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The Measurement and Decomposition of Productivity Change: Exercises on the Netherlands' Manufacturing Industry

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THE MEASUREMENT AND DECOMPOSITION OF PRODUCTIVITY CHANGE: EXERCISES ON THE NETHERLANDS' MANUFACTURING INDUSTRY

Summary: An important issue in productivity measurement, with potential influence on national economic policy design, concerns the relation between aggregate and firm-level figures. Aggregate productivity change depends not only on intra-firm productivity change, but also on the dynamic process of expansion and contraction of firms, emergence of new firms, and disappearance of old firms. Amongst researchers there is discussion not only on the proper decomposition method but also on other conceptual issues.

Taking the Netherlands' part of the study on productivity and firm dynamics, coordinated by the Economics Department of the OECD (see OECD 2001a), as our point of departure, this study focuses on the sensitivity of the results.

First, we conclude that the decomposition methods, discussed by Balk (2001), can be grouped into two sets, between which the results differ remarkably. Using one set of methods, the continuing firms appear to account for most of the aggregate productivity change. Using the other set, the entering and exiting firms appear to be the most important players.

Second, the sensitivity of the results with respect to the productivity concept used (based on gross output or value added) will be examined. For example, it appears that gross output based measures lead to lower percentages of annual productivity change than value added based measures.

Finally, supplementing production survey data with information from the business register leads to a more precise definition of the entry and exit process. This in turn appears to lead to a significantly lower contribution of entering and exiting firms to aggregate productivity change.

Keywords: Productivity change, decomposition methods.

1. Introduction

Over the last decades a number of powerful econometric methods have been developed to explore the sources of productivity change at the firm or industry level. Numerous case studies have been published, and we have learned that productivity change can be caused by technological change, efficiency change, scale effects and input- or output-mix effects. These distinctions are important for industrial policy purposes.

At least as important is to understand the relation between productivity change at the micro level and at the meso or macro level. Here we have the interplay between productivity change at the firm level and changes in the industrial structure which are caused by factors such as growth or decline and entry or exit of firms. The availability of firm-level data underlying officially publicized aggregate figures makes it possible to explore this area.

Recently, the OECD carried out a comparative study on the manufacturing industry of ten countries. The main results were reported in OECD (2001a) and Barnes et al. (2001). The OECD study inspired us to execute further (sensitivity) analyses on the Netherlands' manufacturing industry. In particular we study the dependency of the outcomes on the firm-level productivity measure used, the decomposition method, and the definition of entry and exit of firms.

The structure of the paper is as follows. In section 2 the concepts of productivity measurement and the different decomposition methods will be reviewed. Section 3 describes the data that are available for analysis. Section 4 describes the methodological features of our study and the results of an initial scenario. In section 5 the results of various alternatives will be presented. Section 6 concludes.

2. The measurement and decomposition of productivity change

The productivity *change* of a production unit (firm, industry, or economy) between two time periods is usually defined as the ratio of a quantity index of output to a quantity index of input.[1] Alternatively, the productivity *level* at a certain time period can be defined as some measure of real output divided by some measure of real input. Productivity change is then obtained as the ratio of the productivity levels at the two periods. These concepts will be explained in section 2.1 in more detail. As will appear, the approach to productivity measurement via the level concept is especially fruitful when the population of production units varies through time.

A well-known measure of productivity (change) is (the) labour productivity (index). In the Netherlands' National Accounts, for instance, the labour productivity level is defined as the amount of nominal value added (at basic prices) per full-time equivalent job. Labour productivity levels and indices are presented in a single table for different industries and for the economy as a whole. Table 1 provides some lines from this table for the purpose of illustration.

The productivity figures in this and similar tables concern aggregates of firms. They are frequently used to say something about the productivity change of the 'average firm'. However, the relation between aggregate productivity change and firm-specific change is not that simple. Because of the dynamic behaviour of the underlying population of firms, aggregate productivity change cannot be considered as a simple average of productivity changes at the level of the individual firms. In the economic reality we have to deal with the process of entry, exit, growth, and decline of firms.

[1] Alternative definitions are discussed by Diewert and Nakamura (2003).

Table 1. Labour productivity for the Netherlands' economy and its manufacturing industry

		1996	1997	1998	1999	2000*	2001*
Economy							
Level	*1000 euro*	50	51	53	55	58	60
Volume index	*1995=100*	100.4	100.9	102.2	103.9	105.5	105.1
Volume change	*%*	0.4	0.5	1.3	1.7	1.5	-0.4
Manufacturing							
Level	*1000 euro*	53	54	56	58	62	63
Volume index	*1995=100*	101.7	103.0	105.1	107.6	113.0	113.3
Volume change	*%*	1.7	1.3	2.0	2.4	5.1	0.3

Source: Statistics Netherlands, * provisional figure

In order to obtain insight into the effect of this process on aggregate productivity change, this change must be decomposed into a component attributable to intra-firm productivity change and a component attributable to the process of industrial restructuring. There are several ways to do this, which will be the substance of section 2.2.

2.1 Productivity concepts

A firm will here be considered as an input-output system. At the output side we have the commodities produced: goods and/or services. At the input side we have the various commodities consumed by the firm. These commodities are traditionally classified into five, mutually disjunct, categories: capital inputs (K), labour inputs (L), energy (E), materials (M), and services (S). Let for the output side the commodities be numbered $1,2,\cdots,M$ and for the input side $1,2,\cdots,N$. An important assumption is that the firm operates in a market environment, so that every commodity comes with a value (in monetary terms), a price and/or a quantity. For every commodity it must be so that value equals price times quantity. At the output side we have M commodities, each with their price p_m^{it} and quantity y_m^{it}, where $m=1,2,\cdots,M$, i is a firm label and t denotes an accounting period. Similarly, at the input side we have N commodities, each with their price w_n^{it} and quantity x_n^{it}, where $n=1,2,\cdots,N$.

