

A method for improved capital measurement by combining accounts and firm investment data*

Arvid Raknerud[†], Dag Rønningen[‡] and Terje Skjerpen[§]

ABSTRACT: We propose a new method for estimating capital stocks at the firm level by combining business accounts information and investment data. The method also produces capital estimates at the sector level by summing individual firms' capital stocks, while accounting for firms with missing data by appropriately inflating this sum. Our approach has two major advantages compared to the much used Perpetual Inventory Method (PIM). First, long investments series are not necessary. Second, sectorial capital estimates are automatically adjusted for changes in the capital stock due to entry and exit of firms. Accounts data are often dismissed as a source of capital measurements because book values are registered at historic costs and depreciation profiles are, allegedly, chosen to minimize tax liabilities. We circumvent both these objections: Our method converts historic prices into current prices by combining book values and investment data, adjusting the former by price indices for new capital goods. Furthermore, we use book values from financial accounts, not tax accounts. Our method gives more credible estimates for the capital growth rates in Norwegian manufacturing than the corresponding national accounts estimates obtained by PIM.

JEL classification: C13, C23, D24, E22, M40

Keywords: Capital measurement, Accounts data, Firm panel data, Net capital stocks, Capital services, Depreciation.

*This paper has benefited from numerous comments and suggestions. In particular, we would like to thank Morten Andersen, Erik Biørn, Aadne Cappelen, Rolf Golombek, Eirik Knutsen, and Jarle Møen. This research has been financially supported by The Norwegian Research Council (Grant no. 154710/510).

[†]Corresponding author: Statistics Norway, Research Department, P.O. Box 8131 Dep, N-0033 *E-mail:* arvid.raknerud@ssb.no.

[‡]Statistics Norway, Research Department, P.O. Box 8131 Dep, N-0033 *E-mail:* dag.ronningen@ssb.no.

[§]Statistics Norway, Research Department, P.O. Box 8131 Dep, N-0033 *E-mail:* terje.skjerpen@ssb.no.

1 Introduction

Most studies of production, including some very important topics like measurement of productivity, returns to investments, and economic depreciation, rely on measures of capital stocks and services. Although measurement of capital is one of the most controversial topics in economics (see Hicks, 1974), there exist rather well-established national accounts standards for estimating capital stocks from aggregate (e.g. sectorial) data using the Perpetual inventory method¹ (PIM), see OECD (2001). However, PIM has some well-known deficiencies. When applied to individual firms, there is also the problem that one generally does not have sufficiently long investment time series to apply this method.

Unfortunately, direct stock information is seldom available from micro data. Although information from book values, stock prices, and even fire insurance values have been used in combination with PIM in some studies (see e.g. Klette and Griliches, 1996), no well-documented, stable link between these indirect observations of capital and the capital stock itself has been established.

This paper proposes an alternative to existing methods for estimating capital stocks, which is based on firm level panel data with investments and financial accounts variables. Accounts data are often criticized for being based on historic costs, not current prices. Furthermore, it is often claimed that the depreciation profiles used by firms are chosen to minimize tax liabilities. Our approach addresses these critiques.

First, we propose a method for converting historic prices into current prices by combining time series of book values and investment data for each firm and adjust the former by price indices of new capital goods. Second, financial accounts, not tax accounts are used. In modern accounting, these two accounts are related through the deferred tax model, where the values of e.g. “accelerated tax depreciation schemes” show up as intangible assets in the financial balance sheet.

The term *capital* may have different meanings (see e.g. Hicks, 1974), but in this paper we shall concentrate on capital in the sense of a durable tangible production factor. This corresponds to fixed capital in the national accounts and tangible fixed assets in the business accounts. In this sense, capital is an input in the production process, which

¹If K_t is the capital stock in year t , J_t is gross investment and d_t is the depreciation rate, then PIM says that $K_{t+1} = (1 - d_t)K_t + J_{t+1}$. If one is willing to assume that d_t is time-invariant, this is equivalent to geometric depreciation (see e.g. Hulten and Wykoff, 1996; and Jorgenson, 1996).

generates operating profits.

According to accounting standards, tangible fixed assets are assets that have value beyond the current year. It consists of machines, transport vehicles, buildings, etc. Tangible assets are acquired through investments, which are capitalized and depreciated over the expected lifetime of the asset. Intangible fixed assets such as goodwill are not considered in this paper.

Our first target will be to measure *net capital stocks* for the individual firm. That is, the value of a firm's tangible capital stock in a given year at the prices of similar new assets, subtracting depreciation. For given depreciation and interest rates, the annual cost of capital can be estimated from the net capital stock through the well-known user-price formula, due to Jorgenson (1963). However, to estimate the cost of the capital services in a firm, the cost of rented capital must also be included.

While financial capital may be easily transferable (liquid), that is often not the case with physical capital. Imperfections in, or even lack of, second-hand markets mean that physical capital may have very low alternative value outside its current location or use, making assessment of the value and cost of capital difficult both from a practical and a conceptual point of view.

A particular problem with PIM, when applied to industry level investment data, is due to reallocation and revaluation of capital caused by firm exit. It is not appropriate to assume, as a rule, that capital equipment in firms that have closed down remain operative (with unchanged value) within the industry. Some of the equipment may be sold to firms outside the industry, in which case these sales are investments by the acquiring firms and disinvestments by the exiting firm (but not reported as such, because the firm is not operative). Other equipments may be scrapped, so that the value of the equipments should be subtracted from the capital stock of the industry. Entry of firms also poses problems: Our comparisons of official statistics with a sample of new firms' annual reports, reveal that initial capital stocks are often not reported as "investments", and hence ignored by PIM when applied to aggregate gross investment data.

With our method, by summing over individual firms' capital stocks, we can obtain aggregate capital stock estimates for each category of capital in an industry which automatically account for changes in the population of operative firms. On Norwegian data,

this method seems to give more credible estimates of capital growth rates than corresponding national accounts estimates obtained by PIM from aggregate investment data. For example, according to national accounts figures, capital growth rates in Norwegian manufacturing are almost constant throughout 1993-2001, but our method shows that the growth rates are very responsive to variations in investments over the business cycle. We find that a main reason for this discrepancy is the impact of changes in the population of firms: On average during 1993-2001, almost 25% of the *change* in capital services from one year to the next is the net effect of entry and exit of firms, while 75% is due to changes in capital stocks within firms that are operative in both years. Another important difference between the two methods is that the average depreciation rates used by businesses are much larger, especially for machinery and equipment, than depreciation rates used in the national accounts. PIM, when using low imputed depreciation rates, smooths out variations in annual investments to a very large degree.

Our method for estimating capital stocks requires micro panel data at the firm level containing information about the book values of different categories of assets in the firms' balance sheets, acquisitions of tangible fixed assets, and costs of rented capital. In Norway these variables are available by combining two data sources: (i) accounts statistics containing the non-consolidated financial statements for all joint-stock companies and (ii) structural statistics for the manufacturing sector, which provide annual observations on acquisitions and sales of fixed tangible assets and many other variables.

Many European countries, including the other Nordic countries, have annual panel data at the firm level comprising book values as well as acquisitions of tangible fixed assets, and may therefore be able to apply our method. These data are usually collected for parts of the population of firms fulfilling certain criteria, e.g. based on the number of employees in the firms. However, the sample criteria may vary among countries and may also change over time. The data sources are either based on published commercial accounts, tax returns, special questionnaires, or a mixture of these sources. The financial statements collected are mostly non-consolidated, but a few of the countries have consolidated financial statements. For some important countries, like the United States and Japan, the data situation is poor: only relatively small samples are collected annually,

and there is currently no comprehensive panel data set available.²

The rest of this paper is organized as follows: Section 2 discusses main accounting concepts in relation to a simple text-book model of firm behavior; Section 3 gives detailed definitions of investment, depreciation, and related concepts; Section 4 presents the mathematical model which is used to estimate net capital stocks at the firm level at current and constant prices; Section 5 discusses data and operationalizations; Section 6 uses the proposed methods to estimate the total net capital stock in the manufacturing sector for 1993-2001 and calculates measures of aggregate capital services and productivity; Section 7 concludes.

2 Main concepts

In order to relate accounting concepts to economic theory, it may be useful to look at these concepts in a familiar neoclassical text-book setting (see e.g. Varian, 1984). Assume that the factors of production consist of fixed capital, labor, and materials and that capital of different vintages are perfect substitutes. The production function is:

$$Y_t = f(K_{t-1}, X_{Lt}, X_{Mt}). \quad (1)$$

Here, and throughout the paper, K_t refers to the capital stock at the *end* of year t (or the beginning of year $t + 1$). The variables Y_t , X_{Lt} and X_{Mt} are total amounts of output, labor and materials in year t , respectively. In contrast to K_t , these are flow, not stock, variables.

Operating profit in year t , exclusive capital costs, is $\Pi(K_{t-1})$:

$$\Pi(K_{t-1}) = \max_{L,M} \left(pY_t - \sum_{i=L,M} q_i X_{it} \right),$$

where p is the output price and q_i is the price of input i , assumed time-invariant. The unit price of new capital is q_K . To simplify furthermore, we assume that there are constant returns to scale. In a competitive market, this implies a linear homogeneous profit

²The data situation in 11 European countries and the United States and Japan, who submit data to the database BACH (Bank of the Accounts of Companies Harmonised) are documented in detail on the internet site: http://europa.eu.int/comm/economy_finance/indicators/bachdatabase/bachdatabase_whatishach_en.htm#data.

function. Hence, the return to capital is independent of the total capital stock in the firm. We can then write:

$$\Pi(K_{t-1}) = \pi K_{t-1},$$

for some constant π .

