case.

[52] Replacements of the current and lagged investment variables as in Eq. (7″) for current investment are possible but appear pointless given that Eq. (8) is attractive due to its simplicity.

[53] The higher growth rates of the third series in 1971–1974 can be traced back to the negative investment-based scrap rates of substantial size (Table 4); the fourth series in Fig. 3 is not affected because the (same) underlying effective investment values are not "corrected" through the application of the investment-based scrap rates. The 1974 real fixed asset value in the third series is approximately half of the 1980 value, one-fifth the 1990 value, and one-fifteenth the 2003 value.

[54] The B-C.4 series obtains non-SOU investment prior to 1986 as the difference of gross fixed capital formation and SOU investment (with effective non-SOU investment obtained by multiplying by the non-SOU transfer rate, estimated for the years prior to 1981), and in 1986 switches to the official economy-wide effective investment values. The fifth series, in contrast, uses effective gross fixed capital formation values in *all years*, with the *economy-wide* transfer rate estimated for the years prior to 1981. For the effective gross fixed capital formation values in *all years* and the economy-wide transfer rates see Table 2.

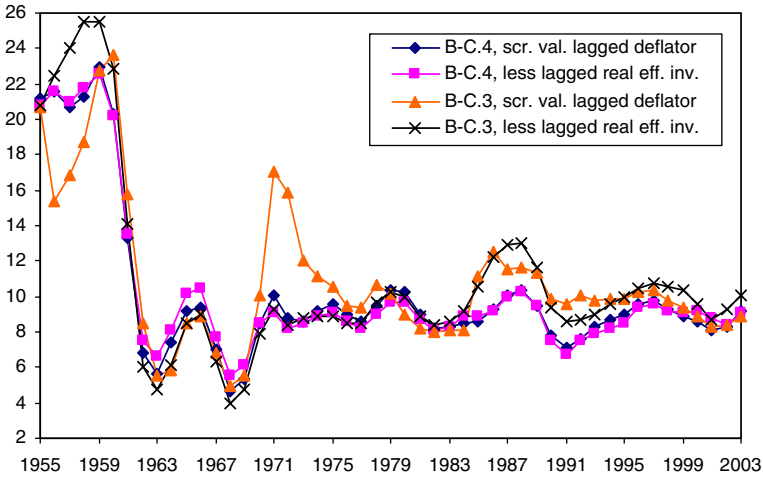

Fig. 3. Growth rates of economy-wide real fixed asset values II. Growth rates are annual real growth rates in percent. Fixed asset values are midyear values. Letter/numbers refer to methods used to derive SOU and non-SOU effective investment (see Table 5). The two series with deflated scrap values are from Eq. (7′) in the case of non-SOU effective investment obtained via method C.4, and Eq. (7″) in the case of non-SOU effective investment obtained via method C.3; scrap rates in Eqs. (7′) and (7″) are depreciation-based scrap rates, and scrap rates underlying the construction of original values of fixed assets are depreciation-based for "B-C.4" and investment-based for "B-C.3." The lagged deflators are the corresponding ones identified in Table 4. The two series with lagged real effective investment values as scrap values are from Eq. (8).

Out of the four (or five) series, two series appear preferable. One, following Eq. (8), is the series where non-SOU effective investment is obtained using method 4 (through 1986 as gross fixed capital formation less SOU investment, times non-SOU transfer rates), and scrap values consist of the real effective investment of k years earlier. In the long run, subtracting

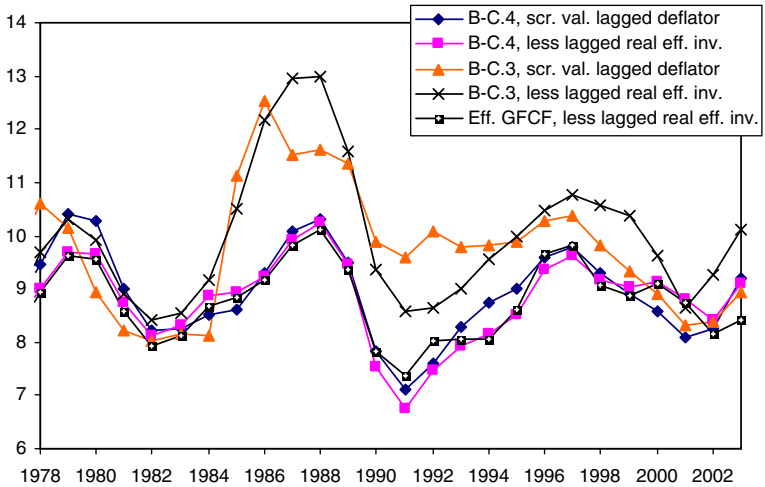

Fig. 4. Growth rates of economy-wide real fixed asset values III. For notes see previous figure. GFCF: gross fixed capital formation.

out all earlier real effective investment appears preferable to relying on an estimated nominal scrap rate applied to original fixed asset values (Eq. (7′)). This series is easy to compile but requires the use of gross fixed capital formation in deriving non-SOU effective investment through 1985 (and still requires scrap rates to determine the lag).

The other choice is the series where non-SOU effective investment follows from method 3 and real scrap values are obtained as scrap values divided by a *k*-period lagged deflator (Eq. (7″)). (Using Eq. (8) seems inferior because of the suspicion that the effective investment values of the early years are underestimates.) This series does not rely on gross fixed capital formation to derive non-SOU effective investment values prior to 1986 (but on the real growth of industrial non-SOE gross output value); the investment-based scrap rate that underlies the original value of fixed assets from which scrap values are calculated potentially corrects for underestimated investment.