The firm i's revenue, the value of nominal gross output (GO), during accounting period t is

$$GO^{it} = p^{it} \cdot y^{it} \equiv \sum_{m=1}^{M} p_m^{it} y_m^{it} \ . \qquad (2.1)$$

Its production cost (PC) is given by

$$PC^{it} = w^{it} \cdot x^{it} \equiv \sum_{n=1}^{N} w_n^{it} x_n^{it} \ . \qquad (2.2)$$

All inputs are assumed to be allocatable to the five categories mentioned earlier. The entire input price and quantity vectors can then be partitioned as $w^{it} = (w_K^{it}, w_L^{it}, w_E^{it}, w_M^{it}, w_S^{it})$ and $x^{it} = (x_K^{it}, x_L^{it}, x_E^{it}, x_M^{it}, x_S^{it})$ respectively. The firm's value added (*VA*) is defined as its gross output minus the combined cost of energy, materials and services, that is

$$VA^{it} = p^{it} \cdot y^{it} - w_E^{it} \cdot x_E^{it} - w_M^{it} \cdot x_M^{it} - w_S^{it} \cdot x_S^{it} . \tag{2.3}$$

Energy, materials and services together form the category of intermediate inputs, that is, inputs which are acquired from other firms or imported. Now we can conceive the firm as producing value added (that is, money) from the primary input categories capital and labour.

The firm's profitability is defined as its revenue divided by its cost, that is

$$\frac{GO^{it}}{PC^{it}} = \frac{p^{it} \cdot y^{it}}{w^{it} \cdot x^{it}} . \tag{2.4}$$

As shown by Balk (2001), the link between the measurement of productivity levels and the measurement of productivity change at the firm level is provided by the concept of real profitability. Nominal profitability is defined as total revenue divided by total cost. Real profitability, that is deflated revenue (output) divided by deflated cost (input), is set equal to the productivity level. The index of productivity change then allows various interpretations, namely as the ratio of two productivity levels, the index of real profitability, the index of deflated revenue relative to the index of deflated cost, or the output quantity index divided by the input quantity index.

There are a number of ways of conceptualizing productivity levels and productivity change. One of the main distinctions is between single factor productivity and multi factor productivity. In the first case a measure of real output is related to a measure of a single type of real input. A well-known example is labour productivity. For multi factor productivity, a measure of real output is related to a measure of a bundle of real inputs. Total factor productivity (*TFP*), a special form of multi factor productivity, relates a measure of real output to a measure of total real input.

For the measure of real output the main choice is between gross output and value added. Gross output includes the value of total turnover, the change in stocks, and the margin on trade and other revenues. Value added, as already mentioned, is defined as the difference between gross output and the cost of intermediate inputs. When all these components of output and input are available, one can construct the four different productivity measures represented in table 2. For a more detailed discussion the reader is referred to the OECD (2001b) manual of productivity measurement.

Table 2. The most important productivity concepts

Output	Single Factor Productivity Input	Total Factor Productivity Input
GO	*L*	*K, L, E, M, S*
VA	*L*	*K, L*

Productivity level per firm

The productivity level of firm *i* at time period *t* is generically defined as

$$PROD^{it} = \frac{real\ output^{it}}{real\ input^{it}}. \tag{2.5}$$

Especially in the intertemporal framework, when monitoring a single firm over time, the concept of real output and real input is important. For example, one wants to see whether its gross output change or its production cost change is caused by changed prices or by changed quantities. We consider two periods, labelled $t = 0$ (which will be called the base period) and $t = 1$ (which will be called the comparison period). Real (gross) output is defined as

$$\begin{aligned} &RGO^{i0} \equiv p^{i0} \cdot y^{i0} \\ &RGO^{i1} \equiv p^{i0} \cdot y^{i0} Q_{out}(p^{i1}, y^{i1}, p^{i0}, y^{i0}) = p^{i1} \cdot y^{i1} / P_{out}(p^{i1}, y^{i1}, p^{i0}, y^{i0}). \end{aligned} \tag{2.6}$$

For the base period, real gross output is simply put equal to nominal gross output. For the comparison period, real gross output is defined as base period gross output inflated by an output quantity index number $Q_{out}(\cdot)$, measuring the effect of differing output quantities. Or equivalently, as comparison period nominal gross output deflated by an output price index number $P_{out}(\cdot)$, measuring the effect of differing output prices. Put otherwise, comparison period real gross output is comparison period gross output at the 'price level' of the base period.

Real input (production cost) is defined as

$$\begin{aligned} &RPC^{i0} \equiv w^{i0} \cdot x^{i0} \\ &RPC^{i1} \equiv w^{i0} \cdot x^{i0} Q_{in}(w^{i1}, x^{i1}, w^{i0}, x^{i0}) = w^{i1} \cdot x^{i1} / P_{in}(w^{i1}, x^{i1}, w^{i0}, x^{i0}). \end{aligned} \tag{2.7}$$

For the base period, real input is simply set equal to nominal production cost. For the comparison period, real input is defined as base period production cost inflated by an input quantity index number $Q_{in}(\cdot)$, or, equivalently, as comparison period nominal production cost deflated by an input price index number $P_{in}(\cdot)$.

Real value added is defined as

$$\begin{aligned} &RVA^{i0} \equiv VA^{i0} \\ &RVA^{i1} \equiv VA^{i0} Q_{inout}(p^{i1}, y^{i1}, w_{EMS}^{i1}, x_{EMS}^{i1}, p^{i0}, y^{i0}, w_{EMS}^{i0}, x_{EMS}^{i0}) \\ &\qquad = VA^{i1} / P_{inout}(p^{i1}, y^{i1}, w_{EMS}^{i1}, x_{EMS}^{i1}, p^{i0}, y^{i0}, w_{EMS}^{i0}, x_{EMS}^{i0}). \end{aligned} \tag{2.8}$$

Since value added is a function of inputs as well as outputs, we expect the price and quantity components to depend on output and input price indices and output and input quantity indices.

