18. PRODUCTIVITY MEASUREMENT AT STATISTICS NETHERLANDS

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Introduction

In 2007 the National Accounts of the Netherlands have been expanded with a set of multi factor productivity (MFP) statistics. There are two guiding principles. The first is to construct a system of productivity statistics at the industry branch and macro level that is, to the extent possible, consistent with National Accounts statistics. By doing this we are joining Australia, Canada, New Zealand, Switzerland, and the United States; see OECD (2006) for a summary of all these systems.

The second principle is that the system should not depend on a particular school of thought about the functioning of an economy. In particular we do not adopt the behavioural and structural assumptions of the neo-classical production framework. As a result, MFP change cannot be interpreted as exclusively the result of technological change (progress or regress), but may also be due to scale effects, efficiency improvements, and other factors.

On the basis of these two principles, this paper presents the computation methods and main results. A range of sensitivity analyses were carried out to investigate the effects of various assumptions on the productivity statistics at the industry and macro level. The most important of these assumptions concern the rate of return to capital and the imputed labour income of self-employed persons.

The layout of the paper is as follows. The next section sketches the main principles of the productivity measurement system. The third and fourth sections discuss the issue of capital and labour input cost measurement at current and constant prices. The other inputs and outputs are discussed in the fifth section. Sensitivity analyses are presented in the sixth section. The seventh section addresses the relationship between gross output and value-added based MFP change. The last section winds up with conclusions and indicates directions for future work.

Measuring productivity change

For any production unit (be it an enterprise or an industry) productivity change is generically defined as output quantity change relative to input quantity change. Expressing change by index numbers, a productivity index is defined as an output quantity index divided by an input quantity index. For this to be operational, one has to decide on what is seen as output and what is seen as input. And this in turn depends on the production model chosen. Two models are particularly important.[267]

The first model stays closest to the actual (physical) production process. Output represents the supply of all the goods and/or services that are being produced. This is also called 'gross output'. The input, then, is the consumption of all the goods and services that are necessary for the production. The various items are usually classified into the groups: (private, owned) capital (K), labour (L), energy (E), materials (M), and services (S). The items belonging to groups K and L are called primary input factors, and those belonging to groups E, M, and S are called intermediate input factors.[268]

In this model, the multi factor productivity (MFP) index is defined as a quantity index of gross output divided by a quantity index of combined KLEMS input. A single factor productivity index, such as a labour productivity (LP) index, is defined as a quantity index of gross output divided by a quantity index of labour (L) input.

The second model is more economically oriented. In this model output is defined as the gross output minus the intermediate inputs that are used in the production process. This is called the 'value added output' concept. Value added is defined as revenue (= value of gross output) minus intermediate input cost (= cost of EMS inputs). Notice that, in contradistinction to gross output, there are no well-defined output quantities related to value added. What can be done, however, is decompose the change of value added through time into a price and a quantity component. Expressing change by index numbers, the quantity index of value added is the output quantity index sought.

In this model, there are only two groups of inputs, namely K and L. Hence, the MFP index is defined as a quantity index of value added divided by a quantity index of combined KL input. Similarly, a LP index is defined as a quantity index of value added divided by a quantity index of labour (L) input.

Can anything be said about the relation between a gross-output based MFP index and a value-added based MFP index? Balk (2003b) showed that under the assumption that total cost is equal to gross output (so that there is no profit), for a fairly large class of index formulas, value-added based MFP change (expressed as a percentage) is larger than gross-output based MFP change, the factor of proportionality being given by the ratio of gross output to value added (the so-called Domar factor).[269]

Finally, there is a generic relation between productivity measurement and growth accounting. Recall that a productivity index is defined as an output quantity index divided by an input quantity index. This relation can also be expressed as: output quantity index = productivity index times input quantity index. After transforming index numbers into percentages, one gets a familiar type of growth accounting relation: output quantity change = productivity change + input quantity change. This relation provides the well-known

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267 Other models are discussed in Balk (2007).

268 The lease of capital goods is considered as belonging to group S.

269 For a derivation of this result under the usual neo-classical assumptions see, for instance, Jorgenson, Ho and Stiroh (2005), p. 298.

interpretation of productivity change as the unexplained, or residual, part of output quantity change. Of course, depending on the type of productivity index the relation can take on more complicated forms.

It is important, however, to be always aware of the fact that in the growth accounting relation the two right-hand side factors, productivity change and input quantity change, are not independent, since productivity change is *defined* as the residual between output quantity change and input quantity change. Put otherwise, productivity change cannot be seen as a separately operating force in the production process. More insight can only be obtained when one is prepared to make a number of (far-reaching) assumptions on the structure of the production process and the 'behaviour' of the production unit under consideration (see Balk 2003a).

Choice of index formula

For the calculation of aggregate quantity or volume change of inputs and outputs, an index formula must be selected. In the standard growth accounting approach, where MFP change represents technological change, the index formula corresponds to a certain specification of the technology (for instance by means of a production function). However, such an approach depends on strong (neo-classical) assumptions, such as that the technology exhibits constant returns to scale and that there is perfect competition.[270] We don't want to make such strong assumptions, and prefer to select an index formula on the basis of its properties.

Common indices, in the context of productivity measurement, are the Laspeyres index, the Törnqvist index and the Fisher index. Because of their different properties, the selection of a specific index is not inconsequential. Balk (1995) reviewed the various indices and their properties.

For the annual publication of productivity statistics, chained Laspeyres volume index numbers will be used. The reasons are twofold. First, convenience of calculation, given the set-up of the Netherlands' supply and use tables. Second, consistency with the volume index numbers as published in the National Accounts.
Generically, a Laspeyres volume index for period *t* relative to period *t*-1 is defined by

$$Q_L^t \equiv \frac{\sum_i p_i^{t-1} q_i^t}{\sum_i p_i^{t-1} q_i^{t-1}} \qquad (1)$$

where q_i^t denotes the quantity of commodity *i* in period *t* and p_i^t its unit price. Then, $p_i^t q_i^t$ is the value of commodity *i* in period *t* at current prices and $p_i^{t-1} q_i^t$ is the value at prices of the previous period (or, at so-called constant prices). The time periods are calendar years. In the case of labour inputs such values are called (labour) compensation, and in the case of capital inputs one speaks of user cost.

270 See, for instance, Jorgenson, Ho and Stiroh (2005), e.g. p. 37.

Assuming that quantities in year t-1 are non-zero, expression (1) can be rewritten as

$$Q_L^t = \frac{\sum_i p_i^{t-1} q_i^t}{\sum_i p_i^{t-1} q_i^{t-1}} = \frac{\sum_i p_i^{t-1} q_i^{t-1} \frac{q_i^t}{q_i^{t-1}}}{\sum_i p_i^{t-1} q_i^{t-1}} = \sum_i \frac{p_i^{t-1} q_i^{t-1}}{\sum_i p_i^{t-1} q_i^{t-1}} \frac{q_i^t}{q_i^{t-1}} \equiv \sum_i s_i^{t-1} \frac{q_i^t}{q_i^{t-1}} \qquad (2)$$

where s_i^{t-1} is the share of commodity i in the total value in year t-1. Though this is the operational form of the Laspeyres index that is generally used, it appears that the set-up of the supply and use tables makes it easier to work directly with expression (1). This form has also distinct advantages when it comes to (des-) aggregation.

Aggregation

Aggregation means that smaller production units are joined to larger units, for instance, enterprises to industry branches, or industry branches to sectors of the economy. Aggregation, however, is more than simple addition. In order that an aggregate of smaller units can be considered as a single big unit, all supply and use streams between the smaller units must be netted out. This netting-out is also called consolidation.

Aggregation has important consequences for productivity indices. This can be seen as follows. First, gross output of the big unit is less than the sum of the gross output of the smaller units, since all the mutual deliveries between the smaller units must be subtracted. Second, while the K and L input of the big unit is a simple sum of the K and L input of the small units (since K and L are unique to the units), the intermediate EMS consumption of the big unit is less than the sum of the EMS consumption of the small units. Since smaller input and/or output quantities imply nothing about the relative magnitude of quantity *changes*, it may safely be concluded that there is no simple relation between a gross-output based MFP index number of the big unit and the gross-output based MFP index numbers of the small units.

Consider now a value-added based MFP index. Value added of the big unit is a simple sum of value added of the smaller units, and K and L input of the big unit is a simple sum of K and L input of the small units. Put otherwise, by using the value added concept, the small units are considered to be disjunct; that is, relations of supply and use do not exist between them. This implies that there is a simple relation between the MFP index number of the big unit and those of the small units. In fact, MFP change (expressed as a percentage) of the big unit can be expressed as a weighted arithmetic average of MFP change of the small units.

As mentioned previously, Balk (2003b) showed that under the assumption that total cost is equal to gross output (so that there is no profit), for a fairly large class of index formulas, value-added based MFP change (expressed as a percentage) is larger than gross-output based MFP change, the factor of proportionality being given by the ratio of gross output to value added (the so-called Domar factor). It is not obvious what will happen when the assumption about the equality of cost and gross output is dropped. Some empirical evidence will be presented in the seventh chapter.

In any case, the higher the level of aggregation the lesser difference there will be between value added and gross output, and thus the lesser difference between the two MFP measures.

Capital inputs

Production usually requires capital assets (buildings, machinery, tools, etcetera). Apart from new investments, which can happen anytime during a bookkeeping period (year), such assets are available at the start of the period and, apart from wear and tear, still available at the end of the period. The user cost of capital is the cost of using these (private, owned) assets during a year. Using owned assets is, economically seen, like leasing those assets, and unit user costs should therefore be comparable to rental prices. The user cost of capital comprises three components:

1. The revaluation of the assets during the year. This revaluation is defined as the value of the assets at the beginning of the year less their value at the end of the year. Usually capital goods are subject to a reduction in value over time, but some assets, such as dwellings, might increase in value over time.
2. The imputed (opportunity) cost of the money that is tied up in the assets.
3. The sum of all taxes-less-subsidies that the government levies on owning certain assets.