The net capital stock is the market value of K_t . We shall now analyze the change in the value of a given, original, capital stock K_0 (acquired at the beginning of year $t = 1$), as it gets older and is subject to loss of productive efficiency as well as retirements (scrapping). Let θ_t denote the reduction in efficiency (including retirements) of this capital stock during year t relative to its stock at the beginning of year t . That is:

$$K_t = (1 - \theta_t)K_{t-1}.$$

The net present value of the capital stock at the beginning of t is the discounted value of the remaining cash flow generated by the original investment:

$$V(K_{t-1}) = \pi K_0 \sum_{s=t}^{\infty} \frac{\prod_{k=1}^{s-1} (1 - \theta_k)}{(1 + r)^{s+1-t}}; \quad t = 1, 2, \dots,$$

where r is the interest rate. In particular, we must have:

$$V'(K_0) = q_K.$$

In the case of geometric depreciation: $\theta_k \equiv \theta$, and we obtain the well-known user-price formula of capital: $\pi = q_K(r + \theta)$, which says that the annual profit of one unit of capital should equal the cost of employing that unit of capital from the beginning of the year until the end of the year (i.e. the cost of capital services). The annual cost of capital thus have two components: depreciation, θq_K , and the risk-free alternative yield, $r q_K$.

Depreciation, D_t , is defined as the reduction in the value of the capital stock from age $t - 1$ to age t :

$$D_t = V(K_{t-1}) - V(K_t).$$

Furthermore, operating profit, Ψ_t , is $\Pi(K_t)$ less depreciation:

$$\Psi_t = \Pi(K_t) - D_t,$$

and the depreciation rate, d_t , is given by:

$$d_t = \frac{D_t}{V(K_t)}.$$

Let us consider an example. Assume that the efficiency profile is of the "one-hoss shay" type, i.e. full efficiency until the time of sudden death, T . Then

$$\theta_t = \begin{cases} 0 & t < T \\ 1 & t = T \end{cases}$$

and

$$K_t = \begin{cases} K_0 & t < T \\ 0 & t \geq T. \end{cases}$$

Some straightforward calculations yield:

$$\begin{aligned} V(K_t) &= \frac{\pi K_t}{r} [1 - (1 - r)^{(T-t)}] \\ D_t &= \pi K_t (1 - r)^{(T-t)} \\ \Psi_t &= \pi K_t [1 - (1 - r)^{(T-t)}] \\ d_t &= \frac{r(1 - r)^{(T-t)}}{1 - (1 - r)^{(T-t)}}. \end{aligned}$$

In this case the equilibrium price of new capital is $q_K = \frac{\pi}{r} [1 - (1 - r)^T]$. Also note the distinction between the rate of reduction in technical efficiency, θ_t , and the depreciation rate, d_t .

This stylized model clarifies the relation between some main accounting concepts, but provides little guidance for calculating depreciation in practice. For example, it does not take into account that the present value of a unit of capital may differ across firms. So what net present value should be used? Market prices on different vintages of the capital good is one alternative, but then there is the problem that organized markets may lack for many types of used capital. Transaction costs could also be very large. An example of the latter is the putty-clay model (see Johansen, 1972), where investment expenditures are considered sunk costs.

To sum up, the concept of depreciation is complicated. In principle, economic depreciation depends not only on efficiency and retirement profiles, but also on general market conditions, interest rates, profit functions, and expectations about future profitability. In practice, depreciation tends to be calculated on an ex ante basis, with allowance for extraordinary adjustments. That is, the purchasing cost of a capital good is distributed throughout its expected service life (ordinary write-downs), with corrections for unexpected and significant changes in value caused by unforeseen events, such as unexpected price changes, accidents, etc.

3 Investment and depreciation

We define as an investment any acquirement of a fixed capital good (new or used) which is capitalized, i.e. taken into the firm's balance sheet, and depreciated over its expected lifetime. Repairs are considered as operating costs, unless it brings the asset to a higher standard so that the value of the asset is increased relative to its ex ante expected value. In the latter case, the increased value is an investment (see the discussion in McGratten and Schmitz, 1999).

Sometimes the firm does not buy the asset, but pays leasing costs. There are two types of leasing: financial and operational. Financial leasing means that most of the risks and rewards are transferred to the firm that leases the tangible fixed asset. In this case the firm that leases should capitalize the asset. Hence, financial leasing is an investment³. The other form of leasing is operational. With an operational leasing agreement, the firm that leases an asset does not capitalize it in its balance sheet, but pays leasing costs⁴. For Buildings and land there might be uncertainty whether the firm that leases the asset will acquire the property right, due to the longsightedness involved for these kinds of assets. In such cases the leasing agreements will often be operational and the risk and reward will stay with the owner.

In the company account, depreciation of tangible fixed assets should be according to a plan covering the expected economic life time of the asset. The firms are free to choose method of depreciation, but linear (straight-line) depreciation is mostly used. Depreciation is governed by general accounting principles, and should reflect useful estimates of the economic life times of the assets (see Hawkins, 1986).⁵

³However, firms that are considered to be small do not have to capitalize financially leased assets. According to the Norwegian accounting law a firm is defined as small if it the two last years fulfils two of the following three criteria:

- i. Revenues less than NOK 40 millions (appr. \$6 millions)
- ii. Total assets of less than NOK 20 millions
- iii. Less than 50 employees

⁴According to our estimates, approximately 13% of annual total capital costs in manufacturing are compensation to owners of rented capital.

⁵The distinction between financial and tax accounts is not well understood even by leading economists, as is vividly displayed in the OECD manual *Measuring Capital*: "Companies will often select depreciation methods that minimize their tax liabilities regardless of whether the depreciation method used ... is a good measure of economic depreciation... . Despite these problems, several countries use depreciation reported by companies in their national accounts. Such estimates cannot even be justified as crude approximations to consumption of fixed capital... . *They are misleading statistics and have no place in the accounting system*" (OECD, 2001, p. 37).

Depreciation in the company accounts differ from depreciation for tax purposes. In Norway, assets in the tax accounts are divided into eight groups according to the expected life times of the assets. Seven of the categories are for tangible fixed assets, and the eighth is goodwill. The method of depreciation is declining balance depreciation (geometric depreciation)⁶.

There is, in principle, no conceptual disagreement between the national and business accounting concept of depreciation: Depreciation is the reduction in the value of an asset along its lifetime. However, there is an important discrepancy with respect to pricing: In the business accounts the historic (acquisition) price is used to evaluate depreciation, while in the national accounts historic prices are converted into current prices using price indices.

As long as a single capital good acquired at a particular point in time is considered in isolation, it is possible to convert book values into net capital stocks. This is equivalent to the familiar problem of converting fixed prices into current prices. However, in practice the situation is complicated by the fact that even narrowly defined capital categories consist of different vintages. For example, if K units of a homogeneous capital good is acquired each year, t , at the price q_t , and depreciation is geometric with rate d , then the net capital stock at the end of year t will be: $q_t \sum_{s=0}^{\infty} (1-d)^s (1-d)K = q_t(1-d)K/d$, while the book value is $\sum_{s=0}^{\infty} (1-d)^{s+1} q_{t-s}K$. Thus, the book value mixes prices of different vintages.

As pointed out in Diewert (1980), the situation becomes even more unclear when n non-homogeneous types of goods; $j = 1, \dots, n$; with different, and possibly time dependent, depreciation rates d_{jt} , are lumped together into one asset category. The capital stock K_t (in that category) at time t will then be: $K_t = \sum_{j=1}^n K_{jt}$, total investment is $I_t = \sum_{j=1}^n I_{jt}$, while total depreciation is $D_t = \sum_{j=1}^n d_{jt}(K_{j,t-1} + I_{jt})$. If we define the *aggregate* depreciation rate d_t as:

$$d_t = \frac{D_t}{K_{t-1} + I_t},$$

then d_t will be a weighted average of the individual depreciation rates d_{jt} :

$$d_t = \sum_j w_{jt} d_{jt}, \quad \text{with} \quad w_{jt} = \frac{K_{j,t-1} + I_{jt}}{K_{t-1} + I_t}.$$

⁶Depreciated asset values below NOK 15 000 are fully deductible from taxable profits.

Hence, depreciation will be time-dependent even in the case of geometric depreciation ($d_{jt} \equiv d_j$) for each individual capital good.

There is some literature concerning the depreciation patterns of individual assets (see Hulten and Wykoff, 1981a and 1981b; Jorgenson, 1996). When it comes to assessing the "true" nature of depreciation, this literature is inconclusive. Data based on transaction of used capital goods can only give a crude indication about depreciation patterns. This is partly due to imperfections in, or even absence of, second hand markets for many goods, and partly due to the self-selection mechanisms which determine which items are sold and which are not (see OECD, 2001).

In general, aggregate asset categories do not consist of homogeneous goods with equal life time parameters. Moreover, the weight w_{jt} given to the individual depreciation rate d_{jt} , is a highly endogenous variable which cannot be determined ex ante. Thus it is impossible to have a *theory* for what are the correct depreciation patterns. This is entirely an empirical matter. For example, the inclusion of computers in the capital stock has led to an increase in depreciation rates for machinery and equipment in recent years. We believe that any model of aggregate depreciation rates are necessarily flawed. Depreciation is best accounted for at the micro level, for each individual asset. Hence, we must rely on the depreciation patterns designated by the firm. In this way changes in the aggregate depreciation rates due to composition effects, extraordinary write downs, etc. will automatically be accounted for.