Comparing these two series with the corresponding two series which deflate scrap values using the current-period deflator (Fig. 5, Table 6), the growth patterns are identical, but recent annual growth rates are up to two percentage points higher for the latter. (In the pre-reform period, not included in Fig. 5, the growth rates closely match).

6. NIA approach to the calculation of fixed asset values

In the income approach to the calculation of GDP, GDP is the sum of the four components labor remuneration, depreciation, net taxes on production, and operating surplus. These data are available for the years since 1978. Dividing the economy-wide depreciation values by depreciation rates yields the economy-wide midyear (original value of) fixed assets.

Depreciation in the NIA is defined sector by sector. According to the National Bureau of Statistics (NBS, 1997, pp. 15f.), depreciation consists of actual and imputed depreciation. Imputed depreciation, such as for government organs, non-enterprise facilities and housing is based on “unified” (presumably centrally determined) depreciation rates and unified original

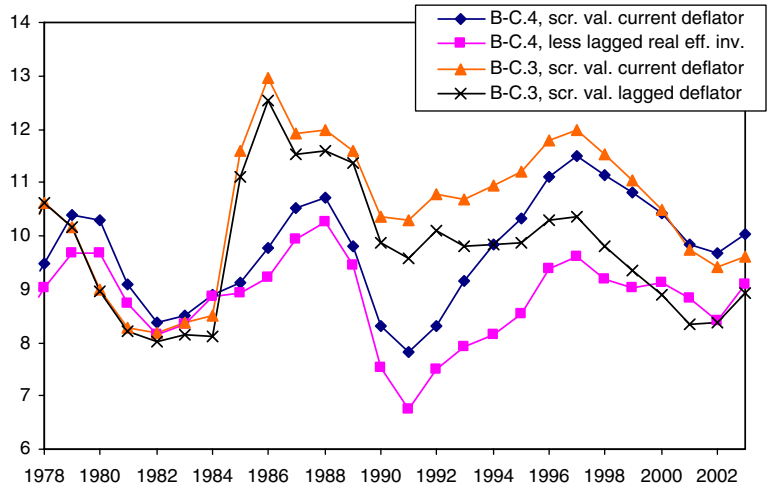

Fig. 5. Growth rates of economy-wide real fixed asset values IV. For notes see Figs. 2 and 3.

fixed asset values. It is acknowledged that, in principle, depreciation should be based on replacement values, but that this is not yet feasible for all fixed assets.

National data on the income approach to the calculation of GDP are not available. What are available are provincial data on income approach (gross) value-added ("provincial GDP") and the four individual components, for the years 1978–1995 in the compendium *GDP 1952–1995*, and for the years 1993, 1994, and 1996–2003 in the *Statistical Yearbook*. For each province, the four components add up to income approach value-added, and provincial income approach value-added usually equals provincial production approach value-added.[55] Consequently, the sum across provinces of production approach value-added and income approach value-added are identical or near-identical (first two data columns in Table 7).

However, the sum of provincial value-added (production or income approach) since the mid-1990s is usually several percentage points higher than the national GDP figure published by the NBS.[56] This is true for national GDP both as first published by the NBS and as officially revised later. (Provincial value-added figures are not revised in the *Statistical Yearbook*; the provincial figures for 1978–1995 from *GDP 1952–1995* are likely to be once-and-for-all final figures.) The largest part of the discrepancy is typically located in the tertiary sector. The NBS expects the results of the economic census of 2004 to yield large upward revisions to national tertiary sector value-added and it is, thus, not altogether certain that the sum of depreciation across provinces is necessarily too large.

Two alternative economy-wide depreciation values can be constructed. In a first step, the ratio of depreciation to income approach GDP, both measured as sum across provinces, is obtained. In a second step, this ratio is applied to national production approach GDP, i.e., to the official national GDP figure. This assumes that the share of depreciation in the sum of provincial value-added (GDP) is a good proxy for the share of depreciation in the slightly different (national) GDP. Two values of national production approach GDP are (i) GDP as first published, since the provincial data at least since 1996 are first published data, and (ii) revised GDP. The two resulting alternative depreciation values differ little (Table 7).

Economy-wide nominal fixed asset values can be obtained by dividing one of the three economy-wide depreciation series—sum across provinces, adjusted to national GDP data as originally published, adjusted to revised national GDP—by the depreciation rates. One choice of depreciation rates is the approximate series in Table 3. Alternatively, one could assume a constant depreciation rate of, say, 5%, as frequently done in the literature.[57] Focusing on depreciation based on revised national GDP, Table 8 first reports the resulting two time series of the original values of fixed assets (with approximate vs. 5% depreciation rates).

Two real fixed asset series (two depreciation rate scenarios) are obtained first, as in the cumulative approach, by assuming that the appropriate deflator for scrap values is the same-period investment deflator (Eq. (7*)); the 1978 original value of fixed assets is deflated in full

[55] Production and income approach GDP calculations are not conducted entirely separately; the production approach makes use of some income approach data. See Carsten Holz (2002) for details. The in most years perfect equality of production and income approach data for most provinces suggests that one component of the income approach may have been derived as residual.

[56] The discrepancy between the sum of provincial value-added and national GDP is highest in 2003, when the provincial figure is 15.60% higher. National GDP exceeds the sum of provincial value-added in some of the earlier years.