For any industry and institutional sector, the end of period user cost for a certain quantity of assets of type[271] i and age[272] j, which is available at the start of the year, is calculated as

$$U_{i,j}^{*t} \equiv (1 + r^{t+,t-}) P_{i,j-0.5}^{t-} K_{i,j-0.5}^{t-} - P_{i,j+0.5}^{t+} K_{i,j+0.5}^{t+} + T_{K,i,j}^{t} \equiv U_{i,j}^{t} + T_{K,i,j}^{t} \qquad (3)$$

where:

t denotes the period $[t_-, t_+]$, $t_- = (t\text{-}1)_+$ and $t_+ = (t+1)_-$; hereafter t will also be used to indicate the midpoint of the period;

$r^{t+,t-}$ denotes a (nominal) interest rate over the period $[t_-, t_+]$;

$P_{i,j-0.5}^{t-}$ denotes the price of an asset of age j-0.5 at time t_-;

$K_{i,j-0.5}^{t-}$ denotes the quantity of assets of age j-0.5 at time t_-;

$T_{K,i,j}^{t}$ denotes the sum of taxes-less-subsidies on the assets of age j in year t;

$U_{i,j}^{t}$ denotes the user cost excluding taxes-less-subsidies on assets of age j in year t.

Usually, it is not possible to determine the taxes-less-subsidies at the level of individual assets. Though for some taxes, such as road tax, it is possible to attribute the tax to a specific asset type, generally taxes-less-subsidies are only known at the level of an industry, and not specified by asset type. In practice, taxes-less-subsidies must therefore added to the user cost at a higher aggregation level.

271 For the calculation of the user cost 60 industries, 18 institutional sectors and 20 assets are distinguished.

272 Since it is assumed that investments are made halfway a year, the age of an asset at the beginning or end of a year is always j ± 0.5 year.

The allocation of taxes-less-subsidies is addressed in a later section. In the remainder of this chapter, taxes-less-subsidies will be deleted from the user cost expression. Furthermore, the subscript *i* will be dropped to simplify the expressions. A detailed theoretical derivation of the user cost (apart from taxes-less-subsidies) is given by Balk and van den Bergen (2006). The same framework will be used here.

In the Dutch version of the Perpetual Inventory Method (PIM) it is assumed that trade in second-hand assets and other volume changes of capital occur between the end of a year and the start of the next year. The quantity of capital can therefore be assumed as constant during a year. This implies that expression (3) can be simplified to

$$U_j^t \equiv (1 + r^{t+,t-}) P_{j-0.5}^{t-} K_j^t - P_{j+0.5}^{t+} K_j^t \tag{4}$$

If the unit user cost is defined as

$$u_j^t \equiv \frac{U_j^t}{K_j^t} = (1 + r^{t+,t-}) P_{j-0.5}^{t-} - P_{j+0.5}^{t+} \tag{5}$$

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then the total user cost of period *t* at period *t* prices can be expressed as

$$U^t = \sum_{j=1}^{\infty} \frac{u_j^t}{P_{j-0.5}^t} \left[\frac{P_{j-0.5}^t}{P_{j-0.5}^{t-1}} P_{j-0.5}^{t-1} K_j^t \right] \tag{6}$$

The right-most term in this expression $P_{j-0.5}^{t-1} K_j^t$ is equal to the net capital stock as calculated by the Dutch PIM. Therefore, expression (6) links the user cost of capital directly to the PIM. The characteristics of the Dutch version of the PIM are described in detail by van den Bergen, de Haan, de Heij and Horsten (2005).

Two assumptions are now introduced. First, it is assumed that all asset price changes, other than those related to aging, are equal, irrespective the age *j* of the asset. Second, it is assumed that the price change over a half year is equal to the square root of the price change over a whole year. Together these assumptions imply that

$$\frac{P_{j-0.5}^{t-}}{P_{j-0.5}^t} \cong \frac{P_0^{t-}}{P_0^t} \cong \left(\frac{P_0^t}{P_0^{t-1}} \right)^{-1/2} \tag{6a}$$

$$\frac{P_{j-0.5}^{t+}}{P_{j-0.5}^t} \cong \frac{P_0^{t+}}{P_0^t} \cong \left(\frac{P_0^{t+1}}{P_0^t} \right)^{1/2} \tag{6b}$$

where P_0^t denotes the price of a new asset at time *t*. Next, we define

$$\frac{P_{j+0.5}^t}{P_{j-0.5}^t} \equiv (1 - \delta_{K,j}) \tag{6c}$$

where $\delta_{K,j}$ denotes the depreciation rate of assets already in use (as distinct from the rate of newly invested assets)[273]. Then the first term under the summation sign of expression (6) can be approximated by

$$\frac{u_j^t}{P_{j-0.5}^t} = (1 + r^{t+,t-})\frac{P_{j-0.5}^{t-}}{P_{j-0.5}^t} - \frac{P_{j+0.5}^{t+}}{P_{j+0.5}^t}\frac{P_{j+0.5}^t}{P_{j-0.5}^t} \cong (1 + r^{t+,t-})\left(\frac{P_0^t}{P_0^{t-1}}\right)^{-1/2} - \left(\frac{P_0^{t+1}}{P_0^t}\right)^{1/2}(1 - \delta_{K,j}) \qquad (7)$$

The depreciation rate, $\delta_{K,j}$, can be obtained directly from the PIM. The relation between this rate and consumption of fixed capital in the National Accounts is given by

$$\delta_{K,j} = \frac{CFC_{K,j}^t}{P_{j-0.5}^t K_j^t} \cong \left(\frac{P_0^t}{P_0^{t-1}}\right)^{-1}\frac{CFC_{K,j}^t}{P_{j-0.5}^{t-1} K_j^t} \qquad (8)$$

where $CFC_{K,j}^t$ denotes the consumption of assets already in use.
The user cost of period t+1 at prices of the previous period t is calculated as

$$U_{CP}^{t+1} \equiv \sum_{j=1}^{\infty} u_j^t K_j^{t+1} = \sum_{j=1}^{\infty} \frac{u_j^t}{P_{j-0.5}^t} P_{j-0.5}^t K_j^{t+1} \qquad (9)$$

The Laspeyres volume index for capital for period t+1 relative to period t is calculated as the ratio of expression (9) to (6). However, in order to execute this calculation, further assumptions with regard to the interest rate and the price indices have to be introduced.

Interest rate

With regard to the interest rate, which is also called rate of return, the first choice is between an exogenous and an endogenous rate. An endogenous rate is in accordance with the standard neoclassical model. This model is based on the twin assumptions of constant returns to scale and perfect competition. These assumptions imply that profit equals zero. All gross output revenue of an enterprise is used to reward the inputs in the production process. The whole operating surplus / mixed income must therefore be allocated to user cost of capital and labour income of self-employed. When labour income of self-employed persons is estimated exogenously, which is common practice, an endogenous interest rate is required to make the equation fit.

An exogenous rate however is chosen independently of the operating surplus. For example the average interest rate on the capital market could be used. Almost certainly an exogenous rate will lead to a difference between the user cost of capital and the operating surplus. Profit will therefore be non-zero.

Although the usefulness of the neoclassical model is generally recognized, its assumptions seem incompatible with economic reality, especially when there is rapid technological progress (and unbiased measurement of productivity change is more important than ever). To avoid making these assumptions, an exogenous interest rate will be employed.

273 For vessels and barges the depreciation rate is time-dependent, since the depreciation profile of older craft differs from the profile of younger craft. From a conceptual point of view, such an asset type should be split into two (or more) types.

Before an exogenous interest rate can be determined, it has to be determined whether the risk premium belongs in the interest rate or in FISIM. This risk premium is the money that a supplier of capital receives for bearing the risk that the lender defaults on his payments, usually when an enterprise goes bankrupt. There are two ways to interpret this risk premium. First, the premium can be seen as inherent in the lending of money, in which case it should be included in the interest rate. Alternatively, it can be seen as an extra service of the supplier, in which case it should be included in FISIM. A choice between these viewpoints has to be made to assign the risk premium to an input.

This choice however exists only for the banking industry. According to National Accounts standards, FISIM can only be produced by the banking industry. Capital suppliers outside the banking industry[274] produce no FISIM or related services. For these suppliers, the risk premium is therefore included in the interest rate. Since the risk premium should be treated equal for all capital suppliers, for the banking industry the risk premium should also be included in the interest rate and not in FISIM.

However, according to Eurostat regulations, FISIM is calculated as the difference between the paid (or received) interest rate and the internal reference rate (IRR) between banks. This means that, according to these regulations, only the risk premium for lending to a bank should be included in the IRR and therefore in the user cost. As a consequence, for capital borrowed from the banking industry, the difference in risk premium between the banking industry and other industries is included in FISIM. When the risk premium is included in the interest rate, therefore some double-counting is created.

Since the part of capital that is financed by borrowing from the banking industry is probably small, it was decided to accept this double-counting. The risk premium is included in the interest rate, and the National Accounts data on FISIM, which includes some risk premium, is included in the intermediate consumption.

The next question is whether the risk premium should vary across industries. The risk of defaulting varies indeed among industries. However, industries with a larger risk of defaulting[275] usually consist of larger enterprises, which have a smaller defaulting risk. This leads to two opposite effect. For enterprises of the same size, the default risk, and therefore the risk premium, may be smaller for industry A than for industry B. But the fact that the average enterprise in industry B is larger than the average enterprise in industry A should lower the default risk of industry B compared with industry A.

It is unlikely that both effects have the same, but opposite magnitude, so there remains some dispersion in the risk premium between industries. Unfortunately, data about these effects is hardly available. It is therefore not possible to quantify this dispersion. Therefore an industry independent risk premium, and interest rate, is used.

The nominal interest rate is based on the average interest rate that companies must pay on outstanding bonds. To get an estimate of this value, the bonds issued by investment funds are used. The funds use these bonds to invest in outstanding bonds of a wide variation of other companies. A lot of bonds offer an estimated return of 1 to 2 percent above the euribor

274 This includes using the company's own capital to buy assets.

275 These are usually the industries where large initial investments are required, or where expected benefits are either insecure or far into the future.

interest rate. Usually this rate is offered only when there are no defaults on the bonds in which the investment funds invest. When there are a lot of defaults, the return diminishes. This means that the risk premium is included in the offered return.

The average cost that investment funds charge for their services is about 1 percent of the deposit. That indicates that the average interest rate companies have to pay on their outstanding bonds is 2 to 3 percent above the euribor interest rate. Since the euribor interest rate did not exist prior to 1999, the interest rate is linked to the internal reference rate (IRR) between banks. In the period 1999 to 2005, the IRR was about 1 percent above the euribor interest rate. *The nominal interest rate is thus set at IRR plus 1.5 percent.* Table 18–1 shows for a number of years the nominal and the real interest rates.[276]

T 18–1 Interest rates
in percents

	1995	2000	2003	2004	2005	2006
Nominal interest rate	7.3	6.7	4.8	4.7	4.5	5.2
Consumer price index	2.1	4.1	1.7	1.5	2.2	2.3
Real interest rate	5.1	2.5	3.1	3.1	2.2	2.7

Price indices

The price ratios in expressions (6), (7) and (8) require price indices. Since the capital stock is revaluated with producer price indices (PPIs), these PPIs are also used for the calculation of the user costs. An exception is made for transfer costs which, according to a National Accounts convention, belong to the capital stock. Since transfer costs cannot be traded, it seems pointless to include holding gains or losses in user costs thereof. In this case CPIs instead of PPIs are used. With the current data and the current choice of the interest rate, this does not lead to negative user costs.