Real capital and labour input is defined as

$$\begin{aligned} RPC_{KL}^{i0} &\equiv w_K^{i0} \cdot x_K^{i0} + w_L^{i0} \cdot x_L^{i0} \\ RPC_{KL}^{i1} &\equiv (w_K^{i0} \cdot x_K^{i0} + w_L^{i0} \cdot x_L^{i0}) Q_{in}(w_{KL}^{i1}, x_{KL}^{i1}, w_{KL}^{i0}, x_{KL}^{i0}) \\ &= w_K^{i1} \cdot x_K^{i1} + w_L^{i1} \cdot x_L^{i1} / P_{in}(w_{KL}^{i1}, x_{KL}^{i1}, w_{KL}^{i0}, x_{KL}^{i0}). \end{aligned} \tag{2.9}$$

Based on (2.8) and (2.9), the value added based total factor productivity levels, *VATFP*, of firm *i* at periods 0 and 1 can be calculated as

$$VATFP^{i0} = \frac{RVA^{i0}}{RPC_{KL}^{i0}} = \frac{VA^{i0}}{w_K^{i0} \cdot x_K^{i0} + w_L^{i0} \cdot x_L^{i0}} = \frac{VA^{i0}}{KC^{i0} + LC^{i0}} \tag{2.10}$$

$$VATFP^{i1} = \frac{RVA^{i1}}{RPC_{KL}^{i1}} = \frac{VA^{i1} / P_{inout}(p^{i1}, y^{i1}, w_{EMS}^{i1}, x_{EMS}^{i1}, p^{i0}, y^{i0}, w_{EMS}^{i0}, x_{EMS}^{i0})}{(KC^{i0} + LC^{i0}) Q_{in}(w_{KL}^{i1}, x_{KL}^{i1}, w_{KL}^{i0}, x_{KL}^{i0})}.$$

In this expression comparison period real value added is nominal value added deflated by a price index number, while real production cost is base period production cost inflated by a quantity index number.

Aggregate productivity level and productivity change

Disregarding interactions between firms, the natural measure of $PROD^t$, the aggregate productivity level of all firms existing at period *t*, is the sum of firm-specific real output divided by the sum of firm-specific real input:

$$PROD^t = \frac{\sum_i real\, output^{it}}{\sum_i real\, input^{it}}. \tag{2.11}$$

This can easily be rewritten as a weighted arithmetic mean of the firm-specific productivity levels $PROD^{it}$,

$$\begin{aligned} PROD^t &= \sum_i \frac{real\, input^{it}}{\sum_i real\, input^{it}} \frac{real\, output^{it}}{real\, input^{it}} \\ &= \sum_i \theta^{it} PROD^{it} \end{aligned} \tag{2.12}$$

where the weights θ^{it} are firm-specific real input shares. They add up to one.

For the value added based total factor productivity levels of (2.10), for instance, the following firm specific real input shares are seen to be appropriate:

$$\theta^{i0} = \frac{KC^{i0} + LC^{i0}}{\sum_i (KC^{i0} + LC^{i0})}$$
$$\theta^{i1} = \frac{(KC^{i0} + LC^{i0}) Q_{in}(w_{KL}^{i1}, x_{KL}^{i1}, w_{KL}^{i0}, x_{KL}^{i0})}{\sum_i (KC^{i0} + LC^{i0}) Q_{in}(w_{KL}^{i1}, x_{KL}^{i1}, w_{KL}^{i0}, x_{KL}^{i0}).} \tag{2.13}$$

Aggregate productivity change between two periods 0 and 1 can be measured as a difference,

$$\Delta PROD^{10} = PROD^1 - PROD^0, \tag{2.14}$$

and the percentage change is obtained by dividing $\Delta PROD^{10}$ by $PROD^0$.

In the OECD (2001a) study the aggregate productivity level was instead of (2.12) defined as a weighted geometric mean

$$PROD_G^t = \prod_i (PROD^{it})^{\theta^{it}}, \tag{2.15}$$

which, by taking natural logarithms, gets the familiar form of a weighted arithmetic mean of logarithmic productivity levels:

$$\ln PROD_G^t = \sum_i \theta^{it} \ln PROD^{it}. \tag{2.16}$$

Aggregate productivity change between periods 0 and 1, measured as the logarithmic difference,

$$\Delta \ln PROD_G^{10} = \ln PROD_G^1 - \ln PROD_G^0, \tag{2.17}$$

can then be interpreted as a percentage change, since

$$\begin{aligned} \ln PROD_G^1 - \ln PROD_G^0 &= \ln\left(\frac{PROD_G^1}{PROD_G^0}\right) = \ln\left(1 + \frac{PROD_G^1 - PROD_G^0}{PROD_G^0}\right) \\ &\approx \frac{PROD_G^1 - PROD_G^0}{PROD_G^0} = \frac{PROD_G^1}{PROD_G^0} - 1, \end{aligned} \tag{2.18}$$

whenever $\frac{PROD_G^1 - PROD_G^0}{PROD_G^0}$ is small.

2.2 Productivity decomposition methods

The two main factors contributing to aggregate productivity change are *intra*-firm productivity change and *inter*-firm reallocation. This reallocation is caused by the dynamic process of expansion, contraction, entry and exit of firms. In this section we will review a number of methods to decompose aggregate productivity change into intra-firm and inter-firm components.

Let us again consider two periods, a base period 0 and a comparison period 1. The set of firms existing in both periods, the continuing firms, will be denoted by *C*. The set of firms existing at period 0 but disappeared since then, the exiting firms, will be denoted by *X*. Finally, the set of firms which came into existence between base and comparison period, the entering firms, will be denoted by *N*. Hence, the set of firms existing at period 0 is $C \cup X$, and the set of firms existing at period 1 is $C \cup N$.

