



Measuring Capital Stock and Capital Services in China, 1949-2012

Harry X. Wu (Hitotsubashi University, Japan)

Paper Prepared for the IARIW 33rd General Conference

Rotterdam, the Netherlands, August 24-30, 2014

Session 7B

Time: Friday, August 29, Morning

Prepared for IARIW 33rd General Conference, Rotterdam, The Netherlands
August 24-30, 2014
Session 7B “Measuring Capital Stock and Capital Services”
Organized by Marshall Reinsdorf

MEASURING CAPITAL STOCK AND CAPITAL SERVICES IN CHINA, 1949-2012

Harry X. Wu
Institute of Economic Research, Hitotsubashi University, Japan

This version: August 8, 2014

ABSTRACT

Based on our best understanding of the major problems related to the Chinese official investment statistics and following the SNA concept of capital stock and capital services, this study first reconstructs industry-level investment flows that conceptually match production accounts, and then constructs net capital stock and estimates capital services. Due to data constraints, different approaches are used to the industrial and non-industrial sectors in establishing the annual investment series. Basically, for the industrial sector investment flows are derived from gross fixed assets in historical costs based on industry accounting statistics, which is arguably to be able to bypass the conceptual flaws in the official industrial investment data. For the non-industrial sectors, the official investment statistics are directly used with adjustment for inconsistencies. For each industry, the initial capital stock is estimated using information from the 1950-51 national asset survey, depreciation rate is estimated based on official accounting rules on asset service lives and declining balance rate used for market economies, and deflator is constructed based on the PPIs of investment goods industries and wage index. By this stage of the work, we have established capital stock series for 24 industries of the industrial sector for the period 1949-2012 and constructed both capital stock and capital services for economy-wide 37 sectors for the period 1980-2010.

Keywords: Flow of investment; initial capital stock; economic depreciation; investment deflator; net capital stock; capital services

JEL Classification: C82, E22, L60, O47

1. INTRODUCTION

A conceptually correct and empirically sound measure of capital input at industry level is essential for the standard productivity analysis. The construction of a proper net capital stock is the primary step for such a measure. However, data problems have long been the major obstacle to that objective. The Chinese statistical authorities have never provided any capital stock estimate in line with the SNA principles. The available statistics are far from sufficient for researchers to construct capital stock and estimate capital services by themselves.

Basically, the available official fixed asset investment data are mixed up with inventories and official gross stock data, that only cover the industrial sector, suffer from inappropriate treatment to aggregation by adding up investment at historical costs and mixing up industrial structures and equipment with dwellings. The stock data are also inconsistent in industrial classification and coverage and lack of information on prices. Furthermore, the available data only cover enterprises in the state statistical reporting system that has used different qualification criteria overtime changed from ownership type to the level of administration and to the size of firms. There is no coverage for the rest enterprises. Besides, there is no information that could help establish the linkage between the national gross fixed capital formation (GFCF) and the industry-level fixed asset investment overtime.

This study extends the author's earlier work (Wu and Xu 2002; Wu 2008 and 2013d) on the industrial sector and the national economy as a whole to the non-industrial sectors. It is the first attempt to integrate all sectors of the economy and to reconcile the results with the national accounts. Such a reconciliation exercise, instead of finding immediate solutions, may help explore the underlying problems in the integration and hence propose possible solutions.

It is important to note that the nature of the present study is heavily data-driven and measurement-oriented rather than theoretical or methodological. In my view, for an economy like China whose official statistics has long suffered from conceptual flaws and methodological deficiencies, it is risky to propose any innovative method that inevitably brings in more strong assumptions and thus more errors. Therefore, fixing explicit inconsistencies in concept, classification and coverage is the top priority. Any future innovation has to work on a consistent series that coherently integrates industry-level investments with the national accounts.

This paper proceeds as follows. [Section 2](#) discusses the main problems in the Chinese investment statistics and how they were tackled in the previous studies. [Section 3](#) presents the theoretical framework of economic depreciation and capital services that is adopted in this study. [Section 4](#) constructs annual investment flows for each sector of the economy with total assets a decomposed into non-residential structures and equipment. [Section 5](#) estimates the initial capital stock and reconstructs GFCF series as national "control totals". [Section 6](#) and [Section 7](#) constructs industry-specific investment price index for structures and equipment and estimates industry-specific depreciation rate, respectively. [Section 8](#) constructs net capital stock by industry following the standard perpetual inventory method (PIM). Finally, [Section 9](#) calculates industry-specific user cost of capital and estimates capital services for industry. [Section 10](#) concludes the paper.

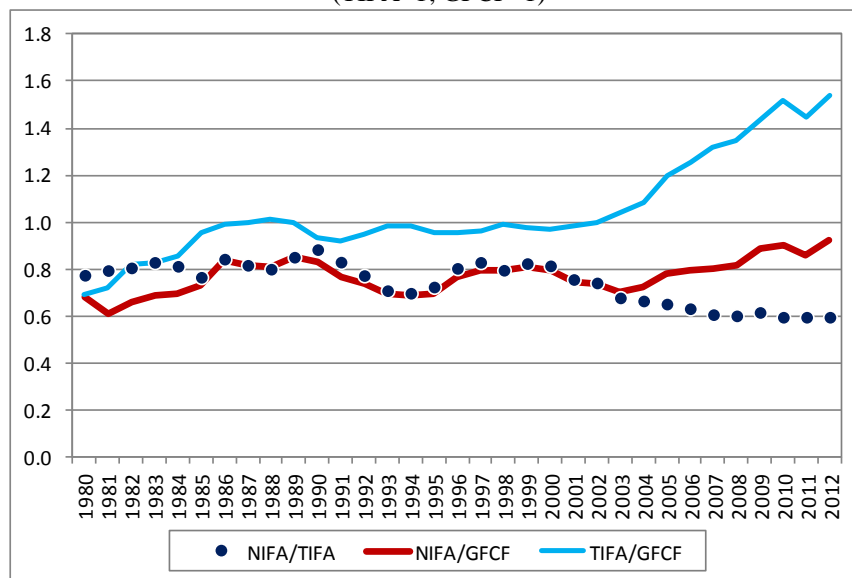
2. PROBLEMS IN MEASURING CAPITAL STOCK IN CHINA

Conceptual problems of the official investment statistics

The Chinese official investment statistics are constructed using data collected through the authorities planning and monitoring capital investment mechanism, consists of mainly two annual series, “total investment in fixed assets (TIFA)” (*quanshehui guding zichan touzi*) and “newly increased fixed assets (NIFA)” (*xinzeng guding zichan*), which are now the basis for the gross fixed capital formation (GFCF) item in the Chinese national accounts.¹

An often made, significant mistake is the direct use of “investment in fixed assets” as the investment variable in estimating capital stock with the perpetual inventory method (Ho and Jorgenson, 2001; Young, 2000a; Huang et al., 2002; Hu and Khan, 1997; Li et al., 1992), which is conceptually inappropriate. By official definition, this indicator refers to the “workload” of activities in construction and purchases of fixed assets in money terms (NBS, 2001, p.220). As correctly noted in Chow (1993, p.816), the work performed in the “investment in fixed assets” may not produce results that meet standards for fixed assets in the current period. In fact, some of the work (investment projects) may take many years to become qualified for fixed assets and some may never meet the standards, hence be completely wasted, which is a typical phenomenon in all centrally planned economies.

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



Sources: Wu (2014, Figure 5).

¹ Official statistics on the two series sometimes include two sub-categories: “investment in capital construction” and “investment in technical update and transformation” (of the existing capital assets). The latter is translated, inappropriately, as “investment in innovation” in recent volumes of China Statistical Yearbook, which causes some confusion. In this section, to simplify our discussion of conceptual issues we will temporarily ignore the distinction between the two subcategories.

The nature of the problem is the same as that commented by Xu (1999) on the item GFCF in China's newly adopted SNA-type national accounts, which is, as above mentioned, based on "total investment in fixed assets". Xu (1999, pp.62-63) points out that the key difference of the Chinese capital account in comparison with the 1993 SNA is that the former does not follow the SNA capital formation criterion of the sales contract-based, complete ownership transaction from producers or constructors to users (investors) of capital goods. For example, in SNA (CEC et al., 1993, p.230) a plant construction is counted as *inventory* if it cannot be sold to a buyer (investor), while in the Chinese national accounts it is included in the fixed capital formation.² This is a significant problem as it exaggerates the amount of capital stock in productive service.

Such a practice is rooted in the central planning period when the state was the dominant, if not sole, owner and player in the economy, and therefore a plant project was counted as (the state) investment once its structure was completed and equipment installed, no matter whether it could meet the standards for production. The problem is aggravated in the case of a large project because its investment "workload" is counted by stage of construction, but it cannot be used for production (hence should be counted as the increase in inventory) before all stages are completed and the operation actually commences. It can be sure that the official TIFA indicator and hence GFCF exaggerates the real level of fixed asset investment.