Summary of expressions

When the above described decisions with regard to the interest rate and price indices are applied, the user cost for all at the start of the year t existing assets, excluding taxes-less-subsidies, is calculated as

$$U^t \cong \sum_i \sum_{j=1}^{\infty} \frac{u_{i,j}^t}{P_{i,j-0.5}^t} \frac{PPI_i^t}{PPI_i^{t-1}} P_{i,j-0.5}^{t-1} K_{i,j}^t \tag{10}$$

$$\frac{u_{i,j}^t}{P_{i,j-0.5}^t} \cong (1+r^t)\left(\frac{PPI_i^t}{PPI_i^{t-1}}\right)^{-1/2} - \left(\frac{PPI_i^{t+1}}{PPI_i^t}\right)^{1/2} (1-\delta_{K,i,j}) \tag{11}$$

276 Real interest rate is defined as nominal interest rate deflated by a headline CPI.

$$\delta_{K,i,j} \cong \left(\frac{PPI_i^t}{PPI_i^{t-1}}\right)^{-1} \frac{CFC_{K,i,j}^t}{P_{i,j-0.5}^{t-1} K_{i,j}^t} \tag{12}$$

$$U_{CP}^{t+1} = \sum_i \sum_{j=1}^{\infty} \frac{u_{i,j}^t}{P_{i,j-0.5}^t} P_{i,j-0.5}^t K_{i,j}^{t+1} \tag{13}$$

For transfer cost, expression (11) is replaced by

$$\frac{u_{i,j}^t}{P_{i,j-0.5}^t} \cong (1+r^t)\left(\frac{PPI_i^t}{PPI_i^{t-1}}\right)^{-1/2} - \left(\frac{CPI^{t+1}}{CPI^{t-1}}\right)^{1/2} \left(\frac{PPI_i^t}{PPI_i^{t-1}}\right)^{-1/2} (1-\delta_{K,i,j}) \tag{14}$$

In expressions (11) and (14), r^t is the nominal interest rate in year *t*.

It is assumed that investments in second-hand assets from abroad and investments in new assets (domestically produced as well as imported) are made halfway a year. Thus, for these assets a different user cost expression must be used. The details of the derivation are provided by Balk and van den Bergen (2006). The user cost for all invested assets is calculated as[277] [278]

$$V^t = \sum_i \sum_{j=0}^{\infty} \frac{v_{i,j}^t}{P_{i,j}^t} P_{i,j}^t I_{i,j}^t \tag{15}$$

$$\frac{v_{i,j}^t}{P_{i,j}^t} \cong \sqrt{1+r^t} - \left(\frac{PPI_i^{t+1}}{PPI_i^t}\right)^{1/2} (1-\delta_{I,i,j}/2) \tag{16}$$

$$\delta_{I,i,j} = 2\frac{CFC_{I,i,j}^t}{P_{i,j}^t I_{i,j}^t} \tag{17}$$

$$V_{CP}^{t+1} \cong \sum_i \sum_{j=0}^{\infty} \frac{v_{i,j}^t}{P_{i,j}^t} \frac{PPI_i^t}{PPI_i^{t+1}} P_{i,j}^{t+1} I_{i,j}^{t+1} \tag{18}$$

For transfer cost, expression (16) is replaced by

$$\frac{v_{i,j}^t}{P_{i,j}^t} \cong \sqrt{1+r^t} - \left(\frac{CPI_i^{t+1}}{CPI_i^t}\right)^{1/2} (1-\delta_{I,i,j}/2) \tag{19}$$

277 In order to avoid confusion, user cost for invested assets is represented by the variable *v* instead of *u*.

278 Because figures are rounded off in the calculations of the net capital stock and consumption of fixed capital, $\delta_{K,i,j}$ and $\delta_{I,i,j}$ differ negligibly.

Finally, total user cost[279], including taxes-less-subsidies, at current prices and previous year prices respectively, is calculated as

$$U^{*t} = U^t + V^t + T^t \qquad (20)$$

$$U_{CP}^{*t+1} = U_{CP}^{t+1} + V_{CP}^{t+1} + T_{CP}^{t+1} \qquad (21)$$

where the subscript CP denotes that the variable is valued at the prices of the previous year. The tax component will be discussed in the fifth chapter.

Labour inputs

Production also requires labour. For any industry[280], labour cost is calculated as the sum of three components,

$$W^{*t} = W_E^t + W_S^t + T_L^t \equiv W^t + T_L^t \qquad (22)$$

where: W^{*t} denotes total labour cost;

W_E^t denotes compensation of employees;

W_S^t denotes labour income of self-employed persons;

T_L^t denotes the sum of taxes-less-subsidies on labour;

W^t denotes total labour cost excluding taxes-less-subsidies.

Thus, per industry two types of labour are distinguished. For each type, the unit of measurement is an hour worked.

Compensation of employees

The compensation of employees at current prices is directly available from the National Accounts. However, the same compensation at previous year prices cannot be used because the deflation in the National Accounts is not executed with volume indexes of hours worked. Following international recommendations (OECD 2001), compensation at previous year prices is calculated as

$$W_{E,CP}^{t+1} \equiv w_E^t L_E^{t+1} = w_E^t L_E^t \frac{L_E^{t+1}}{L_E^t} \equiv W_E^t \frac{L_E^{t+1}}{L_E^t} \qquad (23)$$

where w_E^t denotes the compensation per hour and L_E^t denotes the number of hours worked.

279 Non-produced assets (AN.2) and inventories (AN.12) are not included in the capital stock. Livestock for breeding, dairy, draught, etc. (AN.11141) is included but, because of data availability, slightly different formulas had to be used.

280 For the calculation of labour input of both employees and self-employed, 49 different industries are distinguished.

In order to retain a consistent set of supply and use tables, the National Accounts (in constant prices) should be balanced with this newly calculated compensation of employees at prices of the previous year. This can easily be accomplished by adjusting the operating surplus. In this way consistency is retained without changing any other input or output quantity.

Labour income of self-employed persons

Unlike compensation of employees, no explicit estimate of labour income of self-employed is provided in the National Accounts. Labour income of self-employed is, together with the user cost of capital and the profit of the sector households (S.14), part of mixed income.

When gross fixed capital formation, consumption of fixed capital and the capital stock are broken down into institutional sectors, it is possible to directly calculate the user cost of capital of S.14. However, it is not possible to measure directly either profit of S.14 or labour income of self-employed. Therefore, in order to break down mixed income, some assumption with regard to profit of S.14 or labour income of self-employed must be made. Two feasible assumptions are that self-employed have the same income per hour or per year as employees, or that there is no profit for S.14. The last assumption allows labour income of self-employed to be calculated endogenously.

For calculating the labour-income of self-employed endogenously, it is important that the estimates of mixed income, gross fixed capital formation, consumption of fixed capital and the capital stock of S.14 are reliable. Although estimates of these variables are available at Statistics Netherlands, they currently lack the quality required for the calculation of the labour income of self-employed. Thus we turn to exogenous estimation.

Although firm evidence is lacking, most data suggest that self-employed work more hours than employees without earning substantially more money. It is therefore assumed that self-employed have the same labour income per year as employees.

There are a few exceptions to this assumption. In some medical sectors, for instance in the case of dentists and general practitioners, the self-employed generally have a university degree, whereas the employees mostly have a lower educational level. Since educational level is generally positively correlated with earnings, it is expected that in these sectors self-employed have a higher income than employees. Therefore, for the year 2003, in these sectors labour income of self-employed is set at a so-called standard income[281] of these professions. It is further assumed that the development of labour income of the self-employed equals the development of wages of employees in these sectors.

For some professions, e.g. lawyers, accountants and architects, which are included in the financial and business activities branch, it is also expected that self-employed have a higher income than employees. However, there is no data available with regard to some standard income of these professions. It is therefore assumed that these self-employed have the same income per year as employees.[282]

281 This is a rough estimate used to inform medical students about their expected future salaries.

282 When labour is broken down by education, this problem may cease to exist. The expectation that self-employed have a higher income than employees is primarily based on the difference in education between self-employed and employees. It is expected that self-employed in this industry earn the same income as employees with the same education.

From 2001 on, data on compensation of employees and numbers of full-time equivalent jobs (fte) of employees and self-employed is available for 260 industries. For earlier years, however, numbers of fte's are only available at a higher aggregation level (120 industries). Since the proportion of self-employed (in fte's) differs per industry, imputing the same yearly income for self-employed as employees at a higher aggregation level leads to different results than when imputation is done at a lower aggregation level. For this reason, the average ratio α between the labour income of self-employed per fte and the compensation of employees per fte is calculated for the period 2001–2003 and it is assumed that this ratio is constant over time. For the years before 2001, the labour income of self-employed can then be calculated as

$$W_S^t = \alpha W_E^t \frac{LY_S^t}{LY_E^t} = \alpha \frac{W_E^t}{LY_E^t} LY_S^t \tag{24}$$

where LY^t denotes fte's. The labour income of self-employed at prices of the previous year is then calculated by multiplying the hours worked in the current year with the labour income of employees per hour worked in the previous year; that is

$$W_{S,CP}^{t+1} \equiv w_S^t L_S^{t+1} = w_S^t L_S^t \frac{L_S^{t+1}}{L_S^t} \equiv W_S^t \frac{L_S^{t+1}}{L_S^t} \tag{25}$$

Summary of expressions

Per industry, total labour cost is, at current prices, calculated as

$$W^{*t} = W_E^t + W_S^t + T_L^t \tag{26}$$

and, at previous year prices, as

$$W_{CP}^{*t+1} = W_{E,CP}^{t+1} + W_{S,CP}^{t+1} + T_{L,CP}^{t+1} \tag{27}$$

Again, the tax component will be discussed in the next chapter.

Other inputs and output

Gross output, value added and intermediate consumption (with its E, M, and S components) are estimated in the context of the National Accounts. Production surveys, foreign trade statistics, and surveys on consumption and investments are the most important data-sources. Our National Accounts database consists of data for very detailed product groups, which are further subdivided to origin and destination, and which have different valuation layers. From this database, supply and use tables and input-output tables can be derived. Approximately 120 industries and 275 product groups are distinguished. This level of detail is sufficient for measuring productivity change as described in the foregoing. With respect to constant price estimation, a combination of (chained) Paasche price index numbers and Laspeyres volume index numbers is used. The price statistics for production, international trade and private consumption of households are the main sources for the deflators.