Aggregate productivity change between periods 0 and 1 can then initially be decomposed as

$$\begin{aligned}\Delta PROD^{10} &= PROD^{1} - PROD^{0} \\ &= \sum_{i \in C \cup N} \theta^{i1} PROD^{i1} - \sum_{i \in C \cup X} \theta^{i0} PROD^{i0} \\ &= \sum_{i \in N} \theta^{i1} PROD^{i1} + \sum_{i \in C} \theta^{i1} PROD^{i1} \\ &\quad - \sum_{i \in C} \theta^{i0} PROD^{i0} - \sum_{i \in X} \theta^{i0} PROD^{i0}.\end{aligned} \tag{2.19}$$

With respect to the weights θ^{it}, measuring relative size, we recall that

$$\sum_{i \in C \cup N} \theta^{i1} = \sum_{i \in C \cup X} \theta^{i0} = 1. \tag{2.20}$$

Ideally, as shown in expression (2.12), the relative size measure θ^{it} should be the real input share.

If the aggregate productivity level is measured as a weighted arithmetic mean, then both sides of (2.19) must be divided by $PROD^{0}$ to get a decomposition of the percentage productivity change. If the aggregate productivity level is measured as a weighted geometric mean, then instead of $PROD$ the natural logarithm $\ln PROD$ should be used in (2.19).

Expression (2.19) shows that aggregate productivity change can be decomposed into a contribution of entering firms, a contribution of continuing firms and a contribution of exiting firms. The contribution of continuing firms is the outcome of the interaction between intra-firm productivity change, $PROD^{i1} - PROD^{i0}$, and inter-firm relative size change, $\theta^{i1} - \theta^{i0}$. In the literature, several methods have been developed to further decompose the contribution of the continuing firms. Slightly adapting the review of Balk (2001), five methods can be distinguished.

Decomposition method 1

The first method decomposes the contribution of the continuing firms into a Laspeyres-type contribution of intra-firm productivity change and a Paasche-type contribution of relative size change:

$$\begin{aligned}\Delta PROD^{10} &= \sum_{i \in N} \theta^{i1} PROD^{i1} \\ &\quad + \sum_{i \in C} \theta^{i0} (PROD^{i1} - PROD^{i0}) + \sum_{i \in C} (\theta^{i1} - \theta^{i0}) PROD^{i1} \\ &\quad - \sum_{i \in X} \theta^{i0} PROD^{i0}.\end{aligned} \tag{2.21}$$

The second term at the right hand side relates to intra-firm productivity change and uses base period weights. It is therefore called a Laspeyres-type measure. The third term relates to relative size change and is weighted by comparison period productivity levels. It is therefore called a Paasche-type measure. This decomposition was used in the studies of Baily et al. (1992) for the USA and Hahn (2000) for Korea. Due to the fact that the base period and comparison period weights add up to 1, see expression (2.20), we can insert an arbitrary scalar *a* to obtain

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}(PROD^{i1}-a) \\ &+\sum_{i\in C}\theta^{i0}(PROD^{i1}-PROD^{i0})+\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i1}-a) \\ &-\sum_{i\in X}\theta^{i0}(PROD^{i0}-a).\end{aligned} \tag{D.1}$$

Thus, entering firms contribute positively to aggregate productivity change insofar their comparison period productivity level exceeds *a*, and exiting firms contribute positively insofar their base period productivity level falls short of *a*. Since there are two different periods involved here, it is not quite clear which value for *a* it would be reasonable to take.

It is easily seen that letting *a* tend to zero will lead to a larger contribution of the entering firms, the exiting firms, and the relative size change of continuing firms, at the expense of the component of intra-firm productivity change.

Decomposition method 2

The second method uses a Paasche-type measure for intra-firm productivity change and a Laspeyres-type measure for relative size change. This leads to

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}(PROD^{i1}-a) \\ &+\sum_{i\in C}\theta^{i1}(PROD^{i1}-PROD^{i0})+\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i0}-a) \\ &-\sum_{i\in X}\theta^{i0}(PROD^{i0}-a).\end{aligned} \tag{D.2}$$

Again, it is not obvious which value for *a* it would be reasonable to take.

Decomposition method 3

It is possible to avoid the choice between the Laspeyres-Paasche-type and the Paasche-Laspeyres-type decomposition. The third method uses for the contribution of both intra-firm productivity change and relative size change Laspeyres-type measures. However, this simplicity is counterbalanced by the necessity to introduce a covariance-type term:

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}(PROD^{i1}-a)\\ &+\sum_{i\in C}\theta^{i0}(PROD^{i1}-PROD^{i0})+\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i0}-a)\\ &+\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i1}-PROD^{i0})\\ &-\sum_{i\in X}\theta^{i0}(PROD^{i0}-a).\end{aligned} \tag{D.3}$$

In view of the Laspeyres-type perspective, a natural choice for a seems to be $PROD^{0}$, the base period aggregate productivity level. This leads to the decomposition proposed by Haltiwanger (1997).

Decomposition method 4

Instead of the Laspeyres perspective, one might use the Paasche perspective. The covariance-type term accordingly appears with a negative sign. Thus, the fourth decomposition is

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}(PROD^{i1}-a)\\ &+\sum_{i\in C}\theta^{i1}(PROD^{i1}-PROD^{i0})+\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i1}-a)\\ &-\sum_{i\in C}(\theta^{i1}-\theta^{i0})(PROD^{i1}-PROD^{i0})\\ &-\sum_{i\in X}\theta^{i0}(PROD^{i0}-a).\end{aligned} \tag{D.4}$$

The natural choice for a would now be $PROD^{1}$, the comparison period aggregate productivity level.