In fact, compared with the indicator TIFA, the series of NIFA is much more compatible with the SNA concept of fixed asset investment because it refers to the value of investment projects completed and put into production in the current year (NBS, 2001, p.222), hence reflecting the fixed assets formed in the current period as a result of those *effective* investment projects taking place in the current and previous periods. They are *effective* because they have been turned into new fixed assets for production services rather than wasted.

Let us reconcile the two Chinese concepts of fixed asset investment with the concept of investment used in the perpetual inventory method (PIM). Now, if denote NIFA as N and TIFA as O (or the "workload" of investment projects), assuming no coverage problem and double counting (to be discussed later), then N in period t is the sum of O 's in $\tau + 1$ periods ($i = 0, 1, 2, \dots, \tau$) multiplied by their respective ratios θ ($\theta < 1$), defined as, in value terms, the proportion of actually completed investment in period t in the total "workload" of the investment projects taking place in period $t - i$,³ that is,

$$(2.1) \quad N_t = \sum_{i=0}^{\tau} \theta_{t-i} \cdot O_{t-i}, \quad (i = 0, 1, 2, \dots, \tau).$$

² The general SNA principles governing the time of recording and valuation of gross fixed capital formation is "when the ownership of the fixed assets is transferred to the institutional unit that intends to use them in production" (CEC, 1993, p.223).

³ Therefore, $(1-\theta)$ indicates the proportion of the value of investment projects that is unfinished or wasted or both in a given period.

It should be mentioned that there is little information available on θ and τ . Note that θ is not endogenous in the system.⁴ Here it should be mentioned that an officially often used ratio, namely, “the rate of fixed assets turned over to use”, defined as $N_t/O_t = \left(\sum_{i=0}^{\tau} \theta_{t-i} \cdot O_{t-i}\right)/O_t$, is misleading because it compares two concepts that are virtually incompatible (see figures on the ratio, NBS, 2001, p.174).⁵

However, N is not yet ready to be a good proxy for the investment variable, denoted as I , used in PIM (see Equation 5). Two adjustments have to be made to transfer N to I . The first one is a downward adjustment to remove the investment in residential buildings, a prerequisite for conducting any production function analysis.⁶ The second one is an upward adjustment to include the projects less than half million yuan by non-state firms that are not reported in official investment statistics, plus the value of likely underreporting (Young, 2000). Suppose that the two effects on N can be captured by η (residential structures and double counting) and λ (missing and/or underreported investment), respectively, we can have the following definition for I in line with the standard concept:

$$(2.2) \quad I_t = N_t \frac{1-\eta_t}{1-\lambda_t}, (\eta < 1; \lambda < 1)$$

If both η and λ are stable over time, N could be a good proxy for the growth of I , but not for the level of I . Yet, neither η nor λ has been stable. It is conceptually wrong to substitute O for I as practiced in many studies and it is not appropriate to derive I based on the misleading N/O ratio for the current year (e.g. Li et al, 1992). So far, to our best knowledge only Chow (1993) adopted N as investment flow to construct capital stock in his growth accounting exercise for the period 1952-85, but without any adjustment.

Problems of deflation

All official fixed assets data are published in values at acquisition prices or historical costs. In fact, N is recorded at historical prices over the period $t-i$ (Eq. 2.1) which means it is valued at different prices over time. How to deflate fixed assets so that it can be valued at constant prices is a difficult task for researchers. Information on the prices of capital goods for the pre-reform period is scant. The official producer price indices for capital goods only became available after 1985. From 1992, the statistical authority began to publish investment price index (IPI).

⁴ However, the ratio may be somewhat useful for gauging the possible wastage in China’s capital investment projects. If the composite of projects with different construction periods in value is similar over time and there is no wastage, the ratio should have remained stable over time. If we believe that the reform-led marketization have shortened the average construction period (note that the post-reform correction to the over-investment in heavy industrial projects should have shortened the period of an average project) and reduced wastage (at least for industrial projects), the ratio should have increased since the 1980s. Nevertheless, the official statistics show that the ratio dropped from 80.2% in 1953-57 to 62.7% in 1991-95 with sharp fluctuations over the periods in between (DFAIS, 1997, pp. 186-189).

⁵ It should be noted that this ratio is mistakenly used in Li et al. to derive actual investment (1992, p.348).

⁶ A few studies have so far attempted to tackle the problem (e.g. Maddison, 1998; Li et al., 1993; Chen et al., 1988a), but all adjustments are inevitably rough.

Previous studies often use official retail price indices (RPI) (e.g. Huang, Ren and Liu, 2002) or implicit GDP deflator as a proxy (e.g. Chow, 1993; Hu and Khan, 1997; Wu Y., 1999 and 2000), which is conceptually incorrect. Since official GDP estimates may be exaggerated partially due to the underestimation of price changes (Wu, 2002; Young 2000; Maddison, 1998; Woo, 1998; Ren, 1997),⁷ using GDP deflator may also exaggerate the real investment.

Problems of depreciation

The published official depreciation rates are unusually low from an international perspective. For example, in 1990 the fixed assets depreciation rate (a comprehensive one including all types of fixed assets) is 4.8 percent for all state enterprises and 5.1 percent for state industrial enterprises, increased from 2.9 and 3.7 in 1952, respectively (NBS, 1992, p.28), compared with the empirical evidence of 13.3 percent for equipment and 3.7 percent for structures for the US economy in 1977 found by Hulten and Wykoff (1981b). The low depreciation was, not surprisingly, in line with the overestimated service life of fixed assets in the absence of property market in the central planning period. Furthermore, the official depreciation method assumes a straight-line depreciation function that is different from the geometric depreciation function supported by established empirical studies.

Due to the lack of empirical evidence of the service lives of equipment and structures and their depreciation patterns in China, many studies simply adopt the official depreciation rates (Chen et al., 1988a; Chow, 1993; Hu and Khan, 1997), whereas a few set their depreciation rates based on the experience of market economies (Huang et al., 2002; Li et al., 1993) or arbitrary assumptions (Young, 2000a). Nonetheless, researchers' choices of different depreciation rates together with different deflators, *ceteris paribus*, could significantly affect the estimated growth rate of capital stock.

Problems of official "capital stock"

Official statistics also include two capital stock series that are constructed using data collected at the firm level through routine accounting reports (unfortunately the national aggregates are kept by NBS), that is, "original value of fixed assets" (OVFA) (*guding zichan yuanzhi*) and "net value of fixed assets" (NVFA) (*guding zichan jingzhi*). OVFA is current year's gross capital stock and NVFA is defined as OVFA minus the accumulated value of depreciation (NBS, 2001, pp.461-462). The NBS way of calculating OVFA is to add the value of investment in fixed assets in current year embodying a mix of buildings (factories, offices and dwellings), equipment and machinery, with the value of the existing stock at historical or acquisition prices. Assuming the official depreciation method can be accepted, NVFA cannot be used because it ignores two problems: inaccurate valuation and improper coverage. Firstly, there is not a proper deflator that can deflate a capital stock mixed with different types of assets purchased at different prices and in different periods. Secondly, like the official data on investment the stock series also include residential structures that cannot be easily separated.

⁷ For a critical review on this deflator problem see Wu (2000).

The study by Chen et al. (1988a) is a pioneering one to reconstruct both the gross and net capital stock series for the state industrial sector in 1952-85 based on the official capital stock data.⁸ This widely cited study makes important efforts in three areas. Firstly, it derived annual investment flow from the official stock data so that the problems in the official investment data (i.e. the M series, Eq.1) could be bypassed. Secondly, it decomposed the so-derived investment flow into four types of assets, namely, “equipment”, “industrial construction”, “housing” and “others” so that residential buildings could be separated from non-residential fixed assets. Lastly, it constructed four price indices to deflate each type of the assets.

However, the work by Chen et al. (1988a) is still questionable. Apart from their unconditional acceptance of the official depreciation method, there are other problems yet to be solved. Firstly, the scrapping problem was not carefully tackled in their estimation of investment flow. By the logic of the official definition, the end-year stock data, either OVFA or NVFA, have already excluded the assets that had retired during the current year, hence the so-derived investment flow might have underestimated the actual new investment.⁹

Secondly, the decomposition was largely based on the investment composite of the entire state sector rather than the state industrial sector, which might have underestimated the proportion of industrial assets and hence overestimated the proportion of housing.

Lastly, there are also problems in constructing price indices. For example, it is clearly that the official implicit output deflator heavily influenced the construction of the price index for equipment, hence the level of inflation might have been underestimated. The construction of the price indices for industrial and residential structures was based on the scattered official statistics on construction costs, but no details were given on how the cost data were used. It is also believed that using construction cost data to derive investment deflator could understate the productivity improvement in construction, an issue that is worth further investigating (Hulten, 1990). Besides, it is inappropriate to assume, as in Chen et al. (1988a), that changes in the investment outlay under “others” could have been a pure price effect (i.e. the real value has no change at all). This is because the data are already recorded as “stock” rather than investment.