Although both value added and gross output (in current prices and prices of the previous year) can be directly derived from the National Accounts, gross output must be consolidated before it can be used for the gross output productivity measures.

The cost components of intermediate consumption can also be derived from the National Accounts. The intermediate consumption that is used for the productivity measures is calculated as the intermediate consumption at basic prices plus the sum of taxes-less-subsidies on products. In contrast with the National Accounts, for productivity measurement trade and transport margins are not attributed to the products on which they are imposed, but they are recorded as a service. This way, energy, materials and services are separated properly. In addition, intermediate consumption must also be consolidated.

Three problems remain to be solved: 1) the consolidation of output and intermediate consumption, 2) the allocation of taxes-less-subsidies on production to the various inputs, and 3) the output of non-market producers. These problems will be addressed in the next sections.

Consolidation

The most detailed National Accounts supply-use database has the following three dimensions: industry of supply × industry of demand × product group. Thus, generally, the amounts of intra-industry deliveries can be determined directly for each product group. Trade and transport margins constitute the only exception to this rule. This is caused by the fact that these margins are registered as so-called valuation layers. They are recorded as part of the purchase value of product groups on which these margins are imposed. As a consequence, in the National Accounts' database, the producer of the product on which the margins are imposed instead of the producer of the margins is registered as the origin of the margins. This implies that the intra-industry deliveries of margins cannot be identified since the original producers of these margins are not identifiable.

As a result a certain assumption must be made about the production of those margins. Since a sensitivity analysis has shown that varying the assumptions has little impact on the final productivity numbers, a relatively simple method can be chosen. For the consolidation of margins, it is assumed that the distribution of margins over the producers is the same for all the consumers of margins.

The value of margin type *m* produced by *k* and consumed by user *l* is calculated as[283]

$$M_{k,l,m}^{t} = \frac{M_{k,\cdot,m}^{t}}{\sum_{k} M_{k,\cdot,m}^{t}} M_{\cdot,l,m}^{t} \qquad (27a)$$

where $M_{k,\cdot,m}^{t}$ is the production of margin *m* in year *t* by producer *k* (whereby imports are considered as a "producer");

$M_{\cdot,l,m}^{t}$ is the consumption of margin *m* in year *t* by user *l*.
Data on production and consumption of margins are taken from the input-output table.

283 Three different kinds of margins are distinguished: wholesale trade margins, retail trade margins and transport margins.

The intra-industry deliveries are subsequently determined as those margins that are consumed by the same industry that produces the margins. These intra-industry deliveries of margins, together with the intra-industry deliveries as determined from the supply-use database, constitute the total intra-industry deliveries in current prices.

In principle, the intra-industry deliveries in prices of the previous year could be determined in a similar way. Unfortunately, due to balancing problems, the price index numbers in the most detailed supply-use database are of insufficient quality for this purpose. Only after aggregating over either users or producers the price index numbers become sufficiently reliable. Thus, intra-industry deliveries in current prices of a certain product group are deflated with the price index of the total consumption of that product group by the industry, to obtain the intra-industry deliveries in prices of the previous year.

All the intra-industry deliveries, both in current prices and in prices of the previous year, are excluded from gross output and intermediate consumption to obtain sectoral output and intermediate input.[284]

Taxes-less-subsidies

Productivity measurement requires output to be valued at basic prices; that is, the prices actually obtained by producers. At the same time, input must be valued at purchasers' prices.

Taxes-less-subsidies on *products* are already included in the costs of the intermediate consumption components. Taxes-less-subsidies on *production* (according to the National Accounts classification), at current prices as well as at prices of the previous year, can be obtained directly from the National Accounts. As far as sensible, the components of this expenditure category should be attributed to the various inputs.

Some of these taxes-less-subsidies can directly be attributed to a specific input. Wage subsidies can be attributed to labour, and road taxes as well as property taxes to capital. Other taxes-less-subsidies, like sewage charges and PBO-levies, cannot be attributed to some single category of inputs. Such taxes-less-subsidies on production could somehow be distributed over all the input categories. A practical difficulty, however, is the fact that it is not always possible to separate the taxes-less-subsidies that can be attributed to capital from the remaining taxes-less-subsidies. A pragmatic solution is to attribute all taxes-less-subsidies on production to capital, with the exception of wage subsidies, which are of course attributed to labour.[285]

Finally, tax deductions should be taken into account in the user cost of capital. In the Netherlands, some costs of capital, e.g. interest paid on mortgages, can be deducted from pre-tax income. In effect therefore, the use of such capital goods is subsidized. For the time being, however, such tax deductions will not be taken into account.

284 Since this method of deflating the intra-industry deliveries leads to different intra-industry deliveries in prices of the previous year than may be derived directly from the supply-use database, this procedure leads to (usually small) deviations from the official input-output table in prices of the previous year.

285 We are here following Statistics Canada (2001).

Non-market production

According to the SNA 93, the revenue of non-market producers is defined as the total cost incurred in the production process, the components being intermediate consumption, labour, taxes-less-subsidies, and the consumption of fixed capital (depreciation). Thus, with respect to the user cost of capital SNA 93 implicitly prescribes that the interest rate must be set equal to zero and the non-depreciation part of revaluation must be excluded. This creates an inconsistency in our system, since, as explained in the third section, user cost of capital includes more components than depreciation.

There are several options to resolve the inconsistency. The first is to attribute the full user cost to non-market producers and retain the revenue = cost identity.[286] But this would lead to output value figures that deviate from those in the official National Accounts, which is considered undesirable. It was therefore decided to retain the National Accounts output data for non-market producers.

The polar opposite option is to retain the revenue = cost identity but calculate the user cost of capital for non-market producers according to the implicit SNA 93 prescriptions. In the interest of productivity statistics it is, however, considered important to have for all producers user cost estimates which are calculated in a uniform way.

The third option, which is the option actually chosen, is therefore to drop the revenue = cost identity. At the output side, National Accounts data are used, whereas at the input side the user cost of capital for non-market producers is calculated in the same way as for market producers. The impact of the inconsistency is small since the productivity statistics are restricted to industries which are typically dominated by market producers.

Summary of expressions

Per industry or aggregate of industries, the Laspeyres volume index of the combined KLEMS inputs is calculated as

$$Q^{t+1}_{L,KLEMS} = \frac{U^{*t+1}_{CP} + W^{*t+1}_{CP} + EMS^{*t+1}_{CP}}{U^{*t} + W^{*t} + EMS^{*t}} \tag{28}$$

where

U^{*t} denotes the user cost of capital in year *t*, as given by expression (20);

U^{*t+1}_{CP} denotes the user cost of capital in year *t*+1 valued at prices of year *t*, as given by expression (21);

W^{*t} denotes the labour cost in year *t*, as given by expression (26); W^{*t+1}_{CP} denotes the labour cost in year *t*+1 valued at prices of year *t*, as given by expression (27);

EMS^{*t} denotes the (consolidated) value of energy, materials and services in year *t*;

286 The Advisory Expert Group on National Accounts suggested this to the Statistical Commission (see Inter-Secretariat Working Group on National Accounts (ISWGNA) (2007)), but this was rejected.

EMS_{CP}^{*t+1} denotes the (consolidated) value of energy, materials and services in year t+1 valued at prices of year t.
The Laspeyres volume index of the combined capital and labour inputs is calculated as

$$Q_{L,KL}^{t+1} = \frac{U_{CP}^{*t+1} + W_{CP}^{*t+1}}{U^{*t} + W^{*t}} \tag{29}$$

Since the values of the input components are calculated independently from the value of output, total cost need not be equal to revenue. A new balancing item is created, called net profit. It is defined as

$$NP^t = R^t - U^{*t} - W^{*t} - EMS^{*t} \tag{30}$$

where R^t denotes the value of (consolidated) output (revenue) in year t. Net profit in prices of the previous year is defined as

$$NP_{CP}^t = R_{CP}^t - U_{CP}^{*t} - W_{CP}^{*t} - EMS_{CP}^{*t} \tag{31}$$

Results and sensitivity analyses

The method described in the previous chapters is used to estimate the official MFP figures for the Netherlands. It will henceforth be called the official method. According to this method gross-output based MFP change and value-added based MFP change are computed for the period 1995–2006. Next, the calculations are repeated using alternative assumptions with regard to the volume index formula, the user cost of capital, and the labour income of self-employed. The productivity changes following from these alternative methods are compared with the results of the official method.

Calculations have been performed at three different levels of aggregation: 36 industries, 9 industries and the commercial sector. The commercial sector is defined as the set of all industries for which consistent and independent measures of input and output exist. In practice, this means that the commercial sector contains the whole economy except general government, defence, subsidized education, real estate activities, renting of movables, and private households with employed persons.[287]

For the sake of readability, the results for the aggregation level of 36 industries are not presented in this paper but available at request.

In Tables 18–2 and 18–3, the gross-output based and value-added based MFP change as calculated with the official method are presented. The average (1996/2006) gross-output based MFP change for the commercial sector turns out to be 0.88 percent, and the average value-added based MFP change 1.35 percent.

287 The name ‘commercial sector’ must not be taken too literal. Real estate activities, renting of movables, and private households with employed persons contain activities which are at least partially commercial. On the other hand, industries like research and development services, and sewage and refuse disposal contain non-market (and thus non-commercial) activities.