Decomposition method 5

The fifth method avoids the Laspeyres-Paasche dichotomy altogether, by using a symmetric method which goes in essence back to Bennet (1920). One takes the arithmetic average of the first and the second method or the third and the fourth method. The covariance-type term then disappears. Thus,

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}(PROD^{i1}-a)\\ &+\sum_{i\in C}\frac{\theta^{i1}+\theta^{i0}}{2}(PROD^{i1}-PROD^{i0})\\ &+\sum_{i\in C}(\theta^{i1}-\theta^{i0})\left(\frac{PROD^{i1}+PROD^{i0}}{2}-a\right)\\ &-\sum_{i\in X}\theta^{i0}(PROD^{i0}-a).\end{aligned} \tag{D.5}$$

A rather natural choice for a is now $(PROD^{1} + PROD^{0})/2$, the average aggregate productivity level. Substituting this in the last expression, one obtains

$$\begin{aligned}\Delta PROD^{10} = &\sum_{i\in N}\theta^{i1}\left(PROD^{i1} - \frac{PROD^{1}+PROD^{0}}{2}\right)\\ &+\sum_{i\in C}\frac{\theta^{i1}+\theta^{i0}}{2}(PROD^{i1}-PROD^{i0})\\ &+\sum_{i\in C}(\theta^{i1}-\theta^{i0})\left(\frac{PROD^{i1}+PROD^{i0}}{2}-\frac{PROD^{1}+PROD^{0}}{2}\right)\\ &-\sum_{i\in X}\theta^{i0}\left(PROD^{i0}-\frac{PROD^{1}+PROD^{0}}{2}\right).\end{aligned} \quad \text{(D.6)}$$

For simplicity we refer to this method as (D.6) although it is nothing but a special case of (D.5). Entering firms contribute positively to aggregate productivity change if their productivity level is above average. Similarly, exiting firms contribute positively if their productivity level is below average. Continuing firms may contribute positively in two ways: if their productivity level increases, or if the firms with above (below) average productivity levels increase (decrease) in relative size.[2] Decomposition (D.6) is basically the one used in the pioneering work of Griliches and Regev (1995). In view of its symmetry it should be the preferred one. Moreover, Haltiwanger (2000) notes that (D.6) is less sensitive to (random) measurement errors than (D.3).

Baldwin and Gu (2001) suggested that the choice for the scalar *a* should be the aggregate productivity level of the exiting firms,

$$PROD_{X}^{0} = \sum_{i\in X}\theta^{i0}PROD^{i0} / \sum_{i\in X}\theta^{i0}. \quad (2.22)$$

The idea beyond this suggestion is that entering firms essentially replace exiting firms, so that the productivity level of entering firms must be compared with the aggregate productivity level of exiting firms. Doing this, the term $\sum_{i\in X}\theta^{i0}(PROD^{i0}-a)$ vanishes.

3. The data

The data come from the production surveys of the manufacturing industry in the Netherlands from 1984 to 1999. These annual surveys contain detailed information on revenue and cost of private firms. The variables used can be found in appendix A.

The statistical unit in the production surveys is the firm,[3] considered to be the actual agent in the production process, characterised by its autonomy with respect to that

[2] Notice that it can happen that for all continuing firms $PROD^{i1} > PROD^{i0}$ but that nevertheless the total contribution of the continuing firms to aggregate productivity change is negative. This ‘paradox’ was discussed by Fox (2002).

[3] This corresponds to the Kind-of-activity Unit in the context of the European Union and to the establishment in the context of the United Nations.

process and by the sale of its goods or services to the market. A firm can consist of one or more juridical units or can be part of a larger juridical unit. Firms are classified according to their main economic activity.

For 1984 to 1986 more data are available than for the years thereafter, since the observation threshold was changed in 1987. Prior to this year all firms with 10 or more employees were surveyed, while from 1987 all firms with at least 20 employees were surveyed. Firms with less employees were sampled. Bilateral comparisons are restricted to firms with 20 or more employees.

The focus is on firms of the manufacturing industry, consisting of the 2-digit industries 15 to 37 of the Standard Industrial Classification (SBI)[4] used in the Netherlands. There are no data for SBI 36631, social job creation. Appendix B lists these 2-digit industries. The industrial classification has been changed in 1993. This caused a break in the data series and led to some difficulties in finding appropriate deflators for the years prior to 1993. Also because of that change data for 1992 were classified in two ways.

Nominal gross output and value added are deflated by producer output price index numbers for total turnover. Where available, the indices at the three-digit level of the Netherlands' Standard Industrial Classification were used, otherwise those at the two-digit level. To assign these sectoral price indices to firms, one must know to which industry a firm belongs. This can change through time, however. The pragmatic solution is, that per firm the industry of the comparison period is taken, unless there is no observation in that period. Then the industry of the base period is taken.

The cost of materials, energy and services is deflated by producer input price index numbers for total expenditures at the two-digit level of the SBI classification.

Since the production surveys do not contain data on the capital stock, depreciation cost is used as input variable. The nominal values of depreciation cost will not be deflated.

For each year, firms with an incomplete data record and/or zero or negative values are deleted from the database. In addition, the following outlier removal procedure is applied. Initially, for each firm nominal output is divided by nominal input. The observations falling in the first and the ninety-ninth percentile of the distribution of nominal output divided by nominal input at the most detailed level of the STAN industry classification[5] are deleted.

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[4] The SBI '93 is an extension of the NACE Rev.1 (Nomenclature statistique des Activités economiques dans la Communauté Européenne), formulated by Eurostat. Up to the 4-digit level these classifications are the same. Up to the 2-digit level the SBI '93 is in accordance with the ISIC Rev.3.1 (International Standard Industrial Classification of all economic activities), recommended by the United Nations.

[5] The STAN industry classification is used by the OECD for cross-country analysis. For a detailed scheme of this classification the reader is referred to Bartelsman and Barnes (2001).

The information in the data records allows us, where possible, to link the data over the years. After linking two periods, the firms which appear to be outlier in either one of the periods and the firms with incomplete data in either one of the two periods are deleted. The entry or exit status of a firm is determined from the remaining data. If a firm occurs with data in a base period but not in a comparison period, this firm was defined as an exiting firm. If a firm does not occur with data in a base period but does so in a comparison period, this firm was called an entering firm. The drawback of this approach is that the entry and exit sets are polluted with firms which are sampled in but one of the two periods. It would be better to define exit and entry from a business register. Register-based data allow firms to be tracked through time because addition or removal of firms from the register usually reflects the entry and exit of firms in the 'real world'. We will return to this issue in section 5. Deleting from each comparison firms with incomplete records as well as outliers prevents many cases of unreal entry and exit. Appendix C contains the pseudo-code of the procedure outlined above.