[57] A rate of 5% is used by, for example, Wang Yan and Yao Yudong (2003), who in turn cite other authors to justify this choice. Alwyn Young (2003) assumes a 6% and Wu Yanrui (2004) a 7% depreciation rate.

Table 7
Economy-wide depreciation (b yuan RMB)

	Sum across provinces[a]				National data			
	Prod. appr. GDP	Income approach			Revised data		Original data[b]	
		GDP	Deprec.	Deprec. in %	Prod. appr. GDP	Implied deprec.	Prod. appr. GDP	Implied deprec.
	(1)	(2)	(3)[c]	(3)/(2)*100	(4)	(3)/(2)*(4)[c]	(5)	(3)/(2)*(5)[c]
1978	344.049	344.049	33.394	9.7062	362.41	35.18		
1979	391.799	391.799	37.679	9.6169	403.82	38.84		
1980	436.787	436.787	42.883	9.8178	451.78	44.35		
1981	475.960	475.960	47.464	9.9723	486.24	48.49		
1982	529.158	529.158	53.004	10.0167	529.47	53.04		
1983	593.977	593.977	60.131	10.1235	593.45	60.08		
1984	708.827	708.897	70.828	9.9913	717.1	71.65		
1985	861.903	857.740	85.331	9.9484	896.44	89.18		
1986	965.361	961.045	100.795	10.4881	1020.22	107.00		
1987	1145.521	1139.898	122.525	10.7488	1196.25	128.58		
1988	1446.118	1438.852	153.527	10.6701	1492.83	159.29		
1989	1637.843	1629.663	184.277	11.3077	1690.92	191.20	1579.37	178.59
1990	1834.815	1835.723	214.284	11.6730	1854.79	216.51	1767.11	206.27
1991	2112.774	2114.201	260.608	12.3265	2161.78	266.47	1984.06	244.57
1992	2587.929	2589.232	333.173	12.8676	2663.81	342.77	2402.02	309.08
1993	3418.793	3420.906	397.812	11.6288	3463.44	402.76	3138.03	364.92
1994	4538.369	4538.369	540.688	11.9137	4675.94	557.08	4500.58	536.19
1995	5762.332	5763.278	711.633	12.3477	5847.81	722.07	5826.05	719.38
1996	6858.430	6858.430	878.142	12.8038	6788.46	869.18	6859.38	878.26
1997	7695.661	7695.661	1048.641	13.6264	7446.26	1014.66	7477.24	1018.88
1998	8278.025	8278.025	1198.124	14.4735	7834.52	1133.93	7939.57	1149.14
1999	8767.113	8767.113	1320.904	15.0666	8206.75	1236.48	8191.09	1234.12
2000	9720.937	9720.937	1497.242	15.4022	8946.81	1378.01	8940.36	1377.02
2001	10,676.626	10,676.626	1677.928	15.7159	9731.48	1529.39	9593.33	1507.68
2002	11,802.069	11,802.069	1849.377	15.6699	10,517.23	1648.04	10,479.06	1642.06
2003	13,553.914	13,553.914	2155.147	15.9006	11,739.02	1866.57	11,725.19	1864.37

Sources: Sum across provinces: 1978–1995: *GDP 1952–1995*, tables of each province; 1996–2003: *Statistical Yearbook* of each year, for example, for 2003, *Statistical Yearbook 2004*, pp. 61, 64. National GDP data: revised series: *Statistical Yearbook 2005*, p. 51; as first published (original data): *Statistical Yearbook* of each year (in 1989–1991 as sum of three economic sectors).

[a] Provincial production approach GDP, income approach GDP and (income approach) depreciation in the *Statistical Yearbook* are only published once, in the issue of the following year; revised data are not published. In the table, the provincial data for 1978–1995 are from the compendium *GDP 1952–1995*; these are probably final data, compiled once, retrospectively. (The *Statistical Yearbook* beginning for the year 1993 reports provincial production approach value-added that adds up to GDP in 1993 of 3206.999b, in 1994 of 4558.634, and in 1995 of 5763.278b yuan RMB, 6.20%, 0.45%, and 0.02% lower than the *GDP 1952–1995* figures, which could imply that the *GDP 1952–1995* data for the years 1978 through 1995 are the most up-to-date data, and the ones in the *Statistical Yearbook* are as first published. The 1993 difference could be attributed to possibly pre-tertiary sector census provincial data in the *Statistical Yearbook*.) Data on Tibet are only available and included here starting 1985, with a value of depreciation equal to 0.12% of the sum of depreciation across all provinces.

[b] "Original data" are as first published. National production approach GDP is first published in the *Statistical Yearbook* of the following year (starting with the 1990 issue); a revised national figure is published a year later; a benchmark revision following the tertiary sector census of 1993 revised the data of all earlier years. At the national level, income approach data are not published.

[c] These are the three depreciation rate series that can be turned into original values of fixed assets.

using the 1978 deflator.[58] A second set of two real fixed asset series follows from Eq. (7″) with depreciation-based scrap rates and the deflator lag series of "B-C.4" in Table 4.[59] Table 8 reports the two sets of two real fixed asset series and Fig. 6 charts them.

Fig. 6 shows that whether the current or lagged deflator is applied to the scrap value makes little difference. What matters more is if the approximate depreciation rate is used or a constant (assumed) 5% depreciation rate. In the latter case, the series are much smoother.