3. ECONOMIC DEPRECIATION, NET CAPITAL STOCK AND CAPITAL SERVICES

Capital stock estimates can be derived either using data based on a direct measurement of the stock or using investment data and the perpetual inventory method. As we have seen, even if for countries like China with a long history of central planning that made it easy to monitor and record the process of production, the available official data on the direct measurement of capital stock do not provide detailed information about the vintages of the assets that is necessary to derive stock estimates in the current cost and constant cost valuations.

⁸ Rawski (1980) and Field (1980) made some earlier attempts but with less sufficient and less reliable information compared with Chen et al.

⁹ To be added: a note on the author’s visit to SOE factory accountants in Beijing...

The perpetual inventory method of estimating capital stock has been developed since Goldsmith (1951). Following Jorgenson (1990) and Hulten (1990), we can start by assuming that researchers can observe the quantity of new capital added to the stock via investment in each year, I_t , but not the amount of capital stock itself, K_t . The problem is to develop a reasonable procedure for adding up the individual I 's into an estimate of K , recognizing that part or all of past additions to the stock may have been retired from service and the services yielded to the stock may be less productive. The perpetual inventory method is one attempt at solving this problem.

In the perpetual inventory method, investment from all surviving vintages is weighted by a relative *efficiency* parameter, Φ_{t-v} , between zero and one to allow for the possibility that older capital is less productive than its newer counterparts, and the weighted investment series is then added up to form a total capital measure, expressed by the following equation:

$$(3.1) \quad K_t = \Phi_0 I_t + \Phi_1 I_{t-1} + \dots + \Phi_T I_{t-T}, \quad (0 \leq \Phi \leq 1)$$

where $\Phi_0 = 1$ and $v = t - T$ is the date when the oldest surviving vintage was added into the stock, hence T is the age of the oldest vintage and t , as the convention, denotes the current time (or prime period). Since one unit of vintage v capital is treated as the equivalent of only Φ_{t-v} units of new capital, the stock K_t has the natural interpretation as the number of units of new investment needed to be equal to the productive capacity of past investment (Hulten, 1990).

There has been a vast of literature on the behaviour or the pattern of Φ and the approach of estimating Φ . By far three typical efficiency patterns have been explored, namely, one-hoss shay, straight-line and geometric. In the one-hoss shay form, assets remain full efficiency until they completely fall apart. In the straight-line form, efficiency decays in equal increment every year, following the convention of the depreciation approach in accounting. The geometric form, which is now most popular and followed in this study, suggests that efficiency decays at a constant rate, δ , that is,

$$(3.2) \quad (\Phi_{\tau-1} - \Phi_\tau) / \Phi_{\tau-1} = \delta, \quad (\tau = 0, 1, 2, \dots)$$

implying that $\Phi_0 = 1$, $\Phi_1 = (1 - \delta)$, $\Phi_2 = (1 - \delta)^2$, ..., $\Phi_\tau = (1 - \delta)^\tau$, ..., and hence the perpetual inventory method (3) that follows the geometric depreciation function can be expressed as:

$$(3.3) \quad K_t = I_t + (1 - \delta)K_{t-1}.$$

Here it is important to note that the efficiency variable δ is in fact the Hicksian rate of economic depreciation as explained by Hulten (1990). Hicks (1946) defines income as the maximum amount that can be spent during a period while maintaining capital values intact; then it follows that economic depreciation is the sum of money, in constant dollars, that needs to be set aside in order to maintain that capital value in real terms.

How a capital asset is valued? Assuming that rental markets exist for capital assets of all vintages, the cost minimization behavior of producers implies that capital of each vintage will be rented up to the point that the value of its marginal product ($\partial Q / \partial I$) is equal to its rental price P^K , which implies that

$$(3.4) \quad \Phi_s = \frac{\partial Q / \partial I_v}{\partial Q / \partial I_t} = \frac{P_{t,s}^K}{P_{t,0}^K},$$

where $s = t - v$ denoted asset age. With this relationship, we can then, following Hulten (1990), define the asset price P^I in terms of the relative efficiency sequence and the rental price of new assets:

$$(3.5) \quad P_{t,s}^I = \sum_{\tau=0}^{\infty} \frac{\Phi_{s+\tau} P_{t+\tau,0}^K}{(1+r)^{\tau+1}}.$$

Importantly, in the absence of rental markets, this expression is also valid for the case in which capital is utilized by its owner (Hulten, 1990, p.128). This can be seen clearly by solving (7) to obtain:

$$(3.6) \quad P_{t,s}^K = [r - \rho_{t,s} + (1 + \rho_{t,s})\delta_{t,s}]P_{t,s}^I,$$

where

$$(3.7) \quad \rho_{t,s} = \frac{P_{t+1,s+1}^I}{P_{t,s+1}^I} - 1,$$

is the expected “inflation rate” in the vintage asset price occurring between years t and $t + 1$, and

$$(3.8) \quad \delta_{t,s} = - \left[\frac{P_{t,s+1}^I}{P_{t,s}^I} - 1 \right],$$

is the rate of decline in the asset price with age s . Therefore, equation (3.6) has a straightforward interpretation: when capital is used by its owner, the equilibrium value of the *implicit* rental must cover the real opportunity cost of an investment of value of P^I as well as the loss in capital value as the capital asset ages (Jorgenson, 1963; Hall and Jorgenson, 1967).

As discussed in Jorgenson (1973), equation (3.8) can be rearranged to link economic depreciation to changes in asset efficiency:

$$(3.9) \quad \delta_{t,s} P_{t,s}^I = P_{t,s}^I - P_{t,s+1}^I = \sum_{\tau=0}^{\infty} \frac{(\Phi_{s+\tau} - \Phi_{s+\tau+1}) P_{t+\tau,0}^K}{(1+r)^{\tau+1}},$$

which states clearly that Hicksian economic depreciation is the present value of the rental income loss due to the efficiency decay $\Phi_{s+\tau} - \Phi_{s+\tau+1}$ taking place in each year in the future ($\tau = 0, 1, 2, \dots$).

As emphasized by Hulten, equation (3.9) “shows that economic depreciation (a price effect) and efficiency decay (a quantity effect) are not independent concepts. One cannot select an efficiency pattern independently of the depreciation pattern and maintain the assumption of competitive equilibrium at the same time.” More importantly, “this framework is useful for revealing what economic efficiency is, but it is also useful for revealing what it is *not*. Depreciation is not the replacement cost of the efficiency units used up in any year, that is, $\sum (\Phi_s - \Phi_{s+1})P_{t,0}^I$, because $P_{t,s}^I$ is not generally equal to $\Phi_s P_{t,0}^I$ unless decay is geometric (1990, p.129).”

In conclusion, it is theoretically justifiable to adopt a constant parameter δ or geometric pattern of depreciation in the perpetual inventory method (PIM) as expressed in equation (3.3) should the economic theory of depreciation be followed. This methodology is also justified by empirical studies conducted by Hulten and Wykoff (1981a and 1981b), Koumanakos and Hwang (1988) and Coen (1975 and 1980).

Strictly speaking, depreciation rate of assets should be calculated from the estimated geometric age-price profiles of assets based on the information obtained from equipment rental markets. Hulten and Wykoff (1981b) apply a Box-Cox power transformation model to their samples of used assets classified by prices and ages, also with censored sample biases adjusted by the Winfrey retirement distribution. Then they assign the so-estimated depreciation rates (in average) to those NIPA (the US National Income and Product Accounts) asset classes that contain their asset types. As for those NIPA asset classes that do not contain the Hulten-Wykoff asset samples, an indirect approach is used by following the relationship:

$$(3.10) \quad \delta \equiv R/T,$$

where T is mean asset life and R is a declining balance rate. Firstly, with the age-price profile-estimated δ 's for equipment and non-residential structures, Hulten and Wykoff derive an average R ($R = \delta T$) for the two categories, respectively, that is, $R = 1.65$ for the former and $R = 0.91$ for the latter. Then, based on the estimated R 's and the information on the mean life of NIPA assets, they calculate δ 's for those NIPA assets that do not contain their samples (1981b, p.94). The Hulten-Wykoff estimates were used as the basis for the new depreciation methodology of the Bureau of Economic Analysis (BEA) in 1997 (Fraumeni, 1997).¹⁰

4. RECONSTRUCTION OF ANNUAL INVESTMENT FLOWS

First of all, or before any serious estimation jobs can be carried out, a conceptually simple but practically difficult issue is how to make the industrial classification of the official data consistent over time, a problem that has been ignored by most researchers because there is insufficient information that is readily for an adjustment. Misclassification that violates the basic “homogeneity” principle of classification exists in various Chinese standard of industrial classification prior to 1994. In Appendix, I have explained the way I used to tackle the problem.

¹⁰ There is a detailed list of the depreciation rates in Fraumeni (1997). The new estimates of capital stock using these depreciation rates are described in Katz and Herman (1997).

Sources of data for the industrial sector

To be added...