4. Initial scenario for the computations of productivity change

Our starting point is the project on productivity and firm dynamics of the Economics Department of the OECD, carried out by an international team of experts. The data of the ten countries involved were, to the extent possible, harmonised and a common analytical framework was used. We were kindly permitted to use some of the project's computer codes, but adapted them in several respects, since we are only interested in the Netherlands' situation. For example, instead of using certain values obtained by averaging over the ten OECD countries, only values from the Netherlands are used. We also adapt the measure of real input; instead of a sort of Cobb-Douglas function we measure real input by real input cost.

We define an initial scenario and from thereof we extend and change the variables used. In section 4.1 the initial scenario is described. In section 4.2 the results are presented, respectively the annual percentages of productivity change and their decompositions. Section 5 is devoted to the extensions.

4.1 The productivity concept

The initial scenario uses value added based total factor productivity. Hence, the input factors are capital and labour. Aggregate productivity is a weighted arithmetic mean of firm-specific productivities.

Expression (2.10) provides the formal definition of the value added based total factor productivity level of firm *i* at periods 0 and 1. However, not all variables and index numbers are available. Also the fact that there are entering firms at the comparison period necessitates an adaptation of the equations. For these firms there is by definition no base period information. Therefore their comparison period value added is treated as real output and their capital and labour cost as real input. Thus,

$$VATFP^{i0} = \frac{VA^{i0}}{KC^{i0} + LC^{i0}} \qquad for\ i \in C \cup X \tag{4.1}$$

$$VATFP^{i1} = \frac{VA^{i1} / P^{i1}_{out}}{(KC^{i0} + LC^{i0}) Q_{in}(L^{i1}/L^{i0}, KC^{i1}/KC^{i0})} \qquad for\ i \in C$$
$$= \frac{VA^{i1}}{KC^{i1} + LC^{i1}} \qquad for\ i \in N$$

where VA^{it} is the value added of firm *i* at period *t*, KC^{it} is the depreciation cost of firm *i* at period *t* and LC^{it} is the labour cost of firm *i* at period *t*. Furthermore,

$$Q_{in}(\cdot) = \left(\frac{L^{i1}}{L^{i0}}\right)^{\alpha^i} \left(\frac{KC^{i1}}{KC^{i0}}\right)^{\beta^i} \tag{4.2}$$

is a Törnqvist type input quantity index with L^{it} being the number of employees of firm *i* at period *t* and

$$\alpha^i = \frac{1}{2}\left(\frac{LC^{i0}}{KC^{i0} + LC^{i0}} + \frac{LC^{i1}}{KC^{i1} + LC^{i1}}\right) \tag{4.3}$$

being the average labour factor share of firm *i*. Finally $\beta^i = 1 - \alpha^i$.

Since the production surveys do not contain volume data on the capital stock, depreciation cost is used in the input quantity index.

P^{i1}_{out} is a producer output price index for the industry class to which firm *i* belongs. These index numbers are used since no proper deflators for value added are available.

The aggregate productivity level, $VATFP^t$, is defined as the arithmetic mean of the individual productivity levels, see expression (2.12), with real input shares

$$\theta^{i0} = \frac{KC^{i0} + LC^{i0}}{\sum_i (KC^{i0} + LC^{i0})} \qquad for\ i \in C \cup X \tag{4.4}$$

$$\theta^{i1} = \frac{(KC^{i0} + LC^{i0}) Q_{in}(L^{i1}/L^{i0}, KC^{i1}/KC^{i0})}{\sum_{i \in C} (KC^{i0} + LC^{i0}) Q_{in}(L^{i1}/L^{i0}, KC^{i1}/KC^{i0}) + \sum_{i \in N} (KC^{i1} + LC^{i1}) / P^{i1}_{out}} \qquad for\ i \in C$$
$$= \frac{(KC^{i1} + LC^{i1}) / P^{i1}_{out}}{\sum_{i \in C} (KC^{i0} + LC^{i0}) Q_{in}(L^{i1}/L^{i0}, KC^{i1}/KC^{i0}) + \sum_{i \in N} (KC^{i1} + LC^{i1}) / P^{i1}_{out}} \qquad for\ i \in N.$$

For the entrants in period 1, as already noted, there is no information concerning period 0. In the denominator of θ^{i1}, however, we must sum real capital and labour cost for continuing and entering firms. But for the continuing firms this cost is at base period prices and for the entering firms at comparison period prices. Deflating the cost of the entering firms by the producer output price index numbers pragmatically solves this discrepancy.

4.2 The results

Table 3 presents the numbers of entering, exiting and continuing firms and the average of the labour factor shares per firm, and figure 1 shows the aggregate productivity changes.

Table 3. Mean of the labour factor shares per firm and total numbers of continuing, entering and exiting firms corresponding to VATFP

Period	Mean of α^i	C	N	X
1984-85	0.88	4643	493	451
1985-86	0.88	4633	464	478
1986-87	0.88	4581	529	440
1987-88	0.87	4424	907	651
1988-89	0.86	5060	487	208
1989-90	0.86	5187	431	293
1990-91	0.86	5194	719	354
1991-92	0.86	5448	659	384
1992-93	0.86	5468	502	438
1993-94	0.86	5351	529	432
1994-95	0.86	5288	530	558
1995-96	0.86	5141	488	627
1996-97	0.86	5101	503	506
1997-98	0.86	5197	551	365
1998-99	0.86	5310	558	407