In 1993, growth in the fixed asset series based on the approximate depreciation rates plummets to about zero, which does not appear credible. (The series based on the 5% depreciation rate also falls, but not by as much.) The approximate depreciation rate rose by about one percentage point in 1993, which lowers the ratio of depreciation to the depreciation rate, i.e., fixed assets. This rise in the depreciation rate may be quite accurate because the depreciation rates calculated from depreciation and fixed asset values in industry show a similar jump in 1993 as the published depreciation rates (Table 3). The problem would then rest with the economy-wide depreciation data.

The share of depreciation in GDP (both variables as sum across provinces) fell from 12.87% in 1992 to 11.63% in 1993 before rising again to 11.91% in 1994 and 12.35% in 1995 (Table 7); if the 1993 share had not dipped by more than one percentage point but remained at the 1992 level, fixed assets in 1993 would have grown by 4.40%. If the economy-wide depreciation values are approximated by the statistical authority initially without taking the rise in the depreciation rate into full consideration, the result is an underestimation of fixed assets in 1993, and then possibly the gradual incorporation of the depreciation rate change in later years.[60] Depreciation grew rapidly in 1994–1998 (Table 7, even after accounting for price changes), as did, consequently, fixed assets in 1995 through 1998 (see Fig. 6, with a contrarian development in the depreciation rate in 1994, and a supporting one in 1996). These considerations still ignore the revaluations after 1992; these imply that the derived "original values of fixed assets" no longer constitute "original values."[61]

Fig. 7 compares the NIA fixed asset series, based on the approximate or five percent depreciation rate and incorporating a lagged deflator for scrap values, with the two final fixed asset series from the cumulative investment approach. Both NIA fixed asset series exhibit larger fluctuations than the ones obtained via the cumulative approach, especially after 1992. The variability in the NIA values, given that the capital stock series changes through annual investment and the decommissioning of some fixed assets, appears high. Independent of the

[58] For example, in the case of the approximate depreciation rate, the inflated 1978 value is the original nominal value of 950.71b yuan RMB in Table 8 divided by the 1978 deflator of 0.2725 in Table 3, i.e. 3489.31b yuan constant year-2000 RMB (with more decimals used in the calculations than reported). The 1979 increment of, continuing with the same example, 1021.98 less 950.71, i.e., 71.27, is inflated by the 1979 deflator of 0.2783 (Table 3) and then added to the deflated 1978 value of 3489.31b yuan RMB to yield 1979 economy-wide fixed assets in year 2000 constant prices of 3745.36b yuan RMB.

[59] This assumes the depreciation-based scrap rate is correct; effective investment then follows as residual. (End-year scrap rates are applied to midyear original fixed asset values without attempting to correct for the half-year difference.) Alternatively, economy-wide effective investment could have been inserted in Eq. (2′) to obtain a NIA scrap rate, and both the effective investment values and the NIA scrap rates then used in Eq. (7′). With the economy-wide effective investment data not immediately available for the years prior to 1981, and questions about underestimation through 1985, the first option was chosen. An appendix on the reliability of the NIA fixed asset values further explores their reliability.

[60] The income approach—in which depreciation is one component of GDP— is not the official approach to the calculation of GDP and some values may have been guesstimated or obtained as residuals; the adoption of a new accounting system in 1993 may also have hampered data quality in that particular year.

[61] The derived scrap values are now above original values in all years, while the implicit effective investment values are exaggerated in years with revaluation (driven by higher scrap values and the revaluation) and less so in later years without revaluations (driven by the higher scrap values only). Derived fixed asset growth rates are likely to be exaggerated at the time of first revaluations, and then underestimated later (due to the now higher base).

Table 8
Economy-wide midyear fixed asset values, NIA approach, b yuan RMB (year 2000 prices for real series)

	Original value of fixed assets		Real original value of fixed assets, scrap value deflated using			
			Current-period deflator (Eq. (7*))		Lagged deflator (Eq. (7″))	
Dep. r.	Approx.	5%	Approx.	5%	Approx.	5%
1978	950.71	703.52	3489.31	2582.09	3489.31	2582.09
1979	1021.98	776.70	3745.36	2845.00	3744.84	2844.62
1980	1167.24	887.10	4251.72	3229.83	4248.84	3227.65
1981	1243.31	969.78	4508.71	3509.15	4501.42	3503.62
1982	1359.88	1060.71	4893.64	3809.40	4876.46	3796.15
1983	1501.94	1201.55	5351.43	4263.27	5319.30	4238.37
1984	1747.50	1432.95	6111.96	4979.94	6049.98	4931.15
1985	2026.84	1783.62	6919.18	5993.29	6818.80	5913.01
1986	2377.81	2140.03	7872.38	6961.26	7731.93	6845.72
1987	2857.38	2571.64	9109.86	8074.99	8919.42	7914.46
1988	3462.75	3185.73	10,485.86	9470.81	10,239.07	9259.56
1989	4156.60	3824.07	11,939.60	10,808.25	11,641.97	10,550.23
1990	4920.67	4330.19	13,457.25	11,813.54	13,046.92	11,451.83
1991	5792.89	5329.46	15,039.40	13,626.14	14,495.31	13,146.73
1992	7292.97	6855.39	17,399.38	16,026.79	16,682.77	15,388.67
1993	7322.88	8055.16	17,436.54	17,517.73	16,447.92	16,623.92
1994	9442.00	11,141.56	19,821.87	20,991.84	18,533.76	19,768.59
1995	12,449.50	14,441.42	23,018.56	24,499.28	21,311.43	22,781.59
1996	17,383.66	17,383.66	28,061.41	27,506.33	25,772.12	25,113.34
1997	21,138.68	20,293.13	31,834.98	30,430.18	28,703.87	27,195.37
1998	26,998.41	22,678.66	37,735.47	32,832.30	33,603.41	28,636.58
1999	27,477.25	24,729.53	38,219.58	34,905.73	32,834.06	29,657.09
2000	29,319.34	27,560.18	40,061.67	37,736.38	33,467.76	31,400.20
2001	29,411.34	30,587.80	40,153.30	40,751.94	32,371.82	33,299.43
2002	32,314.58	32,960.87	43,039.20	43,110.84	34,220.58	34,579.71
2003	34,566.09	37,331.38	45,229.09	47,361.72	35,458.28	37,859.36
Average annual growth rate (in %)						
1978–1999			12.07	13.20	11.27	12.33
1978–2000			11.73	12.97	10.82	12.03
1978–2002			10.79	12.34	9.72	11.34