Deriving the value of annual investment spending

In the previously discussion (Section 2.1) we have clarified the relationship between the investment concept in PIM (I) and the official statistics on fixed assets investment (O) (equation 2.1) and newly increased fixed assets (N) (equation (2.2)). Ideally, we can follow equation (2.2) to construct the investment series for individual industries. However, since the official data on newly increased fixed assets lack industry-specific details, we have to rely on the official stock data, OVFA.

Conceptually, a gross capital stock at historical prices K^G (to be distinguished from the net stock K) in the current period t , is a result of accumulated investment minus accumulated scrapings, S , which should be noted also in historical cost, that is,

$$(4.1) \quad K_t^G = \sum_{\tau=0}^T I_{t-\tau} - \sum_{\tau=0}^T S_{t-\tau} \quad (\tau=0, 1, 2, \dots T).$$

and hence, the current period investment should be:

$$(4.2) \quad I_t = K_t^G - K_{t-1}^G + S_t.$$

Now, if we substitute the official “original value of fixed assets” or *OVFA* for K^G in equation (4.2), also taking into account the improper inclusion of residential structure in the data, and assuming no underreporting problem, we can obtain an estimate of the value of investment in the i^{th} industry by the following relationship:

$$(4.3) \quad I_{i,t} = (1 - \eta_{i,t}^{OVFA})(OVFA_{i,t} - OVFA_{i,t-1} + S_{i,t})$$

where $\eta_{i,t}^{FA}$ (< 1) is the proportion of residential structures.

Equation (4.3) expresses that for the i^{th} industry, the value of investment spending equals to the first difference of “original value of fixed assets” ($OVFA_{i,t} - OVFA_{i,t-1}$), plus the value of scrapings ($S_{i,t}$), then adjusted for residential structures ($1 - \eta_{i,t}^{FA}$) in the same period.¹¹

However, one of the main problems in calculating equation (4.3) is that there is little information on scrapings. In both Chen et al. (1988a) and Li et al. (1993),¹² the

¹¹ It should also be noted that conceptually the sum of the value of investment in individual industries as derived in equation 4.3 is equal to equation 2.2, $\sum_{i=1}^n I_{i,t} = I_t = N_t \frac{1 - \eta_t}{1 - \lambda_t}$ ($i = 1, 2, \dots, n$).

Also note that the residential structure parameter in 4.3 differs from that in 2.2 and, that is, $\eta^{FA} \neq \eta$.

¹² There is an earlier study that is also led by Li mistakenly assuming that the official indicator “original value of fixed assets” does not exclude the value of scrapings, and hence it should be removed from rather than added in to the equation (Li et al., 1992, p.348). This is incorrect as the evidence obtained by the author in Beijing factories arranged by NBS.

scraping factor is simply ignored, which underestimates the value of investment. Li et al. (1993, p.97) suggest that scraping may be insignificant in China, especially for the central planning period, because the official standard of service lives of fixed assets was much longer than the normal situation and the delayed retirement or over-service of fixed assets was almost a norm. Empirical evidence is certainly needed to justify such a treatment. The effect of reform has to take into account as it tends to induce earlier retirement due to market competition.

In practice, the official “original value of fixed assets” is calculated at the end of each accounting period (year), so it should not include any equipment that had already retired during the period. Therefore, to avoid underestimating the annual investment flows when exercising equation (4.3) it is conceptually necessary to add the value of retired equipment in historical prices back to the series. In order to do so, we need to know the retirement function of fixed assets for each industry in China under different policy regimes. Empirical evidence is required to support the choice of the functional form of the retirement. While searching for such evidence, we can approximate it based on some strong but reasonable assumptions. First, we take into account the retired assets by assuming that all assets in the same investment cohort would start retiring at the end of their service lives measured according to the mean of their service lives. Second, we assume a normally distributed retirement function for all the assets in this investment cohort that is centered at year corresponding to the mean of their service lives. In the current exercise, following the second assumption, an arbitrary, seven-year range (i.e. the function is maximized in the fourth year), normal-distribution retirement function is assumed in calculating the annual flow of scrapings. The results are used to adjust the investment flows directly derived as first difference.

Decomposing investment spending into major asset types

The data on the official “original value of fixed assets” are available in the total value (in historical prices) that is mixed with all types of assets, structures (both residential and non-residential) and other investment spending. Thus, without a proper decomposition of this total value, the residential structures cannot be removed, as suggested in equation (4.3), and any deflation or depreciation procedure, which should theoretically be asset-specific, cannot be carried out in a proper way.

The official data on the value of fixed assets by major asset type at industry level are scant. In the official “investment” statistics, under the subcategory “capital construction” or/and the subcategory “technical update and transformation” there are scattered data distinguished between “equipment” and “structures” (mixed up with housing) and between “productive” and “non-productive” (with housing as a subcategory), but the two distinctions are never cross classified. Besides, the data are for the state economy as a whole without detailed sector or industry break-downs.

Any attempt to decompose the “original value of fixed assets” using such information in the official “investment” is difficult to justify its result. As expressed in equation (1) and (2), the official “investment” (O) is incompatible with what actually invested (I and N) and, in general, the former exaggerates the latter. But the latter, at least conceptually, forms the official “original value of fixed assets” ($OVFA$). It gets more complicated if we consider that the time required for constructing “structure” is generally longer than that for installing “equipment” and the industrial sector, as well as different industries within the sector, can differ greatly from other sectors in the

shares of “equipment” and “structures”, not to mention the differences in these respects between the state and the non-state sectors. All these problems are not properly handled in previous studies largely due to the inadequacy of data.

In this study, to tackle the problem we use some unpublished data from occasional surveys on state assets by the Ministry of Finance. The data are still far less from systematic and sufficient. For the period prior to 1974 only 1954 data are available, and for the period since 1974, data for 1983, 1986-88 are missing. However, they are industry-specific, though some industrial classification problems that need to be fixed (see Appendix), and somewhat more detailed in distinguishing housing from other assets. Also importantly, the survey data refer to the existing stock, hence they are compatible with the “original value of fixed assets”.

At the end of this exercise, we decompose the series into four categories, namely, “equipment”, “residential structures”, “non-residential structures” and “others”. Furthermore, to simplify the exercise, we redistribute “others”, after removing a component proportional to “residential structures”, into “equipment” and “non-residential structures (3:7).¹³

Estimating investment flows for the nonindustrial sectors

[This part is to be completed following the major steps below...]

- About the sources of data for the construction of investment flows for the non-industrial sectors.
- Methodology – There are no data on OVFA for the non-industrial sectors. We have to assume that the available NIFA is equal to the investment flows (I) as expressed in equation (3.3).
- However, due to lack of information, we do not adjust NIFA for improper inclusion of residential structures and exclusion of assets outside the state monitoring system, or assume that these problems are not as serious as in TIFA.
- The constructed NIFA flows are decomposed into structures and equipment according to an estimated ratio excluding the industrial sector.

5. ESTIMATION OF THE INITIAL STOCK & ANNUAL “CONTROL TOTALS”

This section deals with aggregates, including the estimation of the initial level of capital stock for 1952 and based on which, using the official GFCF series, constructs net capital stock series as *conceptual* “control totals” for the national economy. With relatively more industry-level information for the industrial sector back to the 1950s, we are able to link the constructed investment flows with the initial capital stock. However, we have to rely on the “steady state” assumptions for the initial stock of the industries of the non-industrial sectors which can only start from 1980. This means that with limited information it is difficult to assess the inevitable differences between

¹³ According to the author’s discussion with NBS, most of the spending under the item of “others” incurred in structure construction-related land acquisition. The results are insensitive to ratios from 5:5, 4:6 to 2:8.

the national accounts GFCF and our independently constructed investment flows, and hence the net capital stocks based on the two series, this annual “control totals”. Instead of imposing a forced reconciliation between the two series, we would like to explore their underlying relationship for a reasonable solution.

The initial capital stock

Despite many efforts which have been made in estimating China’s aggregate capital stock,¹⁴ the estimation of its initial (post-war) stock has been left ambiguous. Existing studies have made or adopted very different estimates for the initial capital stock (usually referring to 1952) ranging greatly from less than 50 to over 250 billion yuan in 1952 prices which imply a capital-output ratio (K/Y) ranging from below 0.45 to a level as high as over 2 if based on the official GDP for 1952. Some may argue that the initial stock in the early 1950s does not really matter if the main interest is in the reform period and in growth accounting (Young, 2003, p.1253). But it is however important if we are interested in examining changes in capital-labor ratio, capital-output ratio and the trend of return on capital in the Chinese economy in the long run.