T 18 – 2 Gross output based MFP change using the official method

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	1.0	0.5	2.7	0.5	0.8
Mining and quarrying	-3.3	0.3	-1.7	7.3	-6.5	-2.8
Manufacturing	0.8	0.7	0.7	1.9	0.7	0.7
Electricity, gas and water supply	-0.1	1.5	0.7	0.8	1.1	0.4
Construction	-0.3	-0.2	-0.2	0.2	1.0	0.6
Trade, hotels, restaurants and repair	2.0	0.9	1.6	1.8	1.8	2.9
Transport, storage and communication	2.0	1.8	1.9	2.1	2.2	1.5
Financial and business activities[1]	-0.4	0.9	0.2	3.0	1.1	0.1
Care and other service activities[2]	-0.3	-0.3	-0.3	0.1	-0.2	-0.0
Commercial sector	0.80	0.91	0.88	2.46	1.16	1.14

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18 – 3 Value added based MFP change using the official method

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.3	2.1	0.9	5.3	1.0	1.3
Mining and quarrying	-3.5	0.5	-1.7	10.2	-8.4	-3.0
Manufacturing	2.7	2.1	2.4	6.1	2.6	2.8
Electricity, gas and water supply	-0.4	4.6	2.0	2.8	3.3	1.7
Construction	-0.6	-0.5	-0.3	0.5	2.1	1.4
Trade, hotels, restaurants and repair	3.7	1.5	2.8	3.2	3.4	5.3
Transport, storage and communication	3.8	3.6	3.7	4.1	4.4	3.3
Financial and business activities[1]	-0.5	1.3	0.4	4.5	1.7	0.1
Care and other service activities[2]	-0.4	-0.4	-0.4	0.1	-0.3	-0.0
Commercial sector	1.27	1.35	1.35	3.69	1.80	1.79

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

Paasche volume index

In the official method, Laspeyres volume indices are used, together with Paasche price indices. In order to judge the sensitivity of the outcomes with respect to the index formulas used, MFP change is also calculated with Paasche volume indices and Laspeyres price indices. Generically, the Paasche volume index is given by

$$Q_P^t \equiv \frac{\sum_i p_i^t q_i^t}{\sum_i p_i^t q_i^{t-1}} \tag{32}$$

This expression can be rewritten as

$$Q_P^t \equiv \frac{\sum_i (p_i^t / p_i^{t-1}) p_i^{t-1} q_i^t}{\sum_i (p_i^t / p_i^{t-1}) p_i^{t-1} q_i^{t-1}} \qquad (33)$$

from which it becomes clear, by comparison to expression (1), that such an index requires the same building blocks as the Laspeyres volume index. But additionally, price relatives p_i^t / p_i^{t-1} are required. Here we encounter a problem.

As already mentioned, the price index numbers at the most detailed level of the supply-use database are of insufficient quality. Thus the Paasche volume index computations must start at a higher aggregation level. For gross output this is 118 producers and 207 commodities, whereas for intermediate consumption this is 118 users and 207 commodities.

The resulting gross-output based MFP and value-added based MFP change are presented in tables 18–4 and 18–5. For most industries, using a Paasche volume index leads to higher average MFP change. For the commercial sector, average gross-output based MFP is 0.03 percentage points higher, while value-added based MFP is 0.05 percentage points higher. From 2004 on however, using a Paasche volume index leads to lower MFP change.

The biggest differences in average gross-output based MFP occur in financial and business activities and in care and other service activities. In these industries, average gross-output based MFP is 0.13 percentage points higher. For individual years, the biggest differences are found in agriculture, forestry and fishing and in mining and quarrying. In these industries, differences are up to 0.8 percentage point. In the other industries, the maximum difference is 0.3 percentage point. For value-added based MFP, next to agriculture, forestry and fishing and mining and quarrying there are also large differences in electricity, gas and water supply. For individual years, the maximum differences in these three industries are between 1 and 1.4 percentage point.

T 18 – 4 Gross output based MFP change using a Paasche volume index
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	0.9	0.4	2.2	0.4	0.5
Mining and quarrying	-3.5	0.3	-1.7	7.1	-6.9	-2.9
Manufacturing	0.9	0.7	0.8	2.0	0.7	0.7
Electricity, gas and water supply	0.0	1.6	0.8	1.0	1.2	0.3
Construction	-0.2	-0.1	-0.1	0.3	1.0	0.6
Trade, hotels, restaurants and repair	2.1	0.9	1.6	1.9	1.9	2.9
Transport, storage and communication	2.0	1.9	1.9	2.2	2.2	1.6
Financial and business activities[1]	-0.2	0.9	0.3	2.9	0.9	0.1
Care and other service activities[2]	-0.1	-0.1	-0.1	0.2	-0.0	0.1
Commercial sector	0.88	0.92	0.92	2.40	1.05	1.08

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18 – 5 Value added based MFP change using a Paasche volume index
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.5	1.8	0.7	4.6	1.0	0.9
Mining and quarrying	-3.2	0.6	-1.5	10.1	-8.4	-3.0
Manufacturing	3.0	2.3	2.7	6.4	2.7	2.8
Electricity, gas and water supply	0.1	4.8	2.3	3.0	3.9	1.6
Construction	-0.4	-0.3	-0.2	0.7	2.2	1.5
Trade, hotels, restaurants and repair	3.8	1.7	3.0	3.3	3.5	5.3
Transport, storage and communication	3.8	3.7	3.7	4.3	4.5	3.3
Financial and business activities[1]	-0.2	1.4	0.5	4.4	1.5	0.1
Care and other service activities[2]	-0.2	-0.2	-0.2	0.2	-0.1	0.1
Commercial sector	1.38	1.37	1.41	3.62	1.67	1.71

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

Fisher volume index

In addition to productivity calculations with a Laspeyres and a Paasche volume index, one can construct a productivity index with a Fisher volume index. This index is, in one-step form, given by

$$Q_F^t \equiv \left(Q_L^t Q_P^t\right)^{1/2} = \left(\frac{\sum_i p_i^{t-1} q_i^t}{\sum_i p_i^{t-1} q_i^{t-1}} \frac{\sum_i p_i^t q_i^t}{\sum_i p_i^t q_i^{t-1}} \right)^{1/2} \qquad (34)$$

Results are presented in tables 18–6 and 18–7. As expected, differences between the Fisher index and the Laspeyres index are about half the differences between the Paasche index and the Laspeyres index. For the commercial sector, the average difference in gross-output based MFP is 0.02 percentage point, while the difference in value-added based MFP is 0.03 percentage point.

Other labour income for self-employed

In the official method, it is assumed that the annual labour income of self-employed is equal to the annual labour income of employees. In the literature, for example the OECD manual Measuring Productivity (2001), it is often advised to assume that self-employed have the same *hourly* labour income as employees. Therefore, MFP changes are recalculated under the last assumption.

To calculate the labour income of self-employed under this assumption an approach similar to the official method is employed. Like the full-time equivalent jobs, from 2001 on, hours worked are available for 260 different industries, whereas for other years hours worked are only available at a higher aggregation level (49 industries). At this higher aggregation level, the average ratio β between the labour income of self-employed per hour and the compensation of employees per hour is calculated for the period 2001–2003. It is next assumed that this ratio is constant over time. For the years before 2001 the labour income of self-employed is then calculated as

T 18 – 6 Gross output based MFP change using a Fisher volume index
in percent

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	1.0	0.4	2.4	0.5	0.6
Mining and quarrying	-3.4	0.3	-1.7	7.2	-6.7	-2.9
Manufacturing	0.9	0.7	0.8	1.9	0.7	0.7
Electricity, gas and water supply	-0.1	1.6	0.7	0.9	1.2	0.4
Construction	-0.3	-0.2	-0.1	0.2	1.0	0.6
Trade, hotels, restaurants and repair	2.0	0.9	1.6	1.9	1.9	2.9
Transport, storage and communication	2.0	1.8	1.9	2.1	2.2	1.5
Financial and business activities[1]	-0.3	0.9	0.3	3.0	1.0	0.1
Care and other service activities[2]	-0.2	-0.2	-0.2	0.1	-0.1	0.0
Commercial sector	0.84	0.91	0.90	2.43	1.11	1.11

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18 – 7 Value added based MFP change using a Fisher volume index
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.4	1.9	0.8	4.9	1.0	1.1
Mining and quarrying	-3.4	0.5	-1.6	10.1	-8.4	-3.0
Manufacturing	2.9	2.2	2.6	6.2	2.6	2.8
Electricity, gas and water supply	-0.2	4.7	2.2	2.9	3.6	1.6
Construction	-0.5	-0.4	-0.3	0.6	2.2	1.5
Trade, hotels, restaurants and repair	3.8	1.6	2.9	3.3	3.5	5.3
Transport, storage and communication	3.8	3.6	3.7	4.2	4.5	3.3
Financial and business activities[1]	-0.4	1.3	0.5	4.4	1.6	0.1
Care and other service activities[2]	-0.3	-0.3	-0.3	0.2	-0.2	0.1
Commercial sector	1.33	1.36	1.38	3.66	1.73	1.75

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

$$W_S^t = W_E^t \beta \frac{L_S^t}{L_E^t} = \beta \frac{W_E^t}{L_E^t} L_S^t \qquad (35)$$

The labour income of self-employed valued at prices of the previous year is, in line with the official method, calculated according to expression (25).

In tables 18–8 and 18–9, the resulting gross-output based MFP changes and value-added based MFP changes are presented. In all industries except construction, the average MFP change is higher than the results of the official method. Agriculture, forestry and fishing, construction and trade, hotels, restaurants and repair are the only industries showing a difference of more than 0.1 of a percentage point in average gross-output based MFP change. The average difference in construction is -0.35 percentage point. This difference is caused by a large shift in labour from employees to self-employed in recent years.

At the level of the commercial sector, average gross-output based MFP change increases with 0.05 percentage points, whereas the average value-added based MFP change increases with 0.06 percentage points. In contrast with these average increases, the MFP change (both gross-output based and value-added based) shows a small decrease in 1996, 2004, 2005 and 2006 as compared to the results of the official method.

T 18 – 8 Gross output based MFP change when giving self-employed the same hourly labour compensation as employees
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	1.3	0.6	3.0	0.6	1.0
Mining and quarrying	-3.3	0.3	-1.7	7.3	-6.5	-2.8
Manufacturing	0.8	0.7	0.8	1.9	0.7	0.7
Electricity, gas and water supply	-0.1	1.5	0.7	0.8	1.1	0.4
Construction	-0.4	-0.4	-0.3	-0.1	0.6	0.2
Trade, hotels, restaurants and repair	2.3	0.9	1.7	1.8	1.8	2.9
Transport, storage and communication	2.1	1.8	1.9	2.1	2.2	1.5
Financial and business activities[1]	-0.3	0.9	0.3	2.9	1.1	0.0
Care and other service activities[2]	-0.3	-0.2	-0.2	0.1	-0.1	0.1
Commercial sector	0.90	0.94	0.94	2.44	1.12	1.11

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18 – 9 Value added based MFP change when giving self-employed the same hourly labour compensation as employees
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.4	2.5	1.1	5.8	1.2	1.4
Mining and quarrying	-3.5	0.5	-1.7	10.2	-8.4	-3.1
Manufacturing	2.7	2.1	2.4	6.0	2.6	2.7
Electricity, gas and water supply	-0.4	4.6	2.0	2.8	3.3	1.7
Construction	-0.8	-0.8	-0.7	-0.1	1.2	0.4
Trade, hotels, restaurants and repair	4.1	1.6	3.1	3.1	3.3	5.3
Transport, storage and communication	4.0	3.6	3.7	4.1	4.4	3.2
Financial and business activities[1]	-0.4	1.3	0.4	4.4	1.6	0.0
Care and other service activities[2]	-0.4	-0.3	-0.3	0.2	-0.1	0.1
Commercial sector	1.38	1.39	1.42	3.64	1.72	1.72

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

No holding gains and losses

In the official method, holding gains and losses are included in the user cost of all assets except transfer of ownership. Alternative calculations of MFP change are made under the assumption that holding gains and losses are excluded from the user cost. Results are presented in tables 18–10 and 18–11.