We have seen that aggregate (total) book values are flawed as measures of net capital stocks when different capital goods acquired at different points in time are lumped together into asset categories. While this is often used as an argument for disregarding account statistics altogether for the purpose of capital measurement, we shall argue below that this conclusion is premature if investment time series for individual firms are available. Clearly, for investments in new goods, book values and current values coincide. Furthermore, for one and the same capital good, j , acquired at a given point in time, t , the initial investment, I_{jt} , as well as all subsequent write-downs are measured on the same scale: the purchasing price, q_t . Hence, book values do say something about real depreciation when a unique capital good is considered. We will show that this conclusion can be generalized to non-homogeneous asset categories under quite reasonable assumptions.

4 Methods

Assume first that a firm buys a capital good (e.g. a particular machine) in quantity K_0 at the beginning of year $t = 1$ for a price q_1 . The investment is therefore

$$I_1 = q_1 K_0.$$

In this simplified model, we assume that there is only one capital good, and that no further investments take place. During period 1, the following occur: A share d_1 of the initial investment is written down due to expected depreciation and the book value of the depreciation is:

$$\widehat{D}_1 = d_1 I_1.$$

Furthermore, a share s_1 of the capital good is sold. The book value of the sale is:

$$\widehat{S}_1 = s_1 I_1.$$

The book value, \widehat{K}_1 , at the end of year 1 is therefore:

$$\widehat{K}_1 = I_1 - (\widehat{D}_1 + \widehat{S}_1) = (1 - \delta_1) I_1,$$

where $\delta_1 = d_1 + s_1$ is the *reduction rate* in year 1.

By recursions, we have for $t > 1$:

$$\begin{aligned} \delta_t &= \frac{\widehat{D}_t + \widehat{S}_t}{\widehat{K}_{t-1}} \\ \widehat{K}_t &= (1 - \delta_t) \widehat{K}_{t-1}. \end{aligned}$$

The reduction rate δ_t does not depend on prices even if it is calculated from book values. The reason is that all book values are evaluated at same price q_1 , i.e. the purchasing price. Note that the reduction rate will differ from the depreciation rate when capital goods are sold.

We shall now consider how the book values \widehat{K}_t can be converted into current prices. Let $K_{s|t}$ denote the net capital stock in year s evaluated at the prices of year t . If

$$\rho_t = (q_t - q_{t-1})/q_{t-1} \tag{2}$$

is the relative change in the price index, q_t , then

$$K_{s|t} = K_{s|s} \prod_{u=s+1}^t (1 + \rho_u) \text{ for } s < t.$$

Clearly, we have

$$K_{1|1} = \widehat{K}_1 = (1 - \delta_1)I_1.$$

Repeating the same reasoning for period $t = 2$ and beyond, we obtain

$$\begin{aligned}\widehat{K}_t &= (1 - \delta_t)\widehat{K}_{t-1} \\ K_{t|t} &= (1 - \delta_t)K_{t-1|t} \quad \text{for } t = 2, 3, \dots\end{aligned}$$

If we define $\widehat{K}_0 = K_{0|0} = 0$, we obtain the general formula:

$$\begin{aligned}\widehat{K}_t &= (1 - \delta_t)(\widehat{K}_{t-1} + I_t) \\ K_{t|t} &= (1 - \delta_t)(K_{t-1|t} + I_t) \quad \text{for } t = 1, 2, 3, \dots\end{aligned}$$

(recall that $I_t = 0$ for $t > 1$). The importance of these equations lies in the fact that the reduction rate δ_t can be calculated from book values.

In the above model, an investment is made once and only *reductions* in capital takes place thereafter. The reductions are registered in the book using the purchasing price. This is therefore not a realistic model for a firm, but only for a particular capital good defined by its physical characteristics as well as the particular year in which it was acquired. Hence the same type of capital good acquired at another point in time must be treated as a different good, because the purchasing price may be different.

To elaborate the model, we partition the stock of capital of a particular category into $j = 1, \dots, N$ different capital goods. Unit j is defined by an investment in a specific type of capital made in one particular year, t_j . We assume that the same price index, with relative change ρ_t , apply to all N goods within the category. The total book value of the firm's capital goods at the end of year t is: $\widehat{K}_t \equiv \sum_{j=1}^N \widehat{K}_{jt}$, where \widehat{K}_{jt} is the book value of capital good j . Similarly, the firm's total capital stock in year s measured in year t prices is: $K_{s|t} \equiv \sum_{j=1}^N K_{j,s|t}$. Hence, we obtain:

$$\begin{aligned}\sum_{j=1}^N \widehat{K}_{jt} &= \sum_{j=1}^N (\widehat{K}_{j,t-1} + I_{jt}) - \sum_{j=1}^N \delta_{jt} (\widehat{K}_{j,t-1} + I_{jt}) \\ \sum_{j=1}^N K_{j,t|t} &= \sum_{j=1}^N (K_{j,t-1|t} + I_{jt}) - \sum_{j=1}^N \delta_{jt} (K_{j,t-1|t} + I_{jt}).\end{aligned}$$

The aggregate investment is $I_t \equiv \sum_j I_{jt}$ (where $I_{jt} = 0$ when $t \neq t_j$). Hence, we can

write:

$$\begin{aligned}\widehat{K}_t &= (1 - \delta_t)(\widehat{K}_{t-1} + I_t), \text{ where } \delta_t = \sum_{j=1}^N \widehat{w}_{jt} \delta_{jt} \text{ and } \widehat{w}_{jt} = \frac{\widehat{K}_{j,t-1} + I_{jt}}{\widehat{K}_{t-1} + I_t} \\ K_{t|t} &= (1 - \delta_t^0)(K_{t-1|t} + I_t), \text{ where } \delta_t^0 = \sum_{j=1}^N w_{jt} \delta_{jt} \text{ and } w_{jt} = \frac{K_{j,t-1|t} + I_{jt}}{K_{t-1|t} + I_t}.\end{aligned}\quad (3)$$

There is a difference between the exact aggregate reduction rate δ_t^0 (using the relative current values of the different capital goods as weights) and the approximate aggregate reduction rate δ_t (using relative book values as weights). We can consider δ_t as an estimator of δ_t^0 . This estimator may have good properties in two circumstances: (i) when all the δ_{jt} are of similar magnitude, i.e. the asset categories consist of capital goods with similar life times, or (ii) when δ_{jt} is independent of w_{jt} and \widehat{w}_{jt} . In the latter case both $\delta_t^0 \xrightarrow{P} \delta_t^*$ and $\delta_t \xrightarrow{P} \delta_t^*$ when N becomes large, assuming that $\delta_{jt} \sim i.i.d(\delta_t^*, \sigma^2)$.

The reduction rate δ_t is a purely auxiliary variable, and should not be confused with a depreciation rate. However, since sales of used capital goods are relatively rare for firms that do not close down production units, we will most often have $\delta_t = d_t$. Hence, the *median* (but not the *average*) reduction rate among all firms in a given year, at least when excluding firms that report sales of capital in that year, is a useful location parameter for the distribution of the depreciation rates.

5 Data and implementations

We use data from mainly two sources: (i) Accounts statistics for all Norwegian joint-stock companies (see Statistics Norway, 2000), and (ii) Structural statistics for the manufacturing sector (see Statistics Norway, 1999). Both statistics cover the period 1993-2001. In addition, we have access to an almost complete set of annual reports for Norwegian joint-stock companies for the year 2001. The latter data set is costly to review, since the annual reports do not have a standardized form, but must be read manually from picture files. Nevertheless, annual reports are invaluable sources of information about the quality of the ordinary data sources (i) and (ii) and are used extensively in this paper. Annual reports also give insights into accounting practices and enable us to evaluate methods for adjusting data when the investment figures in the manufacturing statistics are incompatible with the accounts statistics (see Appendix A).

The main statistical unit in the accounts statistics is the firm: A firm is defined as "the smallest legal unit comprising all economic activities engaged in by one and the same owner" and corresponds in general to the concept of a company (Statistics Norway, 2000). A firm may consist of one or more establishments. The establishment is the geographically local unit doing economic activity within an industry class. Another unit is the consolidated group, which consists of a parent company and one or more subsidiaries. Both the parent company and the subsidiaries are firms as defined here. The parent company have control over the subsidiary through ownership of stocks. A consolidated group has to report a consolidated financial statement. This means that the share of ownership in the subsidiaries are taken into the financial statement. Small firms (see footnote 3) do not have to report the consolidated financial statement.

All joint-stock companies in Norway are obliged to publish a company account every year. The accounts statistics consist of information gathered from the company accounts of all non-financial joint-stock companies. It contains data from both the income statement and the balance sheet. In particular, the accounts statistics have information about the book value of a firm's tangible fixed assets at the end of the year. The accounts statistics also have data on ordinary depreciations and write-downs. However, there are no separate data on depreciation and write-downs for tangible fixed assets. Another shortcoming of the accounts statistics is that it does not contain data on acquisitions of tangible fixed assets. The reason is that data for investments do not have a specific standard in the annual report, but is given in the notes to the annual report in a format arbitrarily chosen by the firm.

The structural statistics for the manufacturing industry does, however, contain data about acquisitions of tangible fixed assets at the establishment level. The manufacturing statistics also contain information about financial leasing. Firm level data are obtained from the manufacturing statistics by summing over all establishments within the firm. These data are matched with the data from the accounts statistics.

Both the accounts statistics and the manufacturing statistics distinguish between several groups of assets. However, to obtain consistent definitions of asset categories for the two statistics sources and over the whole observation period, we have chosen to separate between two classes of assets: (i) Buildings and land; and (ii) Other tangible fixed assets.

The latter group consists of machinery, equipment, vehicles, movables, furniture, tools, ships, rigs and aircraft, and is therefore quite heterogeneous. However, the expected lifetimes of the assets in the first group are considerably larger than in the second, and the between-group variation in lifetimes is much larger than the within group variation. Averaging over all years, the median reduction rate among assets in group (i) is about 5.5% and about 25% in group (ii).