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

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

$$(5.1) \quad \varphi_t^* = \frac{dK_t}{K_t} = \frac{dY_t}{Y_t}$$

where K_t is the capital stock and Y_t is real GDP at time t . Since $dK_t = I_t - \delta K_t$ then $\frac{dK_t}{K_t} = \frac{I_t}{K_t} - \delta$ where I_t is gross investment and δ is the depreciation rate of physical capital. Letting i be the investment rate, i.e. $i_t = \frac{I_t}{Y_t}$, thus $\varphi_t^* = \frac{dK_t}{K_t} = \frac{i_t Y_t}{K_t} - \delta$, then the steady-state capital-output ratio is derived as follows:

$$(5.2) \quad \kappa_t^* = \frac{i_t^*}{\delta + \varphi_t^*} \quad \text{that is,} \quad K_t^* = \frac{I_t}{\delta + \varphi_t^*}.$$

¹⁴ For studies in English see, e.g. Chow (1993), Chow and Li (2002), Field (1980), Holz (2006b), Hu and Khan (1997), Maddison (1998a), Wang and Szirmai (2012), Wang and Yao (2002), and Young (2003). For studies in Chinese see e.g. Bai *et al* (2007), He (1992), He *et al* (2003), Ren and Liu (1997), Tang (1999), Wang and Fan (2000), and Zhang and Zhang (2003).

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

$$(5.3) \quad K_{t+1} = I_t + (1 - \delta)K_t$$

Then, based on (5.3) we can generate a function of initial capital stock and investment flows as follows:

$$(5.4) \quad K_t = \sum_{i=0}^{t-1} (1 - \delta)^i I_{t-i} + (1 - \delta)^t K_0$$

where $K_0 = \kappa_t^* Y_0$

To solve for K_0 of Equation 8.4, we need data on investment flows, an average GDP growth rate and a depreciation rate for the initial period. The national accounts GFCF in 1952 can be used for I_0 , official and my alternative measures of the average GDP growth for the period 1952-56 are used for \bar{g} , and δ_0 is assumed to be 2 percent based on the information from the 1951 national asset census (explained below).

Directly using the unadjusted official GFCF, GDP and the expenditure accounts implicit GFCF deflators, plus the 2-percent depreciation rate as revealed by the 1951 asset census, I obtain an initial capital stock of 166.7 billion in 1990 yuan for the midpoint time of 1952-57 (e.g. 1955) based on which the average GDP growth rate is calculated. However, if using my alternative estimates of GFCF, GDP and GFCF deflator, and choosing a 5-percent depreciation rate, the results would be 208.3 billion 1990 yuan. And if I use Maddison's assumption of a K/Y ratio of 0.9, I can obtain an estimate of 286.5 billion 1990 yuan for 1952 using my new estimate of GDP.

I evaluate the above estimates by examining seldom used information from the aforementioned 1951 national asset census that verified and evaluated China's stock of fixed assets, only available for publication in 2000 as a collection of archived planning documents and papers by SETC (2000, Vol. 1, pp.1543-4). It shows that by the end of 1951, the total market replacement value of fixed assets was 128.4 billion in 1952 yuan. Taking off the accumulated depreciation value of 39.2 billion, the net stock would be 89.2 billion 1952 yuan, equivalent to 169.6 billion 1990 yuan (based on 1990/1952 investment price ratio 1.901 by the NBS deflator).

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

There is clear evidence in the census data that the fixed asset in the agricultural sector, dominated by private farmers, is implausibly low – only 0.04 percent of the total net stock. Land is certainly not included. But that is not our problem, at least for

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

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

Aggregate depreciation rate

The estimated depreciation rates for 39 two-digit level industries are on average ranged from 7 to 8.5 percent for equipment and 2.5 to 3.5 percent for structures over three available time points, i.e. 1963, 1985 and 1993 (Wu, 2008b). Considering the likelihood of a market-induced faster depreciation process following the reform, as well as the underlying faster economic depreciation before the reform, it is reasonable to increase these estimates to 10 percent for equipment and 4 percent for structures in industry. This is a basis for us to gauge an average general depreciation rate for the economy as a whole. In Chinese industry, as evidenced in Wu (2008b) equipment accounts for 70 percent of the fixed assets and structures for 30 percent. This is reversed when focusing on the asset structure of the national economy based on investment, that is, approximately 35 percent for equipment and 65 percent for structures excluding housing, based on official investment statistics. Therefore, an average depreciation rate for the whole economy is about 6 percent ($6.1\% = 10\% * 0.35 + 4\% * 0.65$).

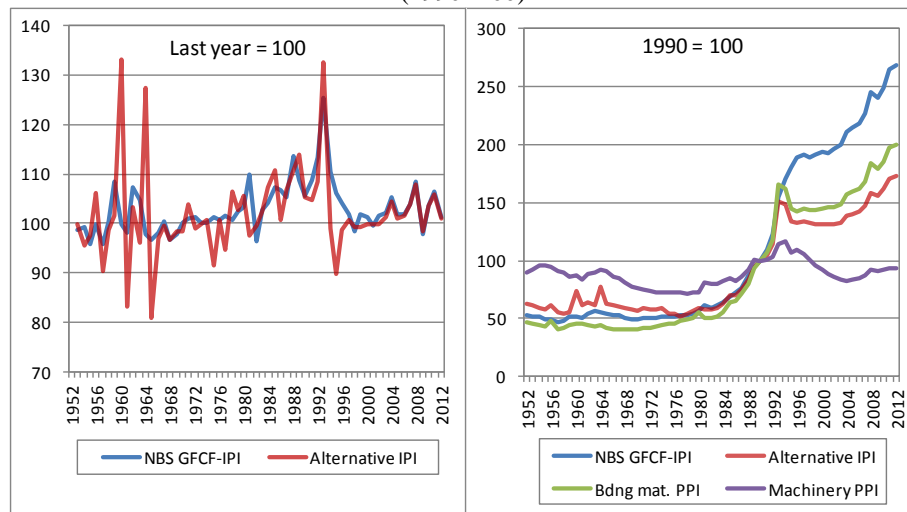
Therefore, the present study sets a depreciation rate of 6 percent ($\delta=0.06$) as the baseline with 5 and 7 percent as the lower and upper bound, respectively. These are alternative depreciation rates for the entire period in question assuming that the depreciation process in the Chinese economy follows a geometric function.

An alternative investment deflator

I construct an alternative investment deflator to the official GFCF deflator that is implicitly given by the expenditure accounts for two reasons. First, the implicit

GFCF-IPI may have overstated the price changes in the period 1995-2004 in which China experienced an unprecedented long deflation in investment goods, much longer than that experienced by the general economy in 1998-2002. Second, the implicit GFCF-IPI is highly likely to be influenced by the rapidly rising prices of land transactions along with China's property boom in the 2000s. As Figure 2 shows, since the mid-1990s, the implicit GFCF-IPI has mainly followed the PPI (producer price index) of building materials rather than the PPI of equipment industries. However, the PPI of building materials well reflects the effect of the long deflation in the Chinese economy but the GFCF-IPI does not. This justifies the use of a PPI weighting both the PPI of building materials and the PPI of equipment industries.

FIGURE 2
WHICH INVESTMENT DEFLATOR IS MORE REASONABLE?
(1990=100)



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

In the construction of the alternative IPI, I first construct two weighted PPIs: one PPI is based on the PPIs of construction materials industries, namely, non-metallic materials and basic and fabricated metals, and the other PPI is based on the PPIs of machinery and equipment industries including ordinary and special purpose machinery, transportation equipment, electrical and electronic equipment and office equipment (Figure 2). I then further weight the two so-constructed PPIs into one IPI, this alternative IPI as depicted in Figure 2.

Table 1 presents a comparison of the implicit GFCF IPI with my alternative IPI. For the planning period, the GFCF IPI shows that there was no change in investment prices but my deflator suggests a decline by 0.8 percent in investment prices. For the reform period, however, the alternative IPI also implies a slower change of investment prices than the official IPI does, i.e. 3.5 compared with 4.8 percent per annum. Consequently, using the alternative IPI will raise the growth of GFCF from 9.9 to 10.8 percent per annum for the planning period and from 11.3 to 12.7 percent for the reform period. It should be noted that other things being equal, this will raise rather than lower the growth of TFP.

TABLE 1
OFFICIAL AND ALTERNATIVE ESTIMATES OF ANNUAL INVESTMENT GROWTH, AND THE SHARE INVESTMENT IN CHINA'S GDP
(Annual compound growth in percent in nominal or 1990 prices, unless specified)

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

Sources: Author's estimates.

Notes: 1) TIFA and NIFA are as defined in the text. 2) GFCF(A) includes residential housing and GFCF(B) excludes residential housing. 3) The official investment price index (IPI) is the expenditure accounts implicit deflator. 4) The alternative IPI is constructed based on PPI of investment goods industries as explained in the text. 5) GFCF(C) is alternative GDP-adjusted GFCF(B) (Wu 2014). 6) The share of GFCF is estimated as GFCF(C)/alternative GDP in 1990 prices.

6. CONSTRUCTION OF INDUSTRY-SPECIFIC INVESTMENT PRICE INDEX (IPI)

Since the perpetual inventory method requires an investment series expressed in real terms, a price deflator is needed to convert data in nominal prices to a constant-price, or inflation adjusted, basis. As indicated by Hulten (1990), there are mainly two potential sources of errors introduced in the process of deflation: the application of a single deflator to goods that are in fact heterogeneous and the adjustment for quality change. In this study, an initial attempt is made to construct price indices for individual industries, which can significantly reduce the degree of the first type of errors. As for the second type of errors, we have to wait until better data become available. However, for the central planning period, this should not introduce a significant bias into the result as it can reasonably be assumed that there was generally no significant quality improvement under central planning.