The economy-wide original value of fixed assets is obtained as economy-wide depreciation divided by the depreciation rate. For the absolute depreciation values see Table 7; these are obtained as "sum provincial depreciation divided by sum provincial gross value-added" times national (revised) GDP. For the approximate depreciation rate series see Table 3.
The real original value of fixed assets series using a current-period deflator is from Eq. (7*), those using a lagged deflator from Eq. (7″) with a depreciation-based scrap rate. The scrap value is obtained using Eq. (3) with the depreciation-based scrap rate. The investment deflator is from Table 3, and the lagged deflator follows from the deflator data in Table 3 and lifetime data in Table 4 (series B-C.4).
All series potentially incorporate (cannot correct for) revaluations after 1992.

variability, the fact that they are distorted by the since 1993 official revaluations of the original values of fixed assets makes their post-1992 values less desirable than those obtained via the cumulative approach.[62]

[62] For the advantages and disadvantages of different approaches to calculating economy-wide real original values of fixed assets see the appendix.

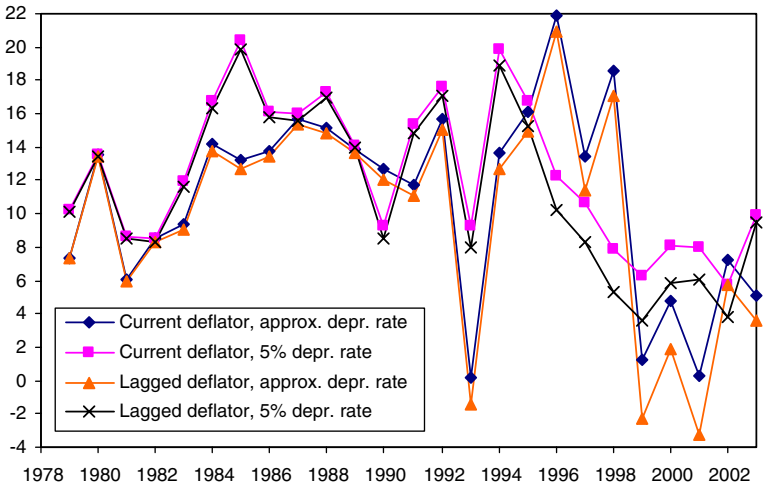

Fig. 6. Growth rates of economy-wide real fixed asset values, NIA approach. Growth rates are annual real growth rates in percent. Underlying original fixed asset values are obtained using the NIA approach. Fixed asset values are midyear values.

NIA fixed asset series may be more appropriate in cross-sectional analysis, such as across provinces in a given year, where the construction of a cumulative series may be too time-consuming or requires too many assumptions to be plausible. Otherwise, a three-year moving average could be used to smooth the fluctuations. The revaluation issue, however, remains unsolvable, unless one is willing to assume that the NIA depreciation values reflect depreciation on fixed assets that are all valued at current-period prices, in all years. A real fixed asset series could then be obtained by applying the deflator to the full original value of fixed assets in each year.

7. Economy-wide real original values of fixed assets compared to the literature

Does the choice of fixed asset series really matter? Do fixed asset series in the literature which take the depreciation rate for a scrap rate (or use net fixed assets as a measure of fixed assets), gross fixed capital formation for investment, and investment for newly increased fixed assets, not perhaps yield similar results? Figs. 8–10 compare the results obtained here to those of Gregory Chow (1994) for 1953 through 1985, Gregory Chow and Kui-Wai Li for 1952–1998, Wang Yan and Yao Yudong (2003) for 1952 through 1999, and Wu Yanrui (2004) for 1952 through 2000, where the values in the literature are turned into midyear values for comparability.[63]

Fig. 8 shows that the annual growth rates of all four alternative time series in the early 1980s are below and in the early/mid-1990s above those of the two cumulative series derived here. In the mid-1990s their growth rates are higher, presumably because they add the full investment expenditures instead of effective investment only; they do not take into account that at a time of high investment growth the transfer rate falls drastically.

[63] Alwyn Young (2003), another author who works with economy-wide values, does not provide year-by-year data on his economy-wide capital stock series.