The accounts statistics should be of a very good quality, as it contains the audited accounting figures of the firms. In a sample of about 120 annual reports examined, we rarely found discrepancies between the book values reported in the accounts statistics and in the annual reports. Also the manufacturing statistics should be of good quality, especially for larger firms (i.e. at least 10 employees), since these figures are obtained electronically from tax return forms and also revised by Statistics Norway.

Denote by I_{it}^M and J_{it}^M acquisitions of tangible fixed assets (new and used) and gross investments, respectively, for firm i in year t obtained from the manufacturing statistics. Gross investments is defined as acquisitions less sales of tangible fixed assets. Furthermore, let \widehat{K}_{it}^A and δ_{it} denote, respectively, the book value obtained from the accounts statistics and the reduction rate defined in (3) for firm i at time t . A reduction rate will always refer to one of the two categories of capital (although we suppress this in the notation, for simplicity). Since the sum of depreciations and sales cannot be negative, the lower limit on the reduction rate is $\delta_{it} = 0$. The upper limit is $\delta_{it} = 1$, which is obtained when all the firm's tangible fixed assets are depreciated or sold.

Our basic equation for estimating δ_{it} , based on (3), is the following:

$$\widehat{K}_{it}^A = (1 - \widehat{\delta}_{it})(\widehat{K}_{i,t-1}^A + I_{it}^M). \quad (4)$$

The estimated reduction rate $\widehat{\delta}_{it}$ in (4), is residually calculated as the sum of ordinary depreciations, write-downs and sales relative to $\widehat{K}_{i,t-1}^A + I_{it}^M$ (see Section 4). For most firms, depreciation is by far the largest part of this sum.

Since there may be errors in the data sources, the estimated reduction rates may differ from the true ones. If there is an underreporting of investment in the structural statistics compared to the annual report, $\widehat{\delta}_{it}$ may even be negative. In Appendix A we present a method for improving the estimate of δ_{it} in the latter case, together with assessments of data quality. These assessments are based on randomized samples of complete annual

reports.

6 Applications

The main output of our method is a panel data set of capital stock estimates covering the years 1993-2001 for a nearly complete sample of all Norwegian joint-stock companies in the manufacturing sector. This data set can be used to obtain estimates of the *total* stock of tangible fixed assets in the manufacturing sector by inflating sample totals with appropriate inverse annual weights. Each weight is the estimated share of the sample total (i.e. the sum over all joint-stock companies within manufacturing) relative to the sector total (i.e. the sum over all establishments in manufacturing). We use weights calculated as moving averages of the joint-stock companies' share of total employment and value added (the share of employment and value added are almost equal; the difference is only 1-2 percentage points each year). These weights increase monotonically from 65 per cent in 1993 to 80 per cent in 2001, reflecting increased popularity of the joint-stock company ownership form.

In this section we will apply our data set for two purposes: First, we obtain net capital stock estimates at the aggregate sector level by summing over the individual firms, and compare with PIM. Second, we calculate measures of capital services at the firm level, including rented capital, and use these figures to obtain measures of capital intensity and productivity at the aggregate level.

6.1 Net capital stocks

Figure 1 shows the development in the book values of Buildings and land, together with the net capital stock of Buildings and land in current and constant prices. We see that the price adjustment has some significance. The value in current prices is about 5 per cent higher than the book value in 1995, rising to 16 per cent in 2001. The development in constant prices also tells us that the period we are looking at experienced substantial price increases. Furthermore, there was a near 40 per cent increase in the stock of Buildings and land between 1993 and 2001, measured in constant prices.

For Other tangible fixed assets, the differences between book values and values in current prices are much smaller (book values are actually about 1% larger than the value

in current prices due to a decrease in prices on other tangible assets). This can be seen from Figure 2. Other tangible fixed assets have lower expected life times than Buildings and land, so the replacement of these assets happens more frequently. Hence, more of the stock of Other tangible fixed assets are valued at current prices or prices close to current prices. Figure 3 shows the development in total tangible fixed assets.

Next, we compare our calculated stocks of tangible fixed assets with the results obtained from PIM. We use 1993 as the base year, with aggregate gross investments equal to manufacturing statistics totals for the period 1990-2001. As before, we calculate values for Buildings and land and Other tangible fixed assets separately. By assumption, the capital stocks in 1993 are equal for the two methods, and equal to the book value. All values are in constant 1999-prices.

In Figure 4 the results for Buildings and land are shown. Despite the sharp drop in gross investments during 1993-1994, the growth rate of capital as measured by PIM is almost unaffected. On the other hand, the net capital stocks estimated by our method give no growth for Buildings and land from 1993-1995.

The results for Other tangible fixed assets are depicted in Figure 5. We see the same pattern as for Buildings and land, but the two methods give more equal results. The average growth rate during 1993-2001 is roughly the same with the two methods. Again, our method shows a little more responsiveness to changes in gross investments than PIM, although both estimators reveal a pattern of monotone increases in the stock of Other tangible fixed assets. Figure 6 shows the results for all tangible fixed assets, by summing both categories of capital in current prices and deflating using a common price index for new capital goods.

A partial explanation of the discrepancy between the two methods is that most businesses use depreciation rates that are well above the aggregate depreciation rates applied in the national accounts. In Figure 7 we see that the depreciation rates for Buildings and land in the national accounts is 4%, while the median reduction rates, even when excluding firms with sales of assets, lie around 5.5%. For Other tangible fixed assets, shown in Figure 8, the difference is even more striking: Depreciation rates in the national accounts lie around 12-13%, compared to median reduction rates calculated from firm level data that are about twice as high.

Another important difference between our method and PIM is that PIM makes no adjustments for firm exits, while our method only includes capital stocks of operative firms. It is also a problem for PIM that new firms do not necessarily report their initial book value as "investments". Hence, some contributions to capital formation will be missed by this method.

6.2 Capital services

From the well-known user-price formula of capital (assuming standard neoclassical technology), it is possible to combine information about the net capital stocks of firms with data about the cost of rented capital, to estimate the total cost of capital services in a given year. If d_t^B and d_t^O are depreciation rates for Buildings and land and Other tangible fixed assets, respectively; r_t^B and r_t^O are the corresponding real interest rates; and R_t is the total cost of rented capital, we can estimate the cost of owned and rented capital in the manufacturing sector in year t as:

$$C_t = (d_t^B + r_t^B)K_{t|t}^B + (d_t^O + r_t^O)K_{t|t}^O + R_t,$$

where $K_{t|t}^B$ and $K_{t|t}^O$ are the aggregate values of Buildings and land and Other tangible fixed assets in current prices, respectively. We estimate d_t^B and d_t^O by the annual median values of the corresponding reduction rates, excluding sales (depicted in Figures 7 and 8). The real interest rates, r_t^B and r_t^O , are defined as nominal interest rates less capital gains. Nominal interest rates are set equal to the yield on ten-year government bonds in the year, while capital gains are assumed equal to the relative change in the corresponding price index of capital goods; see (2). The cost of rented capital, R_t , is available from the manufacturing statistics. A volume index of capital services can then be constructed by deflating C_t by the price index of capital.

Figure 9 depicts the movements in three volume indices for the Norwegian manufacturing sector during 1993 – 2001 (normalized to one in 1993): The indices of output, capital services, and total man-hours. The output index is calculated as value added deflated by the producer price index⁷. We see from Figure 9 that from 1993 until 2001, capital services increased by 88%, output by 28%, and man hours by only 3%. Especially

⁷Value added is defined as: Operating income - Operating costs + Compensation of employees + Depreciation + Costs of rented capital. All these variables are obtained from the accounts statistics, except the cost of rented capital, which are obtained from the manufacturing statistics.

the period after 1998 is characterized by a rapid replacement of labor with capital and a sharp decrease in manufacturing employment.

6.3 Productivity

Change in labor productivity, i.e. value added per man-hour, can be decomposed in two contributions: Change in capital intensity, k_t , i.e. capital services per man hour, and change in total factor productivity, TFP_t . The most common decomposition, based on Cobb-Douglas technology with constant returns to scale, is the following:

$$\begin{aligned} \ln LP_t - \ln LP_{t-1} &= \ln TFP_t - \ln TFP_{t-1} \\ &\quad + (1 - \alpha)(\ln k_t - \ln k_{t-1}), \end{aligned}$$

where α is the cost share of labor.

The developments in labor productivity, total factor productivity, and capital intensity are shown in Figure 10. From 1993 until 2001 labor productivity increased by about 25% (2.5% annually). Total factor productivity increased by 7% (0.7 % annually). Thus, the remaining 18 percentage points increase in labor productivity is due to capital deepening. In fact, capital services per man hour, i.e. capital intensity, increased by 82% in this period. In comparison, labor productivity in U.S. manufacturing increased 4.6% annually during 1995-2000 (see Cobet and Wilson, 2002).

7 Conclusions

In this paper we have proposed and explored a new method for estimating net capital stocks at the firm level, which is based on financial accounts data for the manufacturing sector. The method converts historic acquisition prices into current prices by combining time series of book values with investment data for each firm, and adjust the former using price indices of new capital goods. The main output of the method is a panel data base containing estimates of tangible fixed assets evaluated at both current and constant prices at the firm level. The data base can easily be updated each year, as new data arrives, and it has many potential applications in the study of production and productivity – both at the micro and macro level.

In an application, we have compared capital estimates for the aggregate Norwegian

manufacturing sector with features from the national accounts. We show that our method gives capital growth rates that are more responsive to changes in investments over the business cycle than those obtained by PIM.