[This part is to be completed with details following the steps below...]

For equipment of the industrial sector IPI:

- Level of coverage: 2-digit level of industries (39 sectors from Code 2 to 39, see the coverage and classification appendix, [Table A1](#))
- 1985-1998: geometric mean of 6-digit level asset prices from a data set containing asset evaluation information published by the Ministry of Finance (MoF) (released in 2003; details to be given...)
- 1952-1984: estimated based on the relationship (ratio) between aggregate IPI for equipment and industry-specific IPI (the formal sector) for 1985 (formula to be given), a strong assumption that the “relationship” is held for 1985.
- 1999-2010: estimated based on industry-specific IPI for 1998 and weighted PPIs of machinery industries for investment coded from 30 to 35 ([Table A1](#))
- Note that for the period since 1990, checked and reconciled with aggregate IPI in equipment

For non-residential structures of the industrial sector:

- Level of coverage: industry aggregate only
- 1952-89: the official price index of “construction and installation” (CII)
- 1990-2010: investment price index for structures (no distinction between production and residential structures)

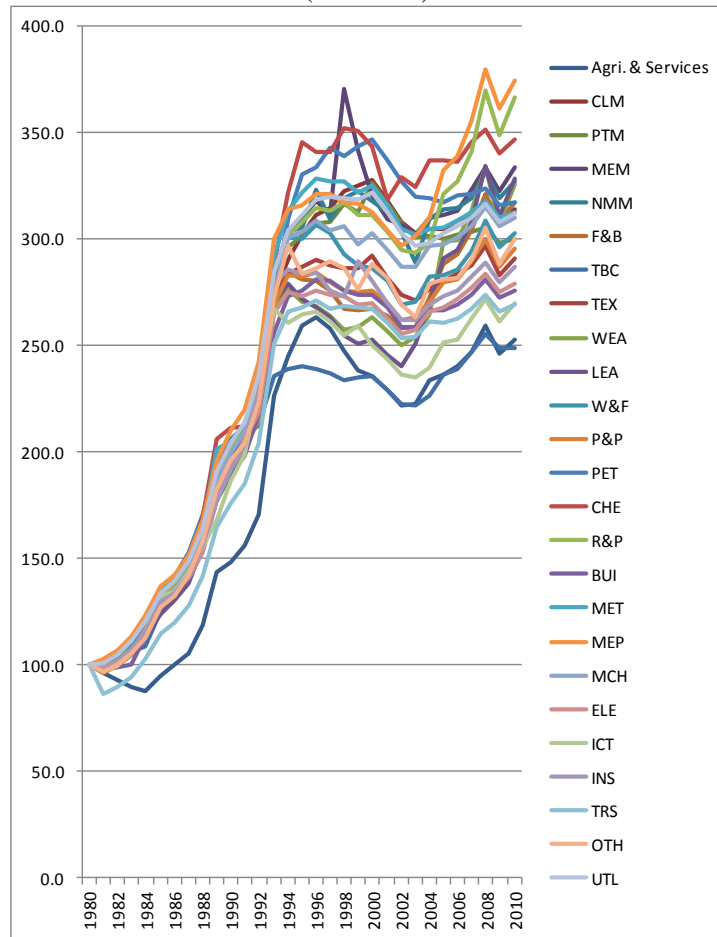
For the non-industrial sectors:

- Weighted PPIs of machinery industries for investment coded from 30 to 35 ([Table A1](#))

List of constructed industry-specific IPIs

See data file attached: [CIP2.1_IPI](#)

FIGURE 3
INVESTMENT PRICE INDICES
(1980=100)



7. ASSET LIVES AND INDUSTRY-SPECIFIC DEPRECIATION RATES

The last step of constructing net capital stock is to depreciate the so-estimated gross capital stock series by proper depreciation rates for equipment and structures of each industry. As defined in equation 3.10, we need proper declining-balance rates (R) and service-life assumptions (T) for equipment and structures of each industry.

TABLE 1
SERVICE LIVES AND ESTIMATED DEPRECIATION RATES (δ) FOR CHINESE INDUSTRIES

	"1963 benchmark" applied to 1953-83				Mid-point value between 1963 and 1993 for 1984-92*				"1993 benchmark" applied to 1993-2010			
	Equipment		Structures		Equipment		Structures		Equipment		Structures	
	Service Life	δ (%)	Service Life	δ (%)	Service Life	δ (%)	Service Life	δ (%)	Service Life	δ (%)	Service Life	δ (%)
CLM	15.6	7.4	27.3	3.3	14.9	7.7	26.2	3.4	14.2	8.1	25.0	3.6
PTM	8.8	13.1	14.8	6.1	11.9	9.7	19.9	4.5	14.9	7.7	25.0	3.6
FMM	15.6	7.4	26.1	3.5	15.3	7.6	25.5	3.5	14.9	7.7	25.0	3.6
NFM	15.6	7.4	26.1	3.5	15.3	7.6	25.5	3.5	14.9	7.7	25.0	3.6
NMM	15.6	7.4	26.1	3.5	15.3	7.6	25.5	3.5	14.9	7.7	25.0	3.6
OMN	15.6	7.4	26.1	3.5	15.3	7.6	25.5	3.5	14.9	7.7	25.0	3.6
TBM	13.6	6.7	23.9	3.8	13.9	6.6	24.4	3.7	14.2	6.4	25.0	3.6
FDP	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
FDM	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
BEV	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
TOB	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
TEX	19.2	6.0	54.0	1.8	16.7	6.9	47.0	2.1	14.2	8.1	40.0	2.4
WEA	19.2	6.0	54.0	1.8	16.7	6.9	47.0	2.1	14.2	8.1	40.0	2.4
LEA	19.2	6.0	54.0	1.8	16.7	6.9	47.0	2.1	14.2	8.1	40.0	2.4
WOO	16.3	7.1	45.7	2.0	15.3	7.6	42.8	2.1	14.2	8.1	40.0	2.3
FNT	16.3	7.1	45.7	2.0	15.3	7.6	42.8	2.1	14.2	8.1	40.0	2.3
PAP	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
PRN	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
CUL	16.3	7.1	45.7	2.1	15.3	7.6	42.8	2.3	14.2	8.1	40.0	2.4
PET	15.5	7.4	43.6	2.2	14.9	7.8	41.8	2.3	14.2	8.1	40.0	2.4
CHE	15.5	7.4	21.8	4.5	14.9	7.8	20.9	4.7	14.2	8.1	20.0	4.9
MED	15.5	7.4	21.8	4.5	14.9	7.8	20.9	4.7	14.2	8.1	20.0	4.9
SYN	15.5	7.4	21.8	4.5	14.9	7.8	20.9	4.7	14.2	8.1	20.0	4.9
RUB	15.5	7.4	21.8	4.5	14.9	7.8	20.9	4.7	14.2	8.1	20.0	4.9
PLA	15.5	7.4	21.8	4.5	14.9	7.8	20.9	4.7	14.2	8.1	20.0	4.9
BUI	18.9	6.1	59.0	1.7	15.9	7.3	49.5	2.0	12.8	9.0	40.0	2.4
FMF	17.7	7.8	47.3	2.1	16.3	8.4	43.6	2.2	14.9	9.2	40.0	2.4
NMF	17.7	7.8	47.3	2.1	16.3	8.4	43.6	2.2	14.9	9.2	40.0	2.4
MET	17.7	7.8	50.5	1.9	15.8	8.7	45.2	2.2	14.0	9.8	40.0	2.4
MAC	20.7	5.6	64.3	1.5	16.8	6.9	52.2	1.9	12.8	9.0	40.0	2.4
SMC	20.7	5.6	64.3	1.5	16.8	6.9	52.2	1.9	12.8	9.0	40.0	2.4
TRS	20.7	5.6	64.3	1.5	16.8	6.9	52.2	1.9	12.8	9.0	40.0	2.4
ELE	20.7	5.6	64.3	1.5	16.8	6.9	52.2	1.9	12.8	9.0	40.0	2.4
TEL	16.3	7.0	56.8	1.7	13.9	8.2	48.4	2.0	11.4	9.9	40.0	2.4
INS	16.3	7.0	56.8	1.7	13.9	8.2	48.4	2.0	11.4	9.9	40.0	2.4
OTH	12.2	9.5	37.8	2.6	12.5	5.3	38.9	2.4	12.8	9.0	40.0	2.4
POW	22.3	5.2	42.3	2.3	21.7	5.2	41.1	2.2	21.1	5.5	40.0	2.4
GAS	22.3	5.2	40.7	2.2	22.1	5.2	40.3	2.4	21.9	5.3	40.0	2.3
WAT	22.3	5.2	40.7	2.4	22.1	9.2	40.3	2.5	21.9	5.3	40.0	2.4
<i>Average</i>	<i>17.0</i>	<i>7.0</i>	<i>41.9</i>	<i>2.6</i>	<i>15.8</i>	<i>7.5</i>	<i>38.3</i>	<i>2.8</i>	<i>14.6</i>	<i>8.1</i>	<i>34.7</i>	<i>2.9</i>

Sources: Author's estimates.