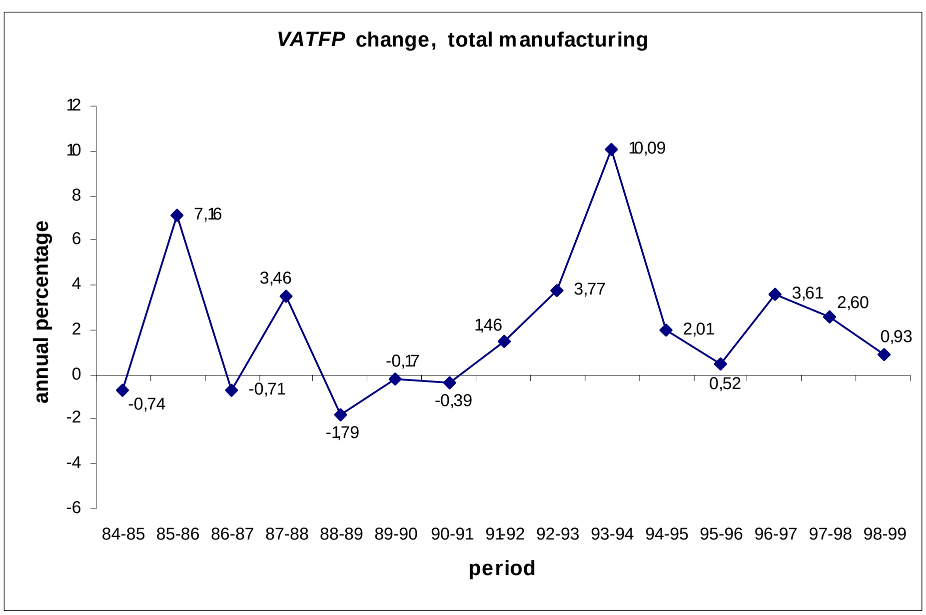


Figure 1. Annual percentage change of VATFP for total manufacturing using weighted arithmetic mean as aggregate productivity level

One sees an irregular pattern of productivity change, with troughs in 1986-87, 1988-89 and 1995-96 and peaks in 1985-86, 1987-88, 1993-94 and 1996-97.

Each of the methods reviewed in section 2.2 decomposes aggregate productivity change into an entry, an exit, a between, and a within component; in two cases there also is a covariance-type term. Figure 2 shows the results of decomposition (D.5) with a = 0, which is the average of decomposition (D.1) and decomposition (D.2), the results of which do not differ much.

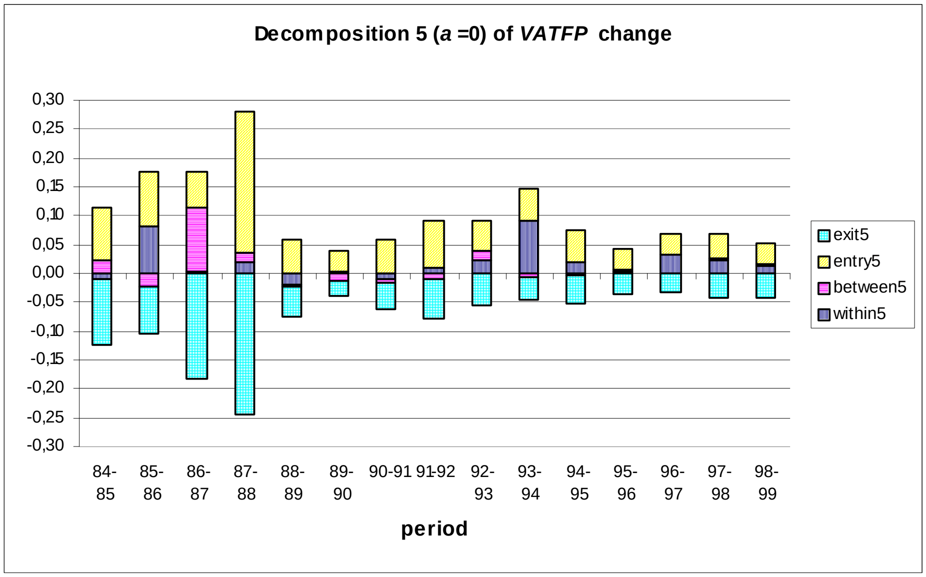
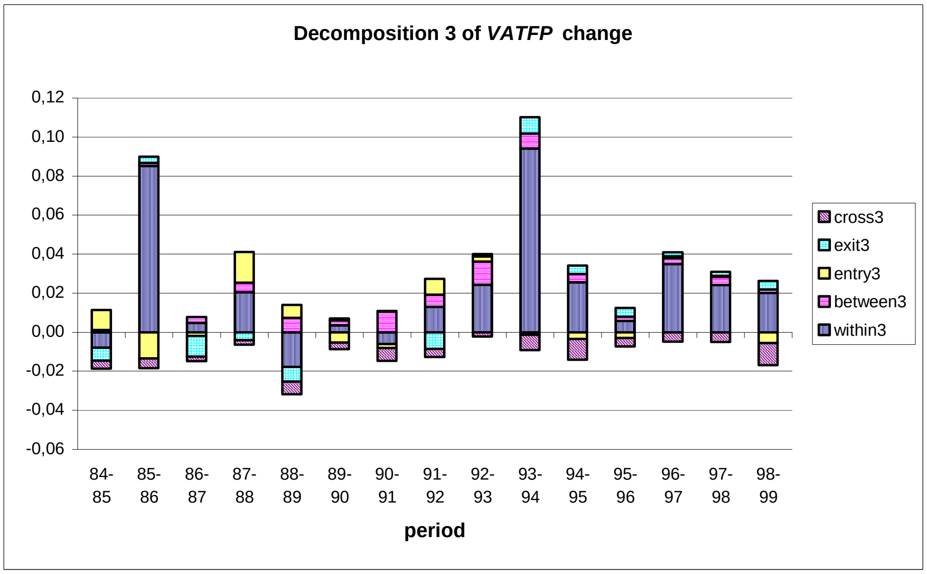


Figure 2. Decomposition 5 of the annual percentage change of VATFP for total manufacturing

For decompositions (D.3) and (D.4) the choice of the value for a is determined in a more 'natural' way. The average of these decompositions is (D.6). In figure 3 decompositions (D.3) and (D.6) are presented.