References

- Biørn, E. (1989): *Taxation, Technology and the User Cost of Capital*. North-Holland (Amsterdam).
- Cobet, A.E. and G.A. Wilson (2002): Comparing 50 years of labor productivity in U.S. and foreign manufacturing. *Monthly Labor Review*, 51-62.
- Diewert, W.E. (1980): Capital and the theory of productivity measurement. *American Economic Review*, 70(2), 260-267.
- Hawkins, D.F. (1986): *Corporate financial reporting and analysis Text and cases*. The Robert N. Anthony/Willard J. Graham Series in Accounting, Irwin (Homewood).
- Hicks, J.R. (1974): Capital controversies: Ancient and modern. *American Economic Review*, 64(2), 307-316.
- Hulten, C.R. and F.C. Wykoff (1981a): The measurement of economic depreciation In C.R. Hulten (Ed.), *Depreciation, inflation, and the taxation of income from capital*. The Urban Institute Press (Washington), 81-125.
- Hulten, C.R. and F.C. Wykoff (1981b): The estimation of economic depreciation using vintage asset prices: An application of the Box-Cox power transformation. *Journal of Econometrics*, 367-396.
- Hulten, C.R. and F.C. Wykoff (1996): Issues in the measurement of economic depreciation: Introductory remarks. *Economic Inquiry*, 34(1), 10-23.
- Johansen, L. (1972): *Production functions*. North-Holland (Amsterdam).
- Jorgenson, D.W. (1963): Capital theory and investment behavior. *American Economic Review*, 53, 47-56.
- Jorgenson, D.W. (1996): Empirical studies of depreciation. *Economic Inquiry*, 34(1), 24-42.
- Klette, T.J, and Z. Griliches (1996): The inconsistency of common scale estimators when output prices are unobserved and endogenous. *Journal of Applied Econometrics*, 11, 343-361.
- McGratten, E.R. and J.A. Schmitz, Jr. (1999): Maintenance and repair: Too big to ignore. *Federal Reserve Bank of Minneapolis Quarterly Review*, 23(4), 2-13.
- OECD(2001a): *Measurement of capital stocks, consumption of fixed capital and capital services*. OECD manual 131 (Paris and Washington).

OECD(2001b): *Measuring Productivity Measurement of aggregate and industry-level productivity growth*. OECD manual (Paris and Washington).

Statistics Norway (1999): *Manufacturing Statistics*. Official Statistics of Norway C 719 (Oslo/Kongsvinger).

Statistics Norway (2000): *Accounts Statistics*. Official Statistics of Norway D 249 (Oslo/Kongsvinger).

Varian, H. (1984): *Microeconomic Analysis*. 2nd. ed. W.W. Norton (New York).

Appendix A: Data quality and adjustments

A closer examination of the data and comparisons with the complete annual reports reveal several sources of errors that we need to address before applying our method for measuring capital stocks described in Section 4 and 5. Our main tool for detecting errors in the data is the calculated reduction rate, $\widehat{\delta}_{it}$, defined in equation (4). We shall first focus on the case when $\widehat{\delta}_{it} < 0$.

From our investigations of the sample of annual reports, it seems that there are three main reasons for negatively calculated reduction rates: (i) A failure on the part of the firm to report all investments to Statistics Norway; (ii) mergers and acquisitions; and (iii) time inconsistencies in the firms' classification of its tangible fixed assets. The first type of error is by far the most common. Although quite rare, the other two of these possible sources of errors deserve special attention.

First; in the annual report a merger or an acquisition is indicated by a revision of the tangible fixed assets at the end of the previous year to make these figures comparable with the figures at the end of the current year. In the accounts statistics, however, there is no direct information about the capital obtained through the merger or acquisition. Since take-overs from mergers and acquisitions are not regarded as investments in the manufacturing statistics, $\widehat{\delta}_t^S$ may be negative: A merger is counted as a "negative reduction". However, our method for estimating capital requires that a merger is specifically identified as an investment, since all means of acquiring capital, regardless of whether this is new capital or merely a change in ownership of old capital, is capitalized in the balance sheet.

Second; tangible fixed assets are divided into several categories on the balance sheet. However, sometimes a firm may not be time-consistent in its classification of an asset, and the category of the asset may suddenly change. This typically leads to a negatively calculated reduction rate for the category which "gains" an asset, and a very high reduction rate in the category which "loses" the asset. Fortunately, such reclassifications are quite rare – but may lead to large errors when they occur.

When $\widehat{\delta}_{it}$ is negative, whatever the reason, we will consider the investment I_{it} as an unobserved variable, and calculate it by replacing $\widehat{\delta}_{it}$ with an imputed non-negative value, $\widehat{\delta}_t^*$: the median estimate of the reduction rate in year t (for that asset category). That is, we solve the equation:

$$\widehat{K}_{it}^A = (1 - \delta_t^*)(\widehat{K}_{i,t-1}^A + I_{it})$$

with respect to I_{it} for given δ_t^* . Investment cannot be negative, so we choose

$$I_{it}^* = \max\left(\frac{\widehat{K}_{it}^A}{(1 - \delta_t^*)} - \widehat{K}_{i,t-1}^A, 0\right) \quad (5)$$

as our estimated investment in the case of $\widehat{\delta}_{it} < 0$. Our final proposed estimator for δ_{it} can therefore be defined as:

$$\widehat{\delta}_{it\text{-adj}} = \begin{cases} \widehat{\delta}_{it} & \text{if } \widehat{\delta}_{it} \geq 0 \\ 1 - \frac{\widehat{K}_{it}^A}{(\widehat{K}_{i,t-1}^A + I_{it}^*)} & \text{if } \widehat{\delta}_{it} < 0. \end{cases}$$

Hence, if $\widehat{\delta}_{it} < 0$, $\widehat{\delta}_{it\text{-adj}} = \delta_t^*$ unless $I_{it}^* = 0$.

The choice of the median as the imputed reduction rate is governed by our concern about robustness and the influence of outliers in the data. However, we first considered using the conditional median of δ_{it} given \widehat{K}_{it} and $\widehat{K}_{i,t-1}$, based on an estimated median regression equation with \widehat{K}_{it} and $\widehat{K}_{i,t-1}$ as explanatory variables: Two samples of annual reports for the accounting year 2001 were randomly selected. The firms in the first sample had non-zero book values on Buildings and land in the accounts statistics, and the other had non-zero book values on Other tangible fixed assets. For both types of assets, the median regression model collapsed to a model with a significant constant, only – the median of δ_{it} . We therefore concluded that for the firms in the sample the median was the best predictor of δ_{it} when $\widehat{\delta}_{it} < 0$. The median reduction rate for Buildings and land in the sample was 0.05 (with a standard error of 0.005), and for Other tangible fixed assets 0.23 (0.03). We finally calculated these medians each year based on the whole population of firms with positive book values and with $\widehat{\delta}_{it} \in [0, 1)$, and used these medians as our imputed δ_t^* .

To check the quality of the estimators $\widehat{\delta}_{it}$ and $\widehat{\delta}_{it\text{-adj}}$, it is useful to divide the whole population of firms into three groups. The first group consists of all firms with a negative $\widehat{\delta}_{it}$, which obviously indicate errors in the data. We find that about 15 percent of the firms have calculated reduction rates which are negative in 2001. The second group of firms have a reduction rate in the interval $[0, 1]$, but have less than 10 employees. Since many firms with less than 10 employees have investment data that are mere imputations made by Statistics Norway, the data in this group may also be of poor quality. The last group of firms have non-negative reduction rates $\widehat{\delta}_{it}$ and 10 or more employees. While it is interesting to compare the overall data quality for all these three groups of firms, the main indication that there is something wrong with the data is that the calculated reduction rate is negative.

To evaluate the two estimators $\widehat{\delta}_{it}$ and $\widehat{\delta}_{it\text{-adj}}$, we calculated their mean and median absolute errors in a sample of approximately 120 firms for which the correct reduction rates, δ_{it} , could be derived from information in their complete annual reports. The sample of annual reports were stratified into six subsamples: three groups of firms (as described above) combined with two types of capital. The results are given in Table 1 for Buildings and land and in Table 2 for Other tangible fixed assets. The mean and median absolute errors were calculated for the two estimators in all three groups of firms. Furthermore, weighted averages for the mean and median error over the three groups of firms were

computed using the share of tangible fixed assets in the population (*not* in the sample) as weights.

For both categories of capital, firms with $\widehat{\delta}_{it} > 0$ and more than 10 employees make up about 70% of the total capital stock in the sector and have a median absolute error of zero. Hence, it seems that the overall quality of the data is quite good. The data for smaller firms are poorer, as expected. In the group of firms with a negatively calculated reduction rate ($\widehat{\delta}_{it} < 0$), both the mean and median absolute error are reduced quite dramatically when using $\widehat{\delta}_{it}$ -adj. So, this way of correcting the reduction rates seems to be promising.

Note that large firms are hugely overrepresented in the category with negative $\widehat{\delta}_{it}$. This suggests that a negatively calculated reduction rate could correspond to a systematic failure of these firms to report all of their investments. The problems with mergers and acquisitions discussed above is also mainly confined to very large firms, although we found no such cases in our random samples, so this does not explain the results.

By considering the size of $I_{it}^* - I_{it}^S$ (see (5)), we have a simple way of identifying outliers in the data. If this discrepancy is large, Statistics Norway should take particular care of these firms and check all available data sources, including annual reports. Since some of these firms are so large that they affect aggregate investments in the sector, a thorough review of large outliers is warranted not only from a micro economic point of view, but also from a national accounts perspective.

Figures and tables

Table 1: **Buildings and land: Absolute errors for two estimators of reduction rates.** Results for three groups of firms based on a stratified sample of complete annual reports, 2001. The weights equal each group's share of total book value of Other tangible fixed assets in manufacturing.