Notes: For sector abbreviations see Table A1. For the approach used in the estimation see text. *By interpolation.

To reflect changes in economic efficiency of different types of fixed assets in Chinese industry, we feel justified to directly adopt the BEA estimates of declining-balance rates for a list of major industrial equipment and structures (Kaze and Herman, 1997, pp.72-3), mainly based on the empirical work by Hulten and Wykoff (1981b).

As for asset lives in different industries, we rely on the state policies that regulate state firms. Three sources of information are used for gauging the service lives of assets in Chinese manufacturing. The first one is the (internally published) depreciation rates used since 1963 by the Ministry of Finance that refer to fixed assets of different industries under responsible ministries. Since depreciation rate is, as a norm, derived from a given service life using a straight-line function, we could detect the official standard for service lives of assets using the same approach. The second one is a State Council No. 63 Circular in 1985 that gives a detailed list of the standard (legal) service lives by major equipment and structures of individual state industries. The third source is a Ministry of Finance No. 574 Document in 1992 that provides a new, presumably updated one to the 1985 regulation, list of required service lives by equipment and structures for state enterprises. [Table 1](#) reports the results.

We have two choices in deciding the standard of asset service lives. We could use the estimates for 1963 for the period 1952-84, the service-life standards adopted in 1985 for the period 1985-92, and the service-life standards adopted in 1992 for the period 1993-2000. By doing so, we actually adopt variant depreciation rates for the three periods, which means that we introduce breaks into the series that is supposed to follow a depreciation-rate-invariant geometric function as given in our perpetual inventory method. However, the significant differences in industrial policies and institutional arrangements over these periods may justify such a treatment. Alternatively, we could use the average of the three standards as a consistent standard over the entire period by assuming that there is a balance in practice between that the authorities have to shorten the required service lives to stimulate technological advance and that they also make assets over serviced to save money. However, all these should not affect the underlying geometric decay function that reflects a process of economic depreciation. The estimates of depreciation rates are presented in [Table 1](#).

For the non-industrial sectors, based on their structure-equipment ratio, assuming constant over the period 1980-2010, their depreciation rates are given without any information of service lives of assets used in these sectors, see [Table 2](#).

TABLE 2
ESTIMATED DEPRECIATION RATES FOR THE NON-INDUSTRIAL SECTORS

	Depreciation rate (%)		Depreciation rate (%)		Depreciation rate (%)
01.AGR	5	44.INF	10	49.EDU	5
40.CON	7	45.FIN	7	50.HEA	5
41.TRD	5	46.REA	5	51.SER	5
42.HOT	5	47.BUS	5		
43.TRA	7	48.PUB	5		

Sources: Author's estimates.

Notes: For sector abbreviations see [Table A1](#).

8. FULL ACCOUNTS FOR INDUSTRY-SPECIFIC NET CAPITAL STOCK

The industrial sector

The full accounts include two parts: formal and informal components of each industry. For the formal component, the annual estimate of industry-specific net capital stock is obtained by Equation 3.3 using the reconstructed investment flows following Equation 4.3 and the geometric depreciation rate given by Equation 3.10.

For the informal component, the annual estimate of industry-specific net capital stock is obtained by using the capital-labor ratio of labor-intensive industries (see CIP background paper No.2). This principle is applied to both “non-residential structures” and “equipment”.

The non-industrial sector

The full accounts include two parts: formal and informal components of each industry. For the formal component, the annual estimate of industry-specific net capital stock is obtained by Equation 3.3 using the official NIFA, conceptually N (equation 2.2), adjusted for consistency. The initial level of net capital stock for 1980 is estimated using Equation 5.2.

For the informal component, we assume it is completely covered by the “residual” after subtracting the estimated “industrial totals” from the national “control totals” (see Section 5).

Note that there are no different asset types that can be decomposed for the non-industrial economy at this stage of the study.

The “residual”

My treatment to the “residual”, which is obtained after subtracting the estimated “industrial totals” from the national “control totals” (see Section 5), is based on the following principles.

- The “residual” mainly refers to the “informal sector” of the national economy, which is not necessarily the underground economy but the part that is not closely monitored by the state statistical reporting system. However, we cannot rule out that there is some fake investment. But it cannot be easily identified.
- Since our approach of deriving the investment flows of the industrial sector (Equation 4.3) is more reliable than that used to construct the investment flows of the non-industrial sectors (Equation 3.3), I propose two approaches to handle the “residual”.
 - Method 1: I assume that the “residual” contains both the missing industrial and non-industrial capital stocks. Thus, to absorb the “residual” entirely I assume that the missing industrial capital stock is proportional to the sum of the constructed industrial net capital stock in both the formal and informal components and that the missing non-industrial capital stock is proportional to the formal component of the industries of the sector. The final results are reported for the standard CIP 37 sectors.

- Method 2: I assume that the “residual” contains only the missing non-industrial capital stock. Thus, in the final step of the estimation, which has to absorb the “residual” entirely, I assume that the missing non-industrial capital stock is proportional to the formal component of the industries of the sector. The final results are reported for the standard CIP 37 sectors.

9. USER COST OF CAPITAL AND ESTIMATES OF CAPITAL SERVICES

[To be completed.]

10. CONCLUDING REMARKS

[To be completed.]

APPENDIX

Coverage

The CIP Projects covers the entire Chinese economy at industry level for the period 1980-2010. It is well known that the inconsistent, incomplete or overlapped coverage of the Chinese official statistics, reported through different authorities by different statistical criteria, ranging from ownership type, administrative jurisdiction to the size of enterprises which often lack of transparency, has caused great confusions in empirical studies on the Chinese economy. Ignoring or mishandling the coverage problem may lead to misread China’s productivity performance. In CIP, based on the Chinese System of National Accounts (CSNA) (Xu, 2009), especially its input-output table (CIOT) system, and national or sectoral level censuses, we aim to first conceptually and then empirically re-establish the full statistical coverage of the economy in all input and output indicators.

In the reconstruction of China’s output and income accounts, since we accept the national accounts as the “control totals”, we do not have to deal with inconsistencies between industries and aggregates caused by improper classifications by ownership type, administrative jurisdiction and various size criteria of firms. Rather, we force any inconsistencies to be consistent with the national “control totals”. In doing so, the results consistently define the overall boundary for more difficult input measures in which CIP has to introduce a “formal sector” vis-à-vis “informal sector” at industry level (Wu 2013a).

Industrial classification

In industrial classification, we in principle adopt the 2002 version of the Chinese Standard Industrial Classification (CSIC/2002) to divide the whole economy into 51 industries (Table A1). For services, we also follow the minor revisions of CSIC/2012.

CIP re-classification is based on Wu’s series of data work to adjust for classification consistency over time because official industrial and employment statistics were reported under different

CSIC systems adopted in 1972, 1985 and 1994. Currently, the standard CIP classification includes 37 industries. The 51 industry/sector system in this study is an extended CIP classification that ensures the best use of industry-level information in time and space.

Despite strong central planning legacy in Chinese industrial classification that emphasized (vertical) administrative controls rather than the nature of production or business (satisfying the homogeneity requirement in the industrial classification), the CSIC since its 1994 version has in principle followed the International Standard Industrial Classification, ISIC, previously Rev. 3 and presently Rev. 4. This makes it easy for the CIP classification to conform to or reconciled with the EU-KLEMS system of industrial classification as explained in Timmer et al. (2007). To facilitate international comparisons or comparative studies using the KLEMS-type of data, in Table 1 we also provide industrial classification codes in CIP (China KLEMS) and in the EU-KLEMS.