When holding gains and losses are excluded, the MFP change increases relatively much in comparison to the official method. For the commercial sector, the average gross-output based MFP change increases with 0.10 percentage points and the average value-added based MFP change increases with 0.16 percentage points.

The difference with the official method is the largest in the period 1997–1999. Since then, the difference is steadily declining. In 2005 and 2006, the differences in gross-output based MFP change are reduced to about 0.02 percentage points. The industry where the differences in the average gross-output based MFP change are the largest is financial and business activities, but even in this industry the differences in 2005 and 2006 are only 0.05 percentage points.

T 18–10 Gross output based MFP change when holding gains are excluded from the user cost
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	0.1	1.0	0.5	2.7	0.5	-0.1
Mining and quarrying	-3.3	0.2	-1.7	7.3	-6.5	-2.9
Manufacturing	0.9	0.7	0.8	1.9	0.7	0.6
Electricity, gas and water supply	-0.0	1.5	0.7	0.8	1.1	0.1
Construction	-0.2	-0.2	-0.1	0.2	1.0	0.5
Trade, hotels, restaurants and repair	2.1	0.9	1.6	1.8	1.9	2.7
Transport, storage and communication	2.1	1.8	1.9	2.1	2.2	1.3
Financial and business activities[1]	-0.2	1.0	0.4	3.0	1.1	-0.2
Care and other service activities[2]	-0.2	-0.2	-0.2	0.1	-0.2	0.1
Commercial sector	0.96	0.97	0.98	2.49	1.18	1.17

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

Other exogenous interest rate

In the official method the interest rate is based on the internal reference rate between banks. This rate varies through time. The implied real interest rate varies also through time, as table 18–1 shows. The question now is: what happens to MFP change when the real interest rate is fixed? We considered two cases, 4 and 10 percent respectively.

In tables 18–12 and 18–13, the results for a real interest rate of 4 percent are presented. The differences in MFP change as compared to the official method are very small. For most years and most industries, the differences in either gross-output based or value-added based

T 18–11 Value added based MFP change when holding gains are excluded from the user cost

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	0.3	2.0	1.1	5.4	1.0	0.2
Mining and quarrying	-3.4	0.5	-1.4	10.2	-8.4	-1.2
Manufacturing	2.9	2.2	2.6	6.2	2.7	3.1
Electricity, gas and water supply	-0.2	4.7	2.2	2.9	3.3	2.3
Construction	-0.4	-0.4	-0.3	0.5	2.1	1.2
Trade, hotels, restaurants and repair	3.9	1.6	3.0	3.2	3.4	5.1
Transport, storage and communication	4.0	3.6	3.8	4.2	4.4	3.8
Financial and business activities[1]	-0.1	1.5	0.6	4.6	1.8	-0.4
Care and other service activities[2]	-0.3	-0.3	-0.3	0.1	-0.2	0.1
Commercial sector	1.53	1.44	1.51	3.75	1.83	1.83

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

MFP change are smaller than 0.1 percentage point. For the market sector, differences are even smaller. The differences are negligible in all years except 2006. In this year, gross-output based MFP change is 0.05 percentage point higher and value-added based MFP change is 0.06 percentage point higher.

T 18–12 Gross output based MFP change when the real interest rate is set at 4 percent

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.1	1.0	0.5	2.7	0.5	0.7
Mining and quarrying	-3.3	0.3	-1.6	7.4	-6.5	-2.8
Manufacturing	0.8	0.7	0.7	1.9	0.7	0.8
Electricity, gas and water supply	-0.1	1.6	0.7	0.9	1.2	0.5
Construction	-0.3	-0.2	-0.2	0.2	1.0	0.6
Trade, hotels, restaurants and repair	2.0	0.9	1.6	1.8	1.9	2.9
Transport, storage and communication	2.0	1.8	1.9	2.1	2.2	1.6
Financial and business activities[1]	-0.4	0.9	0.2	3.0	1.1	0.2
Care and other service activities[2]	-0.3	-0.3	-0.3	0.0	-0.2	-0.0
Commercial sector	0.81	0.91	0.89	2.46	1.17	1.20

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18–13 Value added based MFP change when setting the real interest rate at 4 percent

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	2.0	0.9	5.3	1.0	1.1
Mining and quarrying	-3.5	0.5	-1.7	10.2	-8.4	-3.1
Manufacturing	2.7	2.1	2.4	6.1	2.6	2.8
Electricity, gas and water supply	-0.4	4.6	2.1	2.8	3.2	1.7
Construction	-0.6	-0.5	-0.4	0.5	2.1	1.5
Trade, hotels, restaurants and repair	3.7	1.5	2.8	3.2	3.4	5.3
Transport, storage and communication	3.8	3.5	3.6	4.1	4.4	3.2
Financial and business activities[1]	-0.5	1.3	0.4	4.5	1.7	0.2
Care and other service activities[2]	-0.4	-0.4	-0.4	0.0	-0.3	-0.0
Commercial sector	1.27	1.34	1.36	3.68	1.80	1.86

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

In tables 18–14 and 18–15, the results for a real interest rate of 10 percent are presented. As expected, differences are larger. For the commercial sector, on average gross-output based MFP change is 0.06 percentage point higher than in the official method, whereas value-added based MFP change is on average 0.03 percentage point higher. In 2006, differences in both gross-output based MFP change and value-added based MFP change are over 0.2 percentage points.

T 18–14 Gross output based MFP change when the real interest rate is set at 10 percent

in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.0	0.9	0.4	2.8	0.4	0.6
Mining and quarrying	-2.9	0.4	-1.4	7.6	-6.5	-2.7
Manufacturing	0.9	0.6	0.8	2.0	0.8	0.9
Electricity, gas and water supply	0.0	1.8	0.9	1.2	1.2	0.7
Construction	-0.3	-0.2	-0.2	0.1	1.0	0.7
Trade, hotels, restaurants and repair	2.0	0.8	1.6	1.9	1.9	3.0
Transport, storage and communication	2.2	1.7	1.9	2.2	2.3	1.7
Financial and business activities[1]	-0.3	1.0	0.3	3.1	1.3	0.4
Care and other service activities[2]	-0.3	-0.2	-0.2	-0.1	-0.3	-0.1
Commercial sector	0.90	0.90	0.94	2.50	1.25	1.36

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18–15 Value added based MFP change when setting the real interest rate at 10 percent
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.0	1.7	0.8	5.3	0.9	0.7
Mining and quarrying	-3.4	0.6	-1.6	10.3	-8.4	-3.1
Manufacturing	2.5	1.8	2.2	5.8	2.3	2.7
Electricity, gas and water supply	-0.6	4.7	2.0	2.6	3.1	1.8
Construction	-0.7	-0.5	-0.4	0.4	2.2	1.6
Trade, hotels, restaurants and repair	3.7	1.4	2.8	3.2	3.4	5.4
Transport, storage and communication	3.8	3.3	3.5	4.0	4.2	3.2
Financial and business activities[1]	-0.5	1.4	0.5	4.6	2.0	0.6
Care and other service activities[2]	-0.4	-0.3	-0.4	-0.1	-0.4	-0.1
Commercial sector	1.32	1.31	1.38	3.63	1.85	2.04

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

For agriculture, forestry and fishing, the 1997 and 1998 value-added based MFP change differences are +2.1 and –2.7 percentage point respectively. This can be related to the occurrence of swine fever. In 1997, this led to large-scale “destructions” of pigs, and therefore to high user cost. When the real interest rate is fixed at 10 percent, these once-only cost become a smaller part of total cost, leading to a smaller change in the volume index of the input, and thus to less extreme MFP changes.

Endogenous interest rates

MFP changes are also calculated by using endogenous interest rates. An endogenous interest rate for each industry and year is determined under the condition that

$$U^{*t} + W^{*t} = VA^t \tag{36}$$

where U^{*t} is given by expression (20), W^{*t} by expression (22), and VA^t is value added of year t. Solving r^t from equation (36) gives the so-called endogenous interest rate, and deflating by a headline CPI gives the real rates.

Two different scenarios have been studied. In the first scenario, it is assumed that self-employed persons receive the same *annual* labour income as employees, whereas in the second scenario it is assumed that self-employed persons receive the same *hourly* labour income as employees.

In tables 18–16 and 18–17, the resulting real interest rates are presented. Some of the rates, especially in table 18–16, seem extremely high. For mining and quarrying, wholesale trade and to a lesser extent for trade and repair of motor vehicles/cycles, a plausible explanation for this is the incompleteness of the capital inputs. Natural resources and inventories are still excluded from the capital inputs, and since they are very important in these industries, this exclusion leads to excessively high endogenous interest rates. For some other industries, like construction and computer and related activities, at the end of the nineties, self-employed may have had a higher hourly labour income than employees. The excessive interest rates are in these cases probably caused by an underestimation of labour income of self-employed.