Estimator:		$\widehat{\delta}_{it}^S < 0$	$\widehat{\delta}_{it}^S \geq 0$ and less than 10 employed	$\widehat{\delta}_{it}^S \geq 0$ and more than 10 employed	Weight. average
$\widehat{\delta}_{it}^S$	Mean error	6.96	0.03	0.03	2.16
	Median error	0.48	0.02	0	0.15
$\widehat{\delta}_{it}^S$ -adj	Mean error	0.03	0.03	0.03	0.03
	Median error	0.02	0.02	0	0.01
Weight		0.31	0.04	0.65	
Share of firms in pop.		0.14	0.36	0.50	
Sample size		19	15	24	58

Table 2: **Other tangible fixed assets: Absolute errors for two estimators of reduction rates.** Results for three groups of firms based on a stratified sample of complete annual reports, 2001. The weights equal each group's share of Buildings and land.

Estimator:		$\widehat{\delta}_{it}^S < 0$	$\widehat{\delta}_{it}^S \geq 0$ and less than 10 employed	$\widehat{\delta}_{it}^S \geq 0$ and more than 10 employed	Weight. average
$\widehat{\delta}_{it}^S$	Mean error	1.20	0.09	0.05	0.33
	Median error	.94	0.06	0	0.23
$\widehat{\delta}_{it}^S$ -adj	Mean error	0.15	0.09	0.05	0.07
	Median error	0.12	0.06	0	0.03
Weight		0.25	0.02	0.73	
Share of firms in pop.		0.16	0.43	0.41	
Sample size		17	23	24	64

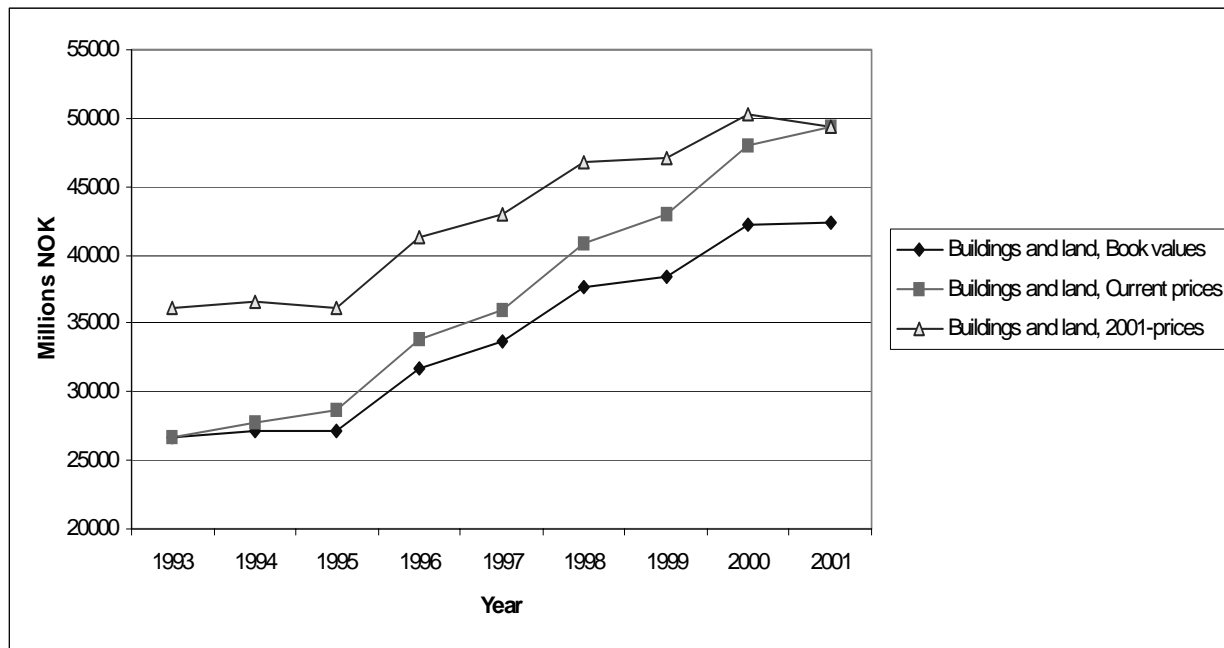


Figure 1: Buildings and land in the Norwegian manufacturing industry 1993-2001

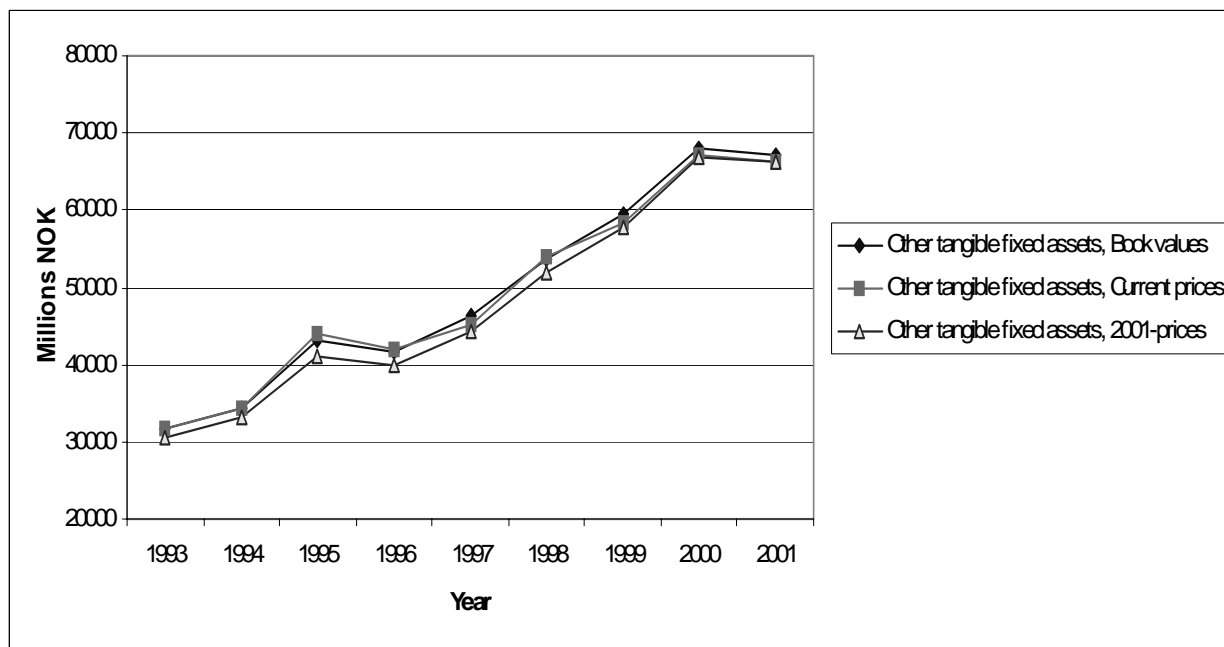


Figure 2: Other tangible fixed assets in the Norwegian manufacturing industry 1993-2001

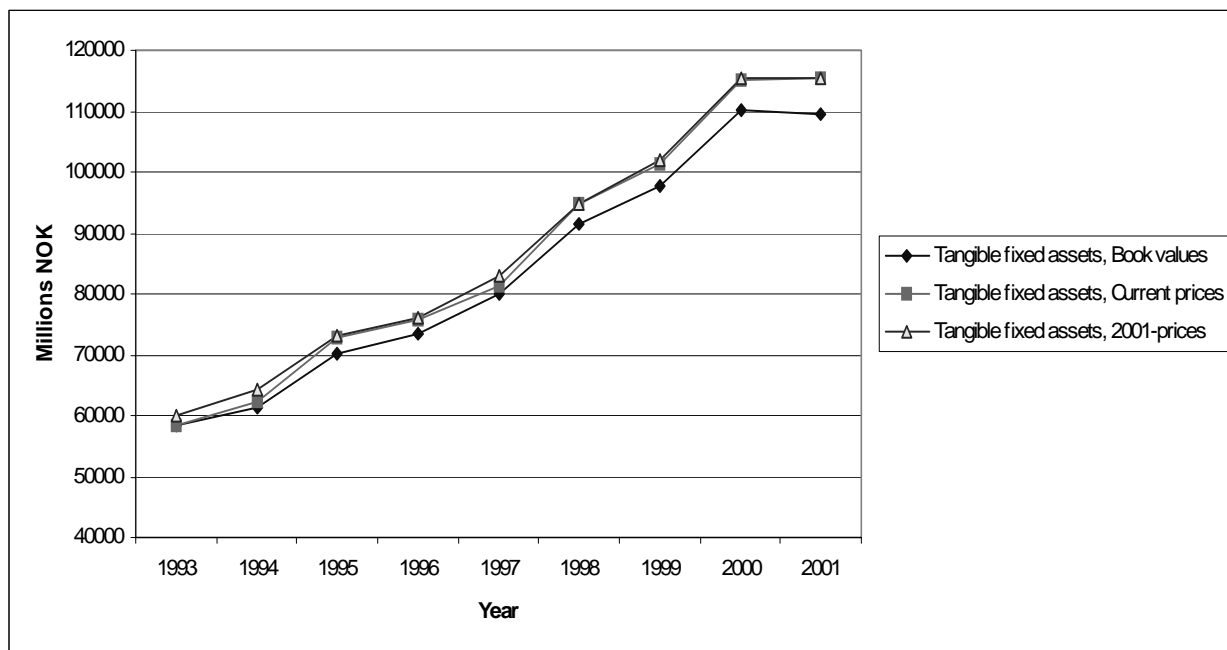


Figure 3: Tangible fixed assets in the Norwegian manufacturing industry 1993-2001