TABLE A1
CIP (CHINA KLEMS) INDUSTRIAL CLASSIFICATION AND CODE

This paper	This paper	CIP (China KLEMS)	EU-KLEMS	Sector
01	AGR	01	AtB	Agriculture, forestry, animal husbandry & fishery
02	CLM	02	10	Coal mining
03	PTM	03	11	Oil & gas excavation
04	FMM	04	13	Mining and processing of ferrous metal ores
05	NFM	04	13	Mining and processing of non-ferrous metal ores
06	NMM	05	14	Non-metallic minerals mining
07	OMN	04	13	Other mining
08	FDP	06	15	Food processing
09	FDM	06	15	Food manufacturing
10	BEV	06	15	Beverage manufacturing
11	TOB	07	16	Tobacco products
12	TEX	08	17	Textile mill products
13	WEA	09	18	Apparel and other textile products
14	LEA	10	19	Leather and leather products
15	WOO	11	20	Saw mill products
16	FNT	11	20	Furniture, fixtures
17	PAP	12	21	Paper
18	PRN	12	22	Printing & publishing
19	CUL	24	36t37	Culture, school and sport products for daily use
20	PET	13	23	Petroleum and coal products
21	CHE	14	24	Basic chemicals
22	MED	14	24	Medicine manufacturing
23	SYN	14	24	Chemical fibers
24	RUB	15	25	Rubber products
25	PLA	15	25	Plastic products
26	BUI	16	26	Stone, clay, and glass products
27	FMF	17	27t28	Primary & fabricated metal industries, ferrous
28	NMF	17	27t28	Primary & fabricated metal industries, non-ferrous
29	MET	18	27t28	Metal products (excluding rolling products)
30	MAC	19	29	Industrial machinery and equipment, general purposed
31	SMC	19	29	Industrial machinery and equipment, special
32	TRS	23	34t35	Motor vehicles & other transportation equipment
33	ELE	20	31	Electric equipment
34	TEL	21	32	Electronic and telecommunication equipment
35	INS	22	30t33	Instruments and office equipment
36	OTH	24	36t37	Miscellaneous manufacturing industries

37	POW	25	E	Power generation and supply, steam
38	GAS	25	E	Gas supply
39	WAT	25	E	Tap water supply
40	CON	26	F	Construction
41	TRD	27	G	Wholesale and retail trades
42	HOT	28	H	Hotels and restaurants
43	TRA	29	I	Transport, storage & post services
44	INF	30	71t74	Information & computer services
45	FIN	31	J	Financial Intermediations
46	REA	32	K	Real estate activities
47	BUS	33	71t74	Leasing, technical, science & business services
48	PUB	34	L	Public administration and defense
49	EDU	35	M	Education
50	HEA	36	N	Health and social security services
51	SER	37	O&P	Other services

Sources and Notes: See the text.

REFERENCES

[To be completed]

Borensztein, Eduardo and Jonathan D. Ostry, 1996 “Accounting for China’s Growth Performance”, *American Economic Review* 86 (2), 224-28.

CEC (Commission of the European Communities), IMF, OECD, UN and the World Bank, 1993, *System of National Accounts*, Brussels/Luxembourg, New York, Paris, Washington, D.C.

Chen, Kuan, Gary H. Jefferson, Thomas G. Rawski, Hongchang Wang, and Yuxin Zheng, 1988a, “New estimates of fixed investment and capital stock for Chinese state industry”, *The China Quarterly*, 114, 243-266

Chen, Kuan, Gary H. Jefferson, Thomas G. Rawski, Hongchang Wang, and Yuxin Zheng, 1988b, “Productivity Change in Chinese Industry: 1953-1985”, *Journal of Comparative Economics* 12 (4), 570-91.

Chow, Gregory C., 1993, “Capital Formation and Economic Growth in China”, *Quarterly Journal of Economics* 108 (3), 809-42.

Coen, Robert, 1972, “Investment Behavior, the Measurement of Depreciation and Tax Policy”, *American Economic Review* 65 (March): 59-74.

Creamer, R., 1972, “Measuring capital input for total factor productivity analysis”, *Review of Income and Wealth*, 18 (1): 55-78

DFAIS (Department of Fixed Assets Investment Statistics, NBS), 1997, *China Fixed Assets Investment Statistical Yearbook 1950-1995*, China Statistical Publishing House, Beijing

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

- Field, R.M., 1980, "Real Capital Formation in The People's Republic of China, 1952-73", in Eckstein, A. (ed.), *Quantitative Measures of China's Economic Output*, 194-245, The University of Michigan Press, Ann Arbor
- Fraumeni, Barbara M., 1997, "The Measurement of Depreciation in the US National Income and Product Accounts", *Survey of Current Business*, July 1997
- Goldsmith, R.W., 1951, "A perpetual inventory of national wealth", in M.R. Gainsburgh (ed.) *Studies in Income and Wealth*, Vol.14, Princeton
- Hall, Robert E. and Dale W. Jorgenson, 1967, "Tax Policy and Investment Behaviour", *American Economic Review*, 57: 391-414
- Hicks, John, 1946, *Value and Capital*, London: Oxford University Press
- Ho, Mun S. and Dale W. Jorgenson, 2001, *Productivity Growth in China, 1981-95*, mimeo, Kennedy School of Government, Harvard University, Cambridge, MA
- Hu, Zuli F. and Mohsin S. Khan, 1997, "Why is China growing so fast?", *IMF Staff Papers*, 44 (1), 103-131.
- Huang, Yongfeng, Ren Ruoen and Liu Xiaosheng, 2002, "Capital Stock Estimates in Chinese Manufacturing by Perpetual Inventory Approach", *China Economics Quarterly*, Vol. 1 (2), 377-396
- Hulten, Charles R., 1990, "The Measurement of Capital," in Berndt, Ernst R. and Jack E. Triplette, eds. *Fifty Years of Economic Measurement: The Jubilee*, NBER, Studies in Income and Wealth, No. 54, University of Chicago Press, 1991
- Hulten, Charles R., and Frank C. Wykoff, 1981a, "The estimation of economic depreciation using vintage asset prices", *Journal of Econometrics*, 15, 367-396
- Hulten, Charles R., and Frank C. Wykoff, 1981b, "The measurement of economic depreciation", in Charles R. Hulten (ed.), *Depreciation, Inflation, and the Taxation of Income from Capital*, 81-125, The Urban Institute Press, Washington D.C.
- Jefferson, Gary H., Thomas G. Rawski and Yuxin Zheng, 1996, "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Developments", *Journal of Comparative Economics*, 23, 146-80.
- Jorgenson, Dale W., 1963, "Capital Theory and Investment Behavior", *American Economic Review*, 53 (2): 247-59
- Jorgenson, Dale W., 1973, "The Economic Theory of Replacement and Depreciation", in W. Sellykaerts ed. *Economics and Economic Theory*, New York: Macmillan
- Kaze, Arnold, J. and Shelby W. Herman, 1997, "Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-95", *Survey of Current Business*, May 1997, pp.69-92

- Koumanakos, Peter, and J.C. Hwang, 1988, "The forms and rates of economic depreciation: the Canadian experience", paper presented at The 50th Anniversary Meeting of the Conference on Research in Income and Wealth, Washington D.C., May 12-14.
- Li, Jingwen, Dale W. Jorgenson, Zheng Youjing and Masahiro Kuroda, 1993, *Productivity and Economic Growth in China, USA and Japan*, China Social Science Publishing House, Beijing
- Li, Jingwen, et al., 1992, "Productivity and China's Economic Growth", *The Economic Studies Quarterly*, 43 (4): 337-350
- Maddison, Angus, 1998, *Chinese Economic Performance in the Long Run*, OECD Development Centre, Paris
- Ministry of Finance, 1992, *Service Life of Industrial Fixed Assets*, Appendix 1, in No. 574 Circular issued on 30 December, 1992.
- NBS (National Bureau of Statistics), various issues, *Statistical Yearbook of China*, Beijing Statistical Publishing House
- Rawski, Thomas, 1980, "China's Industrial Performance, 1949-73", in Eckstein, A. (ed.), *Quantitative Measures of China's Economic Output*, 194-245, The University of Michigan Press, Ann Arbor
- Ren, Ruoan, 1997, *China's Economic Performance in An International Perspective*, OECD Development Centre, Paris
- SETC (State Economic and Trade Commission, China), 2000, *Fifty Years of Chinese Industry*, China Economic Press, Beijing
- State Council, 1985, Probation Regulation on the Depreciation of Fixed Assets in State-owned Enterprises, Circular No. 63, issued on 26 April, 1985
- Woo, Wing Thye, 1998, "Chinese Economic Growth: Sources and Prospects", in M. Fouquin and F. Lemonie (eds.) *The Chinese Economy*, Economica Ltd., Paris
- Wu, Harry X. and Esther Y.P. Shea (2002), What can we learn from productivity analysis of the Chinese economy, The Hong Kong Polytechnic University, mimeo
- Wu, Harry X., 2000, China's GDP level and growth performance: Alternate estimates and the implications, *Review of Income and Wealth*, 46 (4): 475-499
- Wu, Harry X., 2002, "How Fast Has Chinese Industry Grown? – Measuring the Real Output of Chinese Industry", *Review of Income and Wealth*, 48 (2):
- Wu, Yanrui, 1999, "Accounting for China's Growth: The Role of Productivity", University of Western Australia, mimeo.

- Wu, Yanrui, 2000, "Is China's Economic Growth Sustainable? A Productivity Analysis", *China Economic Review* 11, 278-96.
- Xu, Xianchun, 1999, *On Reform and Development of the Chinese System of National Economic Accounting*, Economic Science Press (in Chinese)
- Young, Alwyn, 2000, "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period", *NBER Working Paper Series*, w7856, National Bureau of Economic Research, Cambridge, MA
- Zheng, Yisheng, Xu Po, Jing Ziyin and Jin Zhouying, 1993, "The Measurement and Analysis of Capital Input by Sector", in Li, Jingwen, Dale W. Jorgenson, Zheng Youjing and Masahiro Kuroda (eds.) *Productivity and Economic Growth in China, USA and Japan*, China Social Science Publishing House, Beijing