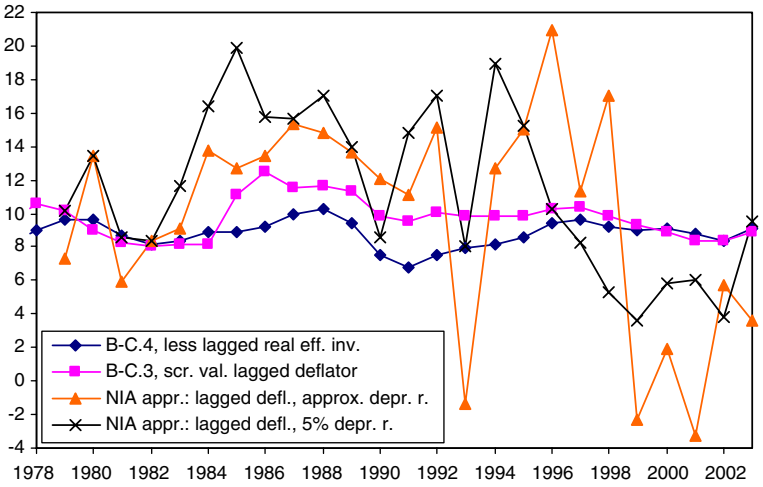

Fig. 7. Growth rates of economy-wide real fixed asset values, cumulative vs. NIA approach. Growth rates are annual real growth in percent. Fixed asset values are midyear values.

Using 4-year growth rates for the years 1958 (with a real growth rate over 1954) through 2003 to sharpen the conflicts between the different series, Fig. 9 shows that all four series in the literature exhibit exceptionally low growth in the late 1950s, and through the early 1990s remain at the lower bound of the growth estimates in this paper. A four-year growth rate twenty

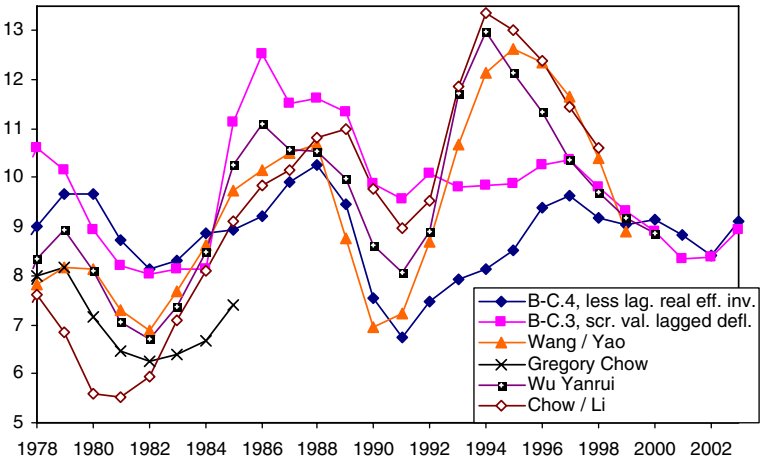

Fig. 8. Comparison with real fixed asset values in the literature, annual growth rates. Growth rates are annual real growth rates in percent. Fixed asset values are midyear values. Wang Yan and Yao Yudong's series is based on cumulative gross fixed capital formation and a "depreciation rate" of 5%; for the end-year data see Wang Yan and Yao Yudong (2003), pp. 49f. Wu Yanrui's data are based on a 7% depreciation rate; for the end-year data see Wu Yanrui (2004), p. 115. For Gregory Chow's end-year data see Gregory Chow (1994), p. 203 (sum of fixed capital stock across five material production sectors) and for the Chow/Li data see Gregory Chow and Kui-Wai Li (2002), p. 250; also see the discussion of the latter two series in an appendix on Gregory Chow and Chow/Li. For comparison purposes, the end-year fixed asset values in all four sources were turned into midyear values.

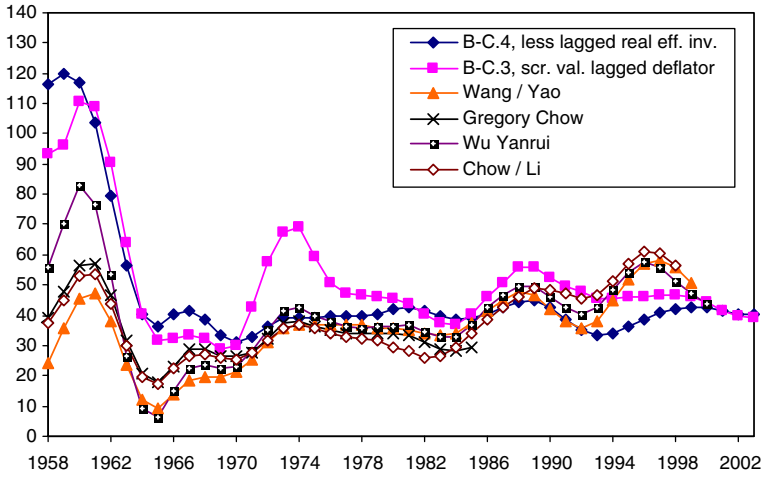

Fig. 9. Comparison with real fixed asset values in the literature, four-year growth rates. Four-year growth refers to the aggregate real growth over the previous 4 years, in percent. Fixed asset values are midyear values. For explanations/sources of Wang/Yao, Gregory Chow, Wu Yanrui, and Chow/Li see Fig. 8.

percentage points below those of the series derived in this paper is not a rarity. The low early growth rates in the literature are in part due to a comparatively high (and ambiguous) 1952/1953 capital value.[64]