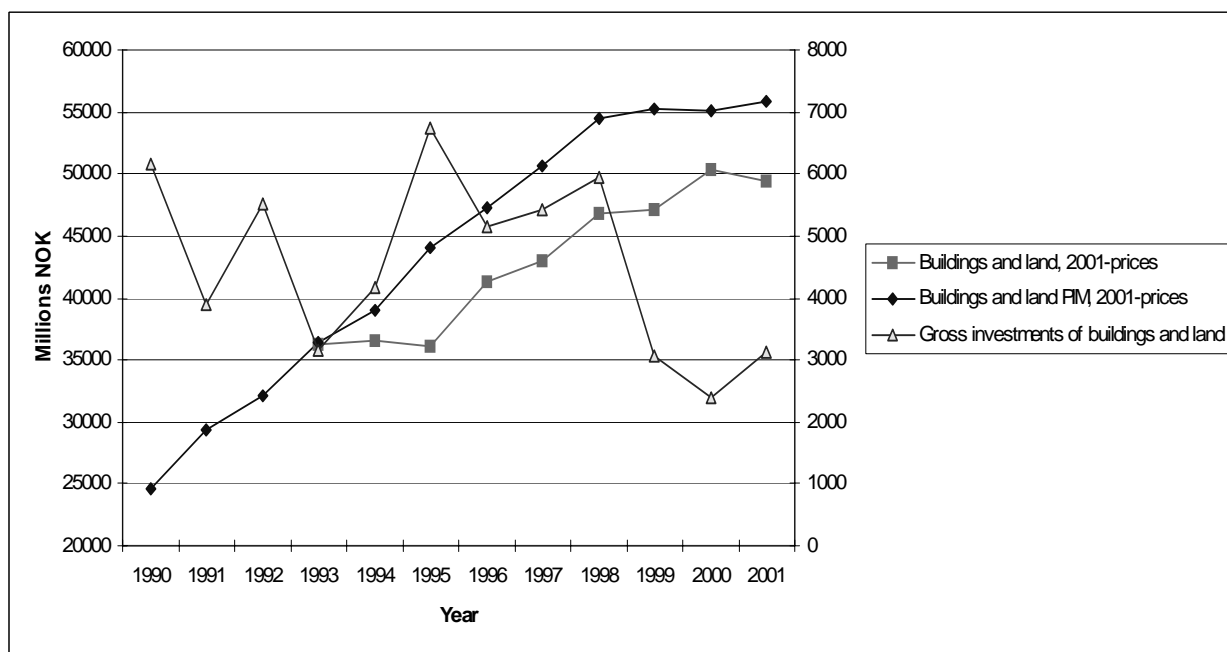


Figure 4: Buildings and land in the Norwegian manufacturing industry calculated with two different methods. Gross investments measured with the scale on the right-hand side, 2001-prices

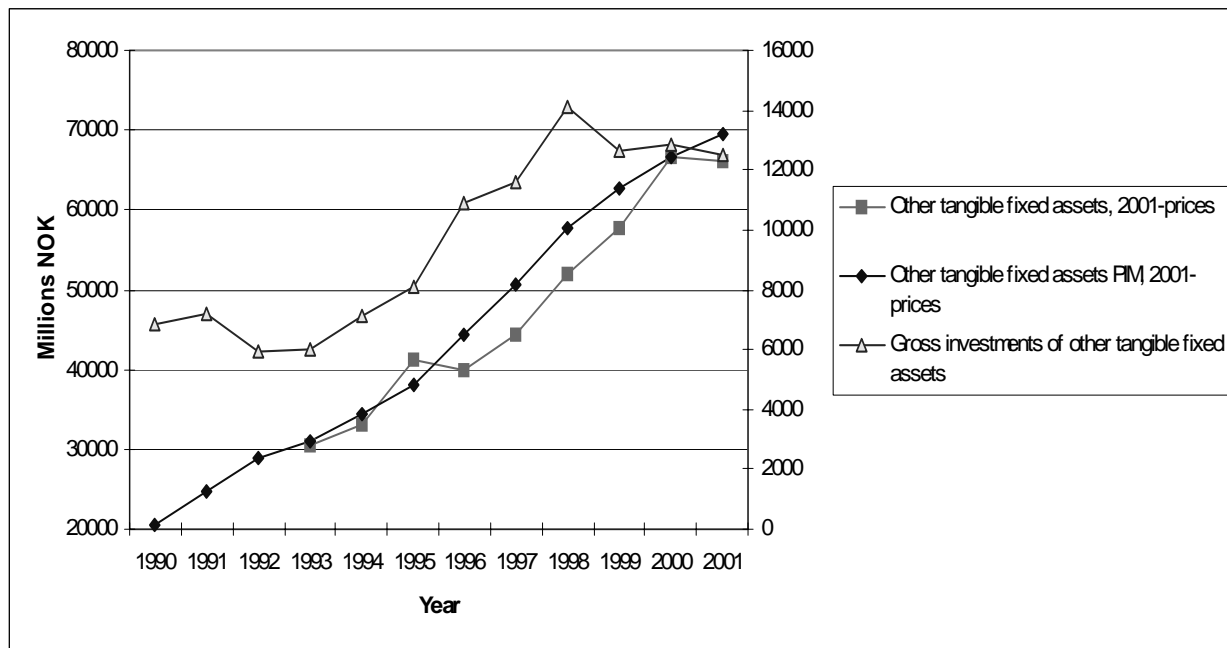


Figure 5: **Other tangible fixed assets in the Norwegian manufacturing industry calculated with two different methods.** Gross investments measured with the scale on the right-hand side, 2001-prices

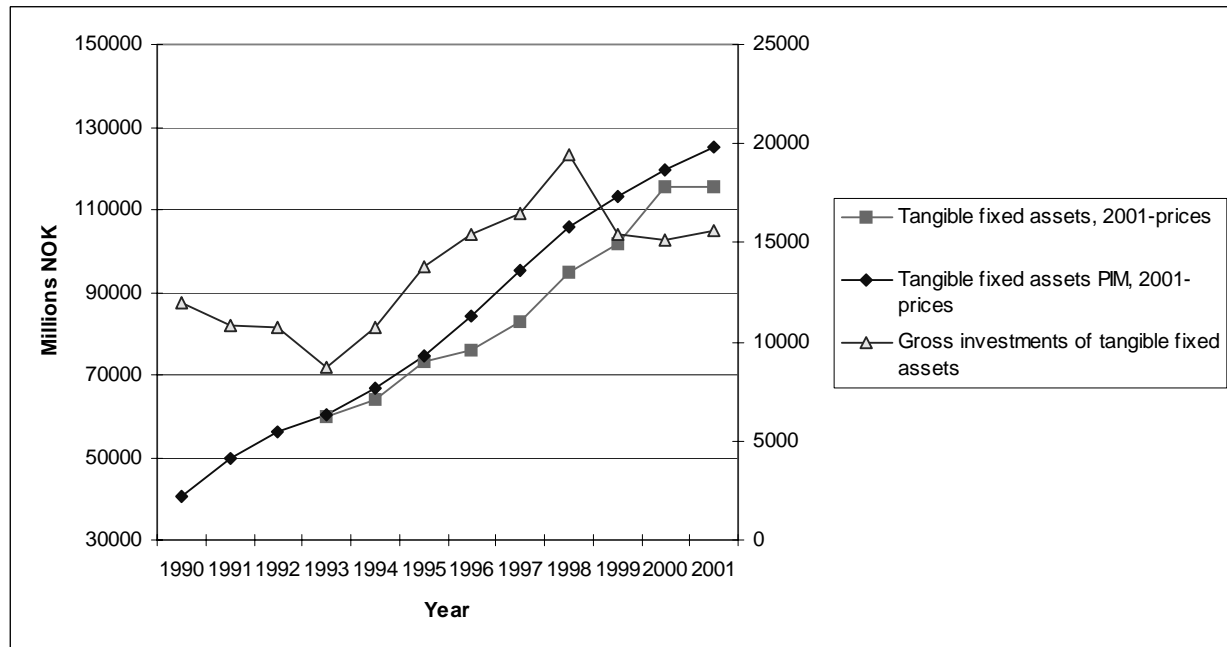


Figure 6: **Tangible fixed assets in the Norwegian manufacturing industry calculated with two different methods.** Gross investments measured with the scale on the right-hand side, 2001-prices