T 18–16 Endogenous real interest rates, using for self-employed the same yearly labour compensation as for employees

in percents

	1995	2000	2003	2004	2005	2006
Agriculture, forestry and fishing	2.4	0.7	-1.4	-2.3	-1.9	0.5
Mining and quarrying	22.7	21.6	23.8	26.0	31.9	40.9
Manufacture of food products, beverages and tobacco	14.3	13.0	16.4	17.1	15.4	13.5
Manufacture of textile and leather products	6.0	7.0	4.5	2.3	2.6	4.0
Manufacture of paper and paper products	2.0	3.0	3.0	4.4	1.9	0.1
Publishing and printing	15.8	17.0	11.5	15.8	17.9	17.8
Manufacture of petroleum products	-2.1	6.2	18.0	27.2	44.4	28.6
Manufacture of basic chemicals and chemical products	12.6	10.1	10.8	13.6	12.1	12.1
Manufacture of rubber and plastic products	7.4	6.7	5.6	5.0	2.8	1.0
Manufacture of basic metals	9.0	8.2	3.3	12.3	19.4	19.7
Manufacture of fabricated metal products	10.9	9.6	3.2	5.3	6.9	6.8
Manufacture of machinery and equipment n.e.c.	10.8	16.3	12.9	18.1	20.6	23.9
Manufacture of electrical and optical equipment	-0.7	6.0	-14.8	-15.0	-16.7	-19.6
Manufacture of transport equipment	2.0	12.7	9.2	12.6	10.7	11.4
Other manufacturing	4.0	7.2	5.1	5.5	6.2	7.0
Electricity, gas and water supply	3.3	2.3	6.4	5.5	6.4	9.1
Construction	21.6	26.1	27.2	24.4	27.7	33.0
Trade and repair of motor vehicles/cycles	6.7	20.3	20.7	19.9	16.9	18.7
Wholesale trade (excl. motor vehicles/cycles)	19.1	41.4	38.8	43.7	48.6	57.2
Retail trade and repair (excl. motor vehicles/cycles)	13.4	14.4	9.1	4.1	-3.3	-5.9
Hotels and restaurants	20.2	33.1	30.9	30.9	29.9	31.3
Land transport	4.1	7.4	7.7	6.5	6.9	8.9
Water transport	-1.8	-1.7	2.1	3.2	2.0	1.7
Air transport	-0.6	-2.5	-11.4	-9.5	-10.6	-9.8
Supporting transport activities	2.6	3.1	2.4	2.2	2.5	3.6
Post and telecommunications	9.6	5.5	15.1	15.5	15.7	15.1
Banking	26.6	7.2	22.3	25.0	26.0	7.0
Insurance and pension funding	10.7	9.2	21.0	22.4	31.6	32.3
Activities auxiliary to financial intermediation	7.8	50.2	27.5	30.3	28.8	41.7
Computer and related activities	5.7	67.8	33.4	43.7	47.4	63.4
Research and development	3.6	-8.7	-6.6	-0.3	3.5	-1.1
Other business activities	33.1	29.1	16.3	16.1	23.2	26.0
Health and social work activities	9.1	9.6	12.8	11.7	10.9	9.5
Sewage and refuse disposal services	0.9	2.5	4.2	2.5	2.8	3.9
Recreational, cultural and sporting activities	-11.9	2.4	5.3	6.2	6.4	8.9
Other service activities n.e.c.	2.4	5.3	6.0	5.5	5.8	6.0

T 18–17 Endogenous real interest rates, using for self-employed the same hourly labour compensation as for employees

in percents

	1995	2000	2003	2004	2005	2006
Agriculture, forestry and fishing	-1.2	-6.5	-7.5	-8.7	-8.1	-5.4
Mining and quarrying	22.7	21.6	23.8	26.0	31.9	40.9
Manufacture of food products, beverages and tobacco	13.7	12.4	16.0	16.7	15.0	13.1
Manufacture of textile and leather products	4.7	5.9	3.0	0.6	0.9	2.4
Manufacture of paper and paper products	2.0	2.9	2.9	4.4	1.9	0.1
Publishing and printing	13.8	15.8	10.6	14.6	16.7	16.6
Manufacture of petroleum products	-2.1	6.2	18.0	27.2	44.4	28.6
Manufacture of basic chemicals and chemical products	12.6	10.1	10.8	13.6	12.1	12.0
Manufacture of rubber and plastic products	6.9	6.5	5.5	4.9	2.7	1.0
Manufacture of basic metals	9.0	8.2	3.3	12.3	19.4	19.7
Manufacture of fabricated metal products	9.7	8.1	2.1	4.1	5.6	5.3
Manufacture of machinery and equipment n.e.c.	9.8	15.2	12.5	17.7	20.1	23.4
Manufacture of electrical and optical equipment	-1.2	5.3	-15.4	-15.6	-17.4	-20.3
Manufacture of transport equipment	1.4	12.3	8.5	11.8	9.8	10.7
Other manufacturing	2.4	5.4	3.9	4.1	4.9	5.6
Electricity, gas and water supply	3.3	2.3	6.4	5.5	6.4	9.1
Construction	13.6	14.9	15.7	11.5	13.0	15.6
Trade and repair of motor vehicles/cycles	-0.2	14.5	15.7	14.5	11.5	13.2
Wholesale trade (excl. motor vehicles/cycles)	13.7	37.9	36.2	41.1	45.9	54.3
Retail trade and repair (excl. motor vehicles/cycles)	4.8	7.5	2.9	-1.9	-9.6	-12.1
Hotels and restaurants	4.8	16.2	16.4	16.7	15.5	17.3
Land transport	3.2	6.4	7.0	5.7	6.1	8.1
Water transport	-5.3	-4.4	0.6	1.7	0.4	0.1
Air transport	-0.6	-2.5	-11.4	-9.5	-10.7	-9.9
Supporting transport activities	2.3	2.8	2.3	2.0	2.3	3.4
Post and telecommunications	9.4	5.3	14.9	15.2	15.4	14.7
Banking	26.6	7.2	22.3	25.0	26.0	7.0
Insurance and pension funding	10.7	9.2	21.0	22.4	31.6	32.3
Activities auxiliary to financial intermediation	-6.5	39.5	20.3	23.8	22.2	34.7
Computer and related activities	-9.8	56.8	21.6	32.0	36.2	49.3
Research and development	3.4	-9.4	-7.3	-1.0	2.7	-2.1
Other business activities	22.0	18.6	7.2	6.2	12.5	14.1
Health and social work activities	9.7	10.2	13.9	12.8	12.1	10.8
Sewage and refuse disposal services	0.9	2.5	4.2	2.5	2.8	3.9
Recreational, cultural and sporting activities	-22.1	-6.4	-3.3	-2.0	-1.3	1.5
Other service activities n.e.c.	-1.2	-0.7	-1.6	-2.1	-1.9	-2.1

The calculations resulted in some instances in negative endogenous interest rates. Furthermore, negative user cost values occurred for some combinations of industry and asset type. In cases where the operating surplus of an industry is negative, the total user cost of capital must be negative as well. However, for the purpose of getting some sensitivity results, MFP change has been calculated in all these instances, disregarding theoretical problems with negative interest rates or negative user cost of capital values.

In tables 18–18 and 18–19, MFP change is presented under the assumption that self-employed persons receive the same *annual* income as employees. In tables 18–20 and 18–21, MFP change is presented under the assumption that self-employed receive the same *hourly* income as employees.

T 18–18 Gross output based MFP change when using an endogenous interest rate
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.2	1.1	0.5	2.6	0.5	0.9
Mining and quarrying	-2.6	0.5	-1.2	8.0	-6.5	-2.5
Manufacturing	0.9	0.6	0.7	1.9	0.7	0.8
Electricity, gas and water supply	-0.1	1.6	0.7	1.0	1.2	0.6
Construction	-0.3	-0.3	-0.2	0.1	1.1	0.9
Trade, hotels, restaurants and repair	2.1	0.8	1.6	2.0	2.0	3.3
Transport, storage and communication	1.9	1.9	1.9	2.4	2.3	1.7
Financial and business activities[1]	-0.5	0.9	0.3	3.2	1.7	1.0
Care and other service activities[2]	-0.3	-0.3	-0.3	-0.1	-0.3	-0.1
Commercial sector	0.77	0.89	0.89	2.55	1.34	1.51

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18–19 Value added based MFP change when using an endogenous interest rate
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.3	2.3	1.1	5.3	1.1	1.9
Mining and quarrying	-3.3	0.7	-1.5	10.4	-8.3	-3.2
Manufacturing	2.6	1.8	2.2	5.7	2.2	2.7
Electricity, gas and water supply	-0.4	4.6	2.1	2.7	3.2	1.8
Construction	-0.8	-0.7	-0.5	0.3	2.4	1.8
Trade, hotels, restaurants and repair	3.6	1.3	2.8	3.3	3.5	5.6
Transport, storage and communication	3.6	3.7	3.6	4.6	4.5	3.4
Financial and business activities[1]	-0.7	1.4	0.4	4.7	2.4	1.5
Care and other service activities[2]	-0.4	-0.4	-0.4	-0.2	-0.5	-0.1
Commercial sector	1.12	1.28	1.30	3.68	1.95	2.23

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18–20 Gross output based MFP change when using an endogenous interest rate and giving self-employed the same hourly labour compensation as employees
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.3	1.7	0.7	2.9	0.7	1.2
Mining and quarrying	-2.6	0.5	-1.2	8.0	-6.5	-2.5
Manufacturing	0.9	0.6	0.8	1.9	0.7	0.8
Electricity, gas and water supply	-0.1	1.6	0.7	1.0	1.2	0.6
Construction	-0.4	-0.4	-0.3	-0.1	0.7	0.3
Trade, hotels, restaurants and repair	2.3	0.9	1.7	1.9	2.0	3.2
Transport, storage and communication	1.9	1.9	1.9	2.4	2.3	1.7
Financial and business activities[1]	-0.3	1.0	0.4	3.2	1.6	0.9
Care and other service activities[2]	-0.2	-0.2	-0.2	-0.1	-0.2	-0.0
Commercial sector	0.85	0.94	0.95	2.53	1.29	1.44

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18–21 Value added based MFP change when using an endogenous interest rate and giving self-employed the same hourly labour compensation as employees
in percents

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.5	3.5	1.6	6.0	1.6	2.8
Mining and quarrying	-3.3	0.7	-1.5	10.4	-8.3	-3.2
Manufacturing	2.6	1.8	2.3	5.7	2.2	2.6
Electricity, gas and water supply	-0.4	4.6	2.1	2.7	3.2	1.8
Construction	-0.9	-1.0	-0.8	-0.2	1.4	0.6
Trade, hotels, restaurants and repair	4.0	1.4	3.0	3.3	3.4	5.6
Transport, storage and communication	3.6	3.7	3.7	4.5	4.5	3.4
Financial and business activities[1]	-0.5	1.4	0.5	4.6	2.4	1.3
Care and other service activities[2]	-0.3	-0.4	-0.3	-0.1	-0.3	-0.0
Commercial sector	1.25	1.36	1.38	3.65	1.87	2.12

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

For mining and quarrying the differences in average MFP change, as compared with the results of the official method, are very large. As already mentioned when discussing the high interest rates in this industry, this is probably due to the exclusion of natural resources as capital input. Endogenous interest rates are only meaningful when all inputs in the production process are accounted for. For mining and quarrying, natural resource extraction constitutes quite likely the most important production factor. By using endogenous interest rates, these production costs are completely assigned to the other capital services.