The average annual real growth rate over the period 1978–1999 in the series of Wang/Yao, Wu Yanrui, and Chow/Li is 9.43%, 9.61%, and 9.52% (1978–1998 for Chow/Li) compared to 8.80% and 9.93% in the case of the two series derived here (B-C.4, B-C.3; bottom Table 6). For the period 1954–1999 the comparison is between 7.79%, 8.82% and 8.33% (1954–1998 for Chow/Li) in the literature and 10.28% and 11.11% here. In other words, the difference in the long-run average annual growth rate of capital is two to four percentage points but in the reform period largely disappears. In a growth accounting exercise, the higher long-run growth rates of fixed assets obtained here reduce TFP growth. For example, Wang/Yao's data suggest an average annual TFP growth rate for the period 1954–1978 of negative 1.43%; using the two fixed asset series here, this TFP growth rate reduces to negative 4.04% or negative 4.32%. For the reform period 1978–1999, the values are similar with 2.62% vs. 2.94% or 2.38% average annual TFP

[64] The 1953 end-year fixed asset values derived here, for the two series included in Fig. 9, *in 1953 prices*, are 55.763 and 41.106b yuan RMB (Table 6). In contrast, Gregory Chow (1994) has a 1952 value of 175b yuan RMB which consists of his derived 31.56b yuan RMB and 26.70b yuan RMB (total 58.26b yuan RMB) values for the fixed and the circulatory capital stock (the latter includes inventories and such items as bank deposits and accounts receivable), an assumed 45b yuan RMB in agriculture, and an assumed land value of 72b yuan RMB. For details on a number of shortcomings in Gregory Chow's calculations see the appendix on Gregory Chow and Chow/Li. Wang Yan and Yao Yudong (2003) adopt Gregory Chow's 1952 value of 175b yuan RMB (ignoring the fact that the increments they add to this initial value exclude circulatory capital and land). Wu Yanrui (2004) uses an initial value of 95.2b yuan RMB which he adopts from another source in the literature. Gregory Chow and Kui-Wai Li (2002) use Gregory Chow's 1952 value augmented to 221.3b yuan RMB (ignoring the fact that the increments they add to this initial value exclude land, and that the increments include inventories but not other circulatory capital).

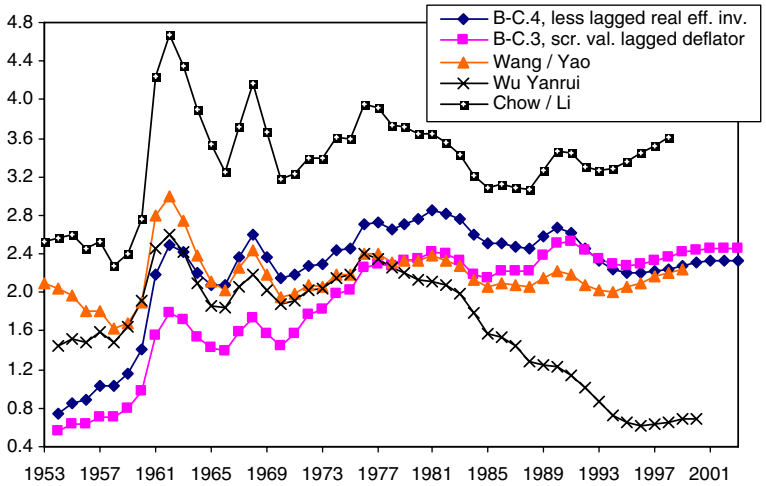

Fig. 10. Value of fixed assets per unit of GDP. Fixed asset and GDP series are in constant prices. Fixed asset values are midyear values. Sources: Wang Yan and Yao Yudong (2003), pp. 49f., for their real capital stock and real GDP series (in 1995 constant prices); Wu Yanrui (2004), pp. 115, 121 ("K0" and "GDP0," both in billion 1952 values); Gregory Chow and Kui-Wai Li (2002), p. 250; otherwise see above for the fixed asset series, with GDP data from the *Statistical Yearbook 2004*, pp. 53 (nominal 2000 value) and p. 56 (real growth since 1979), and *GDP 1952–1995*, p. 36 (real growth 1953–1995, with identical data as the *Statistical Yearbook* for the years since 1979).

growth; but growth patterns differ across sub-periods, such as, for example, 1992–1996 with 4.12% vs. 5.85% or 5.12% average annual TFP growth.[65]

Fig. 10 relates annual midyear fixed asset values to GDP (except for Gregory Chow's case, since he does not provide value-added data), all in real terms.[66] Compared to the fixed asset series developed in this paper, the three series in the literature start at a two to five times higher level of capital relative to GDP. Wang/Yao's ratio ends in 1999 at a largely unchanged value. Wu Yanrui's ratio begins to drop precipitously in the mid-1970s; by 2000, one unit of real capital in Wu Yanrui's series produced four times more real value-added than in the mid-1970s. Chow/Li's ratio is by far the highest throughout but shows a long-run falling trend between 1961 and 1998. In contrast to all three series in the literature, the two series developed in this paper exhibit a long-run gradually rising capital–output ratio (with the "B-C.4" ratio roughly stable over the past 30 years). This is probably what a development economist would have predicted. In other words, established patterns in economics confirm the fixed asset series derived in this paper but not those in the literature.