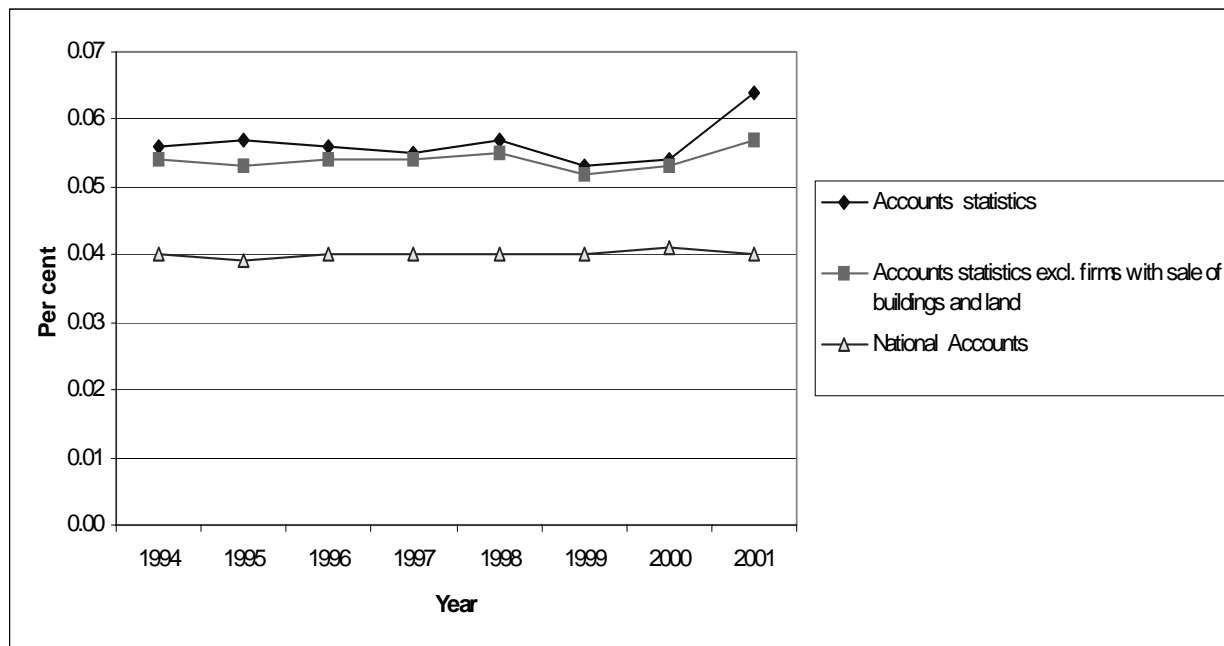


Figure 7: Median reduction rates for Buildings and land in the Norwegian manufacturing industry 1993-2001. Calculated from the accounts statistics and mean aggregate depreciation rates from national accounts

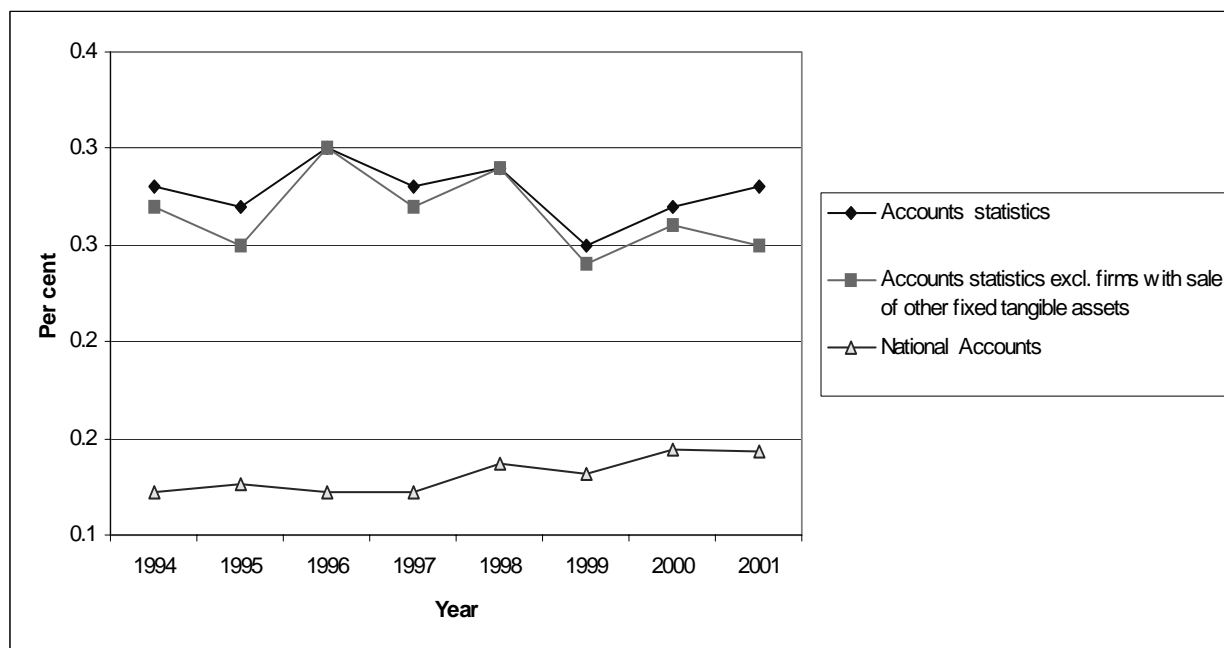


Figure 8: Median reduction rates for Other tangible fixed assets in the Norwegian manufacturing industry 1993-2001. Calculated from the accounts statistics and mean depreciation rates from national accounts

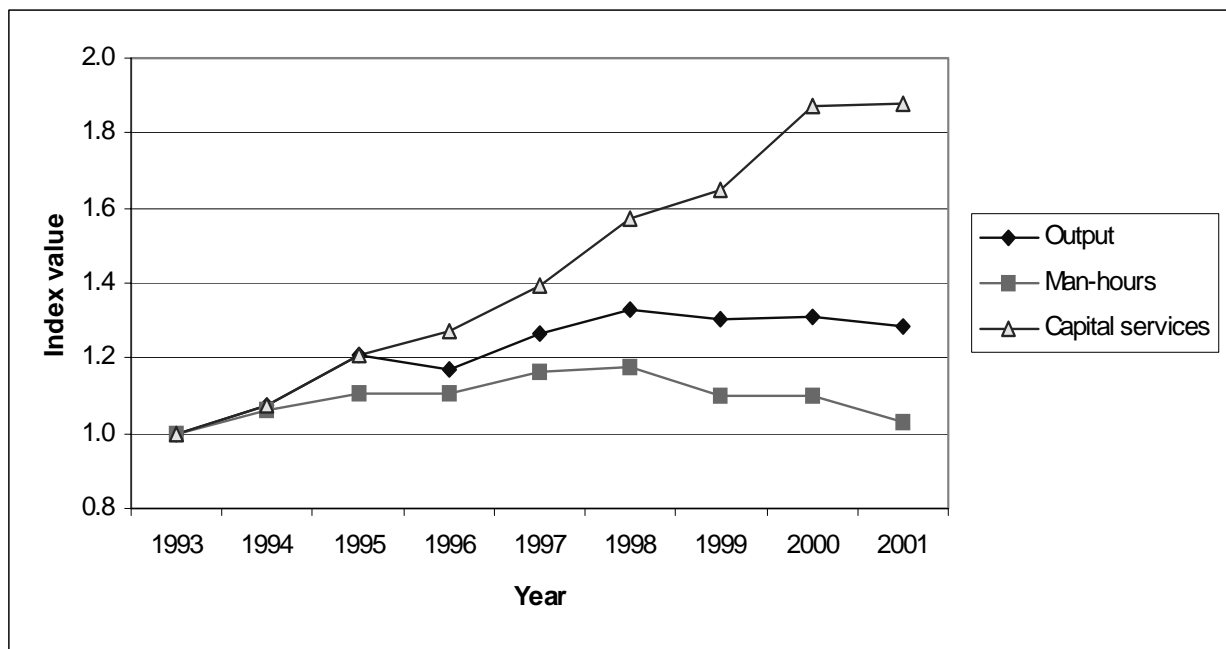


Figure 9: Indices of output and factor inputs in manufacturing 1993-2001

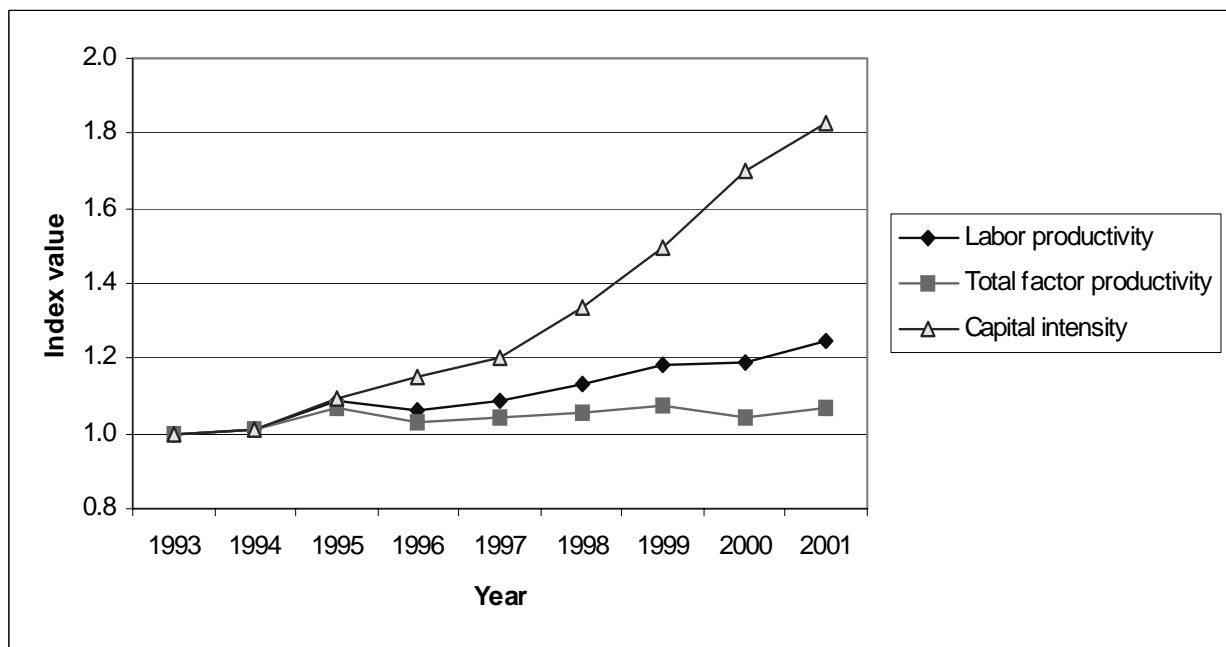


Figure 10: Indices of productivity and capital intensity in manufacturing, 1993-2001