Apart from mining and quarrying, the most extreme differences with the official method occur in agriculture, forestry and fishing. When endogenous interest rates are used and self-employed persons are given the same hourly labour income as employees, the differences with the official method in value-added MFP change are up to 4 percentage points. This volatility is probably caused by the large share of self-employed in this industry, inducing a large uncertainty with respect to the compensation of self-employed persons and therefore also a large uncertainty in the endogenously determined user cost of capital. The combination of the assumption that the hourly labour income for self-employed persons is the same as that for employees with the assumption of endogenous interest rates causes the compensation of the self-employed to be much higher and the user cost of capital to be much smaller than in the official method.

From 2005 on, differences are increasing. In 2006, for the commercial sector the difference in gross-output based MFP change between the official method and the method using an endogenous interest rate is 0.4 percentage points. For financial and business activities, the difference is even 0.9 percentage points. These large differences are caused by a change in capital input that differs substantially from the change in the other inputs, combined with large profits. When large profits occur, the share of capital in the total cost changes a lot when using an endogenous instead of an exogenous interest rate. Since the change in capital input is much lower than the change in the other inputs, the differences in the share of capital in the total cost lead to large differences in the total input change, so differences in MFP change are also large.

Sensitivity analyses: main conclusions

From the sensitivity analyses presented in the preceding subsections, it follows that for the commercial sector, MFP change is fairly insensitive to variations of the method of calculation. Only when holding gains are excluded from the user cost (and thus the effect of computers and software is downplayed), differences in average MFP change exceed 0.1 percentage point. However, almost all alternatives result in a higher average MFP change than the official method. Only with an endogenous instead of an exogenous interest rate, average value-added based MFP change is lower than in the official model. For gross-output based MFP, all the alternatives give a higher average MFP change.

The insensitivity to variations of the calculation method is confirmed when comparing our results with findings by EU-KLEMS as reported by van Ark, O'Mahony and Ypma (2007). EU-KLEMS, where different choices were made for the volume index, the labour income of self-employed, and the interest rate, estimates the average value-added based MFP change for the Dutch market sector[288] in the period 1995–2004 at 1.0 percent. After including the effect of labour composition this becomes 1.2 percent, which is comparable to our 1.26 percent.

288 The EU-KLEMS definition of the market sector differs from what we called the commercial sector. EU-KLEMS excludes care from the market sector but includes real estate activities, renting of movables, and private households with employed persons. Results are therefore not completely comparable.

In 2006, however, alternative assumptions on the user cost have larger effects on MFP change. Setting the interest rate at 10 percent or using an endogenous interest rate leads to differences for the commercial sector exceeding 0.2 percentage point. The reason is that in 2006 the volume change of capital input differs appreciatively from the volume change of the other inputs. Changing then the cost share of capital has consequences for MFP change.

At the industry level, the insensitivity is less. Average differences in gross-output based MFP change may be up to 0.15 percentage points, whereas average differences in value-added based MFP change may be up to 0.3 percentage points. With an endogenous instead of an exogenous interest rate, results for mining and quarrying show large differences. This can be explained by the incompleteness of the capital inputs in the accounting exercise.

Domar factors

As mentioned in the second section, Balk (2003b) showed that under the assumption of zero profit, for a fairly large class of index formulas, the ratio of value-added to gross- output based MFP change (each expressed as the logarithm of an index number) is proportional to the ratio of gross output to value added, which is the so-called Domar factor. Thus, the Domar factor can be approximated by dividing the value-added based MFP change by the gross-output based MFP change as in

$$D_1^t = \frac{\ln(\Pi_{VA,KL}^t)}{\ln(\Pi_{GO,KLEMS}^t)} \tag{37}$$

where $\Pi_{VA,KL}^t$ denotes the value-added based MFP index and $\Pi_{O,KLEMS}^t$ the gross-output based MFP index. The original computation method for the Domar factor is by dividing (consolidated) gross output by value added; that is, using year $t-1$ values,

$$D_2^t = \frac{R^{t-1}}{VA^{t-1}} \tag{38}$$

where R^{t-1} denotes the value of (consolidated) gross output (revenue) in year t–1 and VA^{t-1} denotes value added in year t–1 (both in current prices).

Since in the official method it is not assumed that total cost is equal to gross output, these two approaches to the Domar factor do not necessary deliver the same results. In table 18–22, Domar factors are presented as calculated according to expression (37), and in table 18–23 according to expression (38). Their ratios are presented in table 18–24.

Though many of the ratios are near unity, sometimes the two approaches differ quite a lot. This happens mostly when the MFP change is small. In such cases, small changes in MFP change may lead to large changes in the ratio between the two estimates of the Domar factor. Extreme values of this ratio do therefore not necessarily correspond with large differences between the two measures of MFP change.

T 18 – 22 Domar factor calculated as the ratio between value added based MFP change and gross output based multi-factor productivity change

	1996	2000	2003	2004	2005	2006
Agriculture, forestry and fishing	1.58	1.88	2.02	1.97	2.19	1.71
Mining and quarrying	2.33	0.94	2.83	1.38	1.31	1.07
Manufacturing	3.27	3.03	3.00	3.12	3.58	3.71
Electricity, gas and water supply	2.37	2.68	0.98	3.45	2.85	3.97
Construction	2.20	4.37	2.03	3.28	2.22	2.34
Trade, hotels, restaurants and repair	1.98	1.97	1.46	1.73	1.84	1.80
Transport, storage and communication	1.70	1.94	1.86	1.93	2.01	2.13
Financial and business activities[1]	1.27	1.28	1.37	1.49	1.55	1.18
Care and other service activities[2]	1.50	1.56	1.46	1.47	1.49	1.90
Commercial sector	1.51	1.66	1.36	1.49	1.54	1.56

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

T 18 – 23 Domar factor calculated as the ratio between gross output and value added

	1996	2000	2003	2004	2005	2006
Agriculture, forestry and fishing	1.90	2.02	2.09	2.04	2.15	2.13
Mining and quarrying	1.24	1.36	1.32	1.30	1.29	1.26
Manufacturing	2.79	2.92	2.96	2.89	2.94	3.09
Electricity, gas and water supply	2.55	2.60	2.54	2.54	2.68	2.90
Construction	2.23	2.25	2.11	2.09	2.10	2.11
Trade, hotels, restaurants and repair	1.66	1.69	1.69	1.68	1.69	1.72
Transport, storage and communication	1.82	1.93	1.92	1.88	1.90	1.97
Financial and business activities[1]	1.43	1.44	1.45	1.43	1.44	1.43
Care and other service activities[2]	1.47	1.49	1.45	1.45	1.44	1.44
Commercial sector	1.44	1.45	1.45	1.43	1.44	1.46

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

To test this, value-added based MFP change is calculated from output-based MFP change and the Domar factor; that is, by

$$\Pi^{*t}_{VA,KL} = \exp(\ln(\Pi^{t}_{GO,KLEMS})D^{t}_{2}) \tag{39}$$

The results of expression (39) are presented in table 18–25. For mining and quarrying, this leads to differences of up to 2.5 percentage points with value-added based MFP change as calculated with the official method (table 18–3). This may be due to the exclusion of natural resources as input factors, which causes gross output to be much larger than cost. For the other industries, as well as for the commercial sector as a whole, the differences with value-

T 18 – 24 Ratio between the two versions of the Domar factor

	1996	2000	2003	2004	2005	2006
Agriculture, forestry and fishing	0.83	0.93	0.97	0.97	1.02	0.80
Mining and quarrying	1.87	0.69	2.15	1.06	1.02	0.85
Manufacturing	1.17	1.04	1.01	1.08	1.22	1.20
Electricity, gas and water supply	0.93	1.03	0.39	1.36	1.06	1.37
Construction	0.99	1.94	0.96	1.57	1.06	1.11
Trade, hotels, restaurants and repair	1.19	1.17	0.86	1.03	1.09	1.05
Transport, storage and communication	0.93	1.01	0.97	1.02	1.06	1.08
Financial and business activities[1]	0.89	0.89	0.94	1.04	1.08	0.83
Care and other service activities[2]	1.02	1.05	1.01	1.01	1.03	1.31
Commercial sector	1.05	1.15	0.94	1.05	1.07	1.07

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

added based MFP change as calculated with the official method are much smaller. The largest difference, 0.8 percentage points, is found in electricity, gas and water supply in 2004. For care and other service activities, the differences are the smallest. The largest difference found in this industry is 0.04 percentage points in 2000.

T 18 – 25 Value added based multi-factor productivity change based on gross output based multi-factor productivity change and the Domar factor

	1996/2000	2000/2005	1996/2006	2004	2005	2006
Agriculture, forestry and fishing	-0.5	2.2	0.9	5.5	1.0	1.7
Mining and quarrying	-4.3	0.4	-2.1	9.6	-8.3	-3.6
Manufacturing	2.4	2.0	2.2	5.6	2.1	2.3
Electricity, gas and water supply	-0.3	4.5	2.0	2.1	3.1	1.2
Construction	-0.7	-0.5	-0.4	0.3	2.0	1.3
Trade, hotels, restaurants and repair	3.4	1.5	2.7	3.1	3.1	5.0
Transport, storage and communication	3.8	3.5	3.6	4.0	4.2	3.0
Financial and business activities[1]	-0.6	1.3	0.3	4.3	1.5	0.1
Care and other service activities[2]	-0.4	-0.4	-0.4	0.1	-0.3	-0.0
Commercial sector	1.17	1.31	1.28	3.53	1.68	1.68

[1] excluding real estate services and renting of movables
[2] excluding private households with employed persons

Conclusions and future work

In the foregoing we discussed the main results of the Netherlands' system of productivity statistics. The model has been explained, its various assumptions discussed, and a large number of sensitivity analyses executed.

Although official figures were presented, the system is far from final. Further improvement is expected from an extension of the National Accounts in the following three directions:

- The inclusion in the calculation of hours worked and the compensation of employees by industry branch of a breakdown by educational attainment. This means that in the near future quality changes in labour will be covered better in the productivity statistics.
- The annual production of a so-called knowledge module[289] will provide statistics on knowledge related inputs such as the capital services of R&D and ICT. The representation of R&D capital services in the National Accounts constitutes yet another deviation from mainstream national accounting.
- It is scheduled to construct complete balance sheets for non-financial assets. For productivity measurement this implies that the coverage of assets will be extended to inventories and non-produced assets such as land and subsoil assets.

[289] See for details De Haan and Horsten (2007) and Tanriseven et al. (2007).

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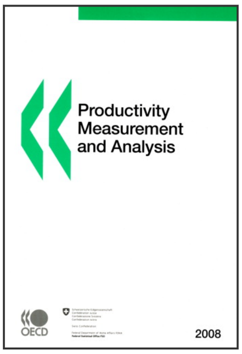

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