[65] The calculations use Wang/Yao's real GDP value, Wang/Yao's real capital (with end-year series turned into midyear values) vs. the capital series derived here, and human capital stock values from Wang/Yao's "Appendix A." The weight (labor share) is Wang/Yao's value of 0.5. Wang/Yao do not provide labor data or precise sources of their labor data; they only mention "total labor force of society" in the text. This variable experiences a severe statistical break in 1990. What is used here is (midyear) total labor force of society for 1954 and 1978 (*Statistical Yearbook 1992*, p. 97), and the comparable (midyear) sum-across-sector employment data for 1992, 1996, and 1999 (*Statistical Yearbook 2000*, pp. 120f.).

[66] Gregory Chow provides national income data in the Material Product System. In contrast to value-added, national income does not include depreciation and includes service payments to non-productive units (for example, interest payments).

8. Conclusions

Physical capital series are an essential part of economic growth studies. In the absence of official data on economy-wide fixed asset data, China researchers resort to self-constructed series. The derivation of economy-wide fixed asset series and the adjustments to the available (limited, sectoral) fixed asset data are invariably flawed at the conceptual level. Authors use the depreciation rate instead of a scrap rate, gross fixed capital formation instead of investment, and investment instead of effective investment. Alternatively, they use the accounting artifact "net fixed assets" (which bears no relation to the contribution of fixed assets to production) and calculate depreciation wrongly. Sectoral or ownership-focused analyses that use available fixed asset data ignore the revaluations of the mid-1990s and use depreciation instead of scrap values.

The result of these approximations is a hodgepodge of contradictory deviations from the (unknown) true fixed asset series. In the derivation of an economy-wide fixed asset series, using the depreciation rate instead of the scrap rate leads to the underestimation of the annual increase in fixed assets at least in the pre-reform and early reform period; on the other hand, using investment expenditures instead of effective investment implies that increases in fixed assets are overestimated, and incorporated into the capital series in the year when the expenditures occurred rather than in the year when the investment was completed (turned into a fixed asset). The resulting time series may not be that far off the mark—otherwise, researchers would probably have already noticed that something is conceptually wrong—but the four alternative economy-wide series in the literature all exhibit lower growth rates through the early 1990s, and a different pattern in the 1990s than the series derived here. The fact that the economy-wide capital–output ratio according to one series in the literature has remained approximately constant over 50 years and is on a downward trend according to two others does not make these fixed asset time series particularly plausible.

This paper addresses the shortcomings at the conceptual level by laying out how fixed asset variables are related to other variables by the logic of the accounting system. It proceeds to use these identities to construct conceptually correct fixed asset series via investment accumulation. These are supplemented by fixed asset series obtained through a hitherto unexplored direct approach of dividing depreciation in the national income accounts by the depreciation rate. The perhaps most reliable fixed asset series is the one in the cumulative approach with non-SOU effective investment values through 1986 approximated as difference of gross fixed capital formation and SOU investment, times the non-SOU transfer rate, and current-period scrap values approximated by real effective investment of a corresponding earlier year. Another choice is the series where non-SOU effective investment prior to 1986 is approximated using the real growth rate of industrial non-SOE gross output value, and real scrap values are obtained as scrap values divided by a *k*-period lagged deflator. (See seventh and sixth data columns in Table 6, marked with a superscript "a".)

A simple procedure to extend these fixed asset series forward in future years is to start with the *end-year* 2003 values provided at the bottom of Table 6 (in year 2000 constant prices). For the first series, (i) later (more recent) effective investment values are reported annually in the *Investment Yearbook*, (ii) the investment in fixed assets price index is readily available (for example, in the *Statistical Yearbook*), and (iii) absent any new information one may choose to continue to in each year decommission the real effective investment of 14 years earlier (as the 2003 lag suggests).[67] This

[67] The *Investment Yearbook 2004*, for example, provides economy-wide effective investment of 2003 (p. 3) with a breakdown by ownership (p. 27) and by urban–rural areas (pp. 73, 431). The *Statistical Yearbook 2005* provides urban values for 2004 (p. 213), 1995–2002 (p. 219), 2003 and 2004 (p. 220), and 1995–2004 (p. 224); the 2003 urban value is identical to that reported in the *Investment Yearbook 2004*; the *Statistical Yearbook 2005* does not report a rural value.

procedure is straightforward and requires only two new data points every year combined with a plausible assumption. For the second series, beyond items (i) and (ii), assumptions have to be made about (iii) the deflator lag of the scrap value and (iv) the scrap rate; one may choose to continue with a 13-year deflator lag (as the 2003 lag suggests), and a scrap rate of 2.5% (as in 2003). Depending on if investment growth in the future slows or accelerates, the scrap rate could be slightly raised or reduced.

For the period covered in this paper, a number of additional variations are possible and the data are provided in this paper to explore these further. For example, the 1992 SOU benchmark value could be taken as the true value and a fixed asset series for SOUs constructed by adding/subtracting effective investment of all other years from this benchmark value (taking into account scrap values and deflating for price changes). The original value of fixed assets of 1978 obtained in the NIA approach could be taken as a starting point to which to add annual real effective investment and from which to subtract the annual real scrap value. A deterministically upward trending scrap rate series could be substituted for those used here. If one believes that the gross fixed capital formation data accurately proxy for economy-wide investment, the fixed asset series that uses these data could be used for all years. (It is provided in the last column in Table 6, with near-identical results to the first choice of fixed asset series here, and similarly extendable into the future).

Since the results derived in this paper under a wide variety of assumptions do not vary much, further scenarios will probably not yield much different results. The close match of the various cumulative series derived here is good news. While we may not have one perfect fixed asset series, as long as the derivation is conceptually correct, minor variations in assumptions have little impact.

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