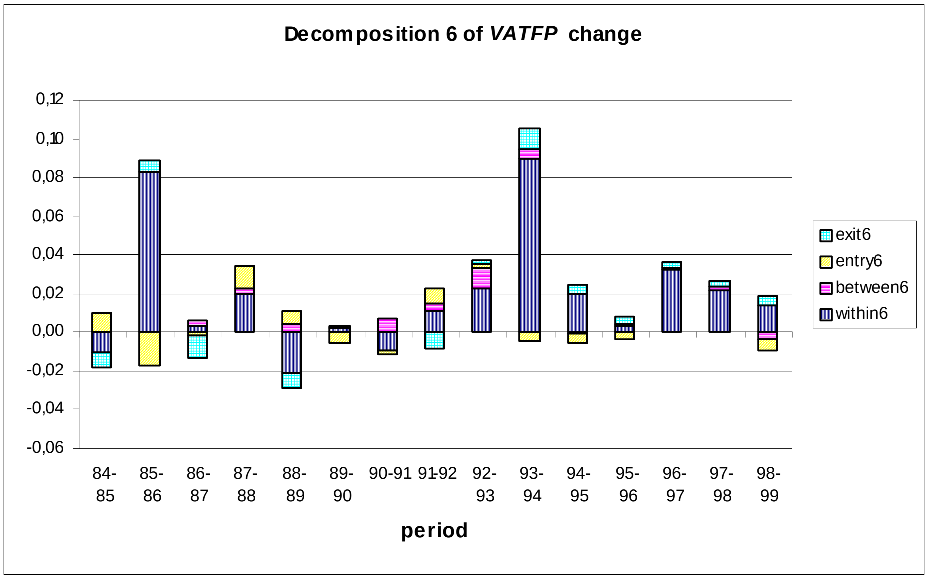


Figure 3. Decompositions 3 and 6 of the annual percentage change of VATFP for total manufacturing

Figures 2 and 3 show what we already have noticed in the discussion of the decomposition expressions; letting *a* tend to zero will lead to larger contributions of the entry, exit, and between component at the expense of the within component.

We prefer decomposition (D.6) because of its symmetry. Also the fact that this method is arguably less sensitive to measurement errors contributes to this preference. From figure 3 one sees that the most important factor behind aggregate productivity change is the within component, that is, the productivity change within the firms. The between component is relatively small and for most years positive. The entry component is alternately positive and negative. The exit component is from the period 1992-93 onwards positive, which means that the productivity level of exiting firms is on average below the average aggregate productivity level.

There are many country-specific studies of the decomposition of productivity change, but it is difficult to compare them due to the variation in time period, frequency and measurement method. Foster, Haltiwanger and Krizan (2001) and Ahn (2001) reviewed a number of those studies. There appeared to be some common patterns. Among others Foster et al. (2001) for the US, Disney et al. (2000) for the UK, and Hahn (2000) for Korea found evidence that the within effect rises in cyclical upturns and falls in recessions, thus exhibiting procyclical behaviour. The effects of entry and exit exhibit reverse behaviour. Looking at the relative importance of these components in the Netherlands we find similar patterns.

For the impact of entry and exit the time span of the comparison is an important factor. Ahn (2001) observes that the share of entrants or exiters is likely to increase as the length of the interval over which the comparison was made increases. This is due to the fact that all firms that entered before the last year are regarded as entrants and all firms that exited after the first year are regarded as exiters. In the OECD study five-yearly productivity changes were considered. Compared with the results of Barnes et al. (2001), the share of net entry is indeed smaller when productivity change is measured between two adjacent years than over a five year interval.

If we follow the suggestion of Baldwin and Gu (2001), the exit component disappears. The results look like those of the 'basic' methods. The within components are the same, and the between and entry components remain small relative to the within components. The results do not provide additional insights.

In Appendix D the detailed results of the six decompositions for each pair of adjacent years are given. Table 4 presents the averages over the whole period 1984 - 1999. We find for total manufacturing an average aggregate productivity change of about 2.1% per year, with a standard deviation of 3.1%.

Table 4. Percentage change of VATFP, averages and standard deviations for decompositions 1, 2 and 5 $(a = 0)$ and 3, 4 and 6 over the period 1984-1999, total manufacturing

Decomposition	**D.1 average**	**D.2 average**	**D.5 average**	**D.1 st dev**	**D.2 st dev**	**D.5 st dev**
***VATFP* change**	0.0212	0.0212	0.0212	0.0309	0.0309	0.0309
Within	0.0216	0.0162	0.0189	0.0301	0.0298	0.0299
Between	0.0049	0.0103	0.0076	0.0307	0.0297	0.0302
Cross						
Net entry	-0.0053	-0.0053	-0.0053	0.0327	0.0327	0.0327
Entry	0.0688	0.0688	0.0688	0.0503	0.0503	0.0503
Exit	-0.0741	-0.0741	-0.0741	0.0598	0.0598	0.0598
Decomposition	**D.3 average**	**D.4 average**	**D.6 average**	**D.3 st dev**	**D.4 st dev**	**D.6 st dev**
***VATFP* change**	0.0212	0.0212	0.0212	0.0309	0.0309	0.0309
Within	0.0216	0.0162	0.0189	0.0301	0.0298	0.0299
Between	0.0048	-0.0004	0.0022	0.0032	0.0042	0.0034
Cross	-0.0054	0.0054		0.0027	0.0027	
Net entry	0.0002	0.0000	0.0001	0.0058	0.0061	0.0060
Entry	0.0006	-0.0011	-0.0003	0.0070	0.0076	0.0071
Exit	-0.0004	0.0011	0.0004	0.0055	0.0068	0.0060

5. Several modifications and extensions

5.1 Alternative value added based productivity concepts

We vary the analysis with respect to the following points. First, instead of the weighted arithmetic mean (2.12), the aggregate productivity level will be computed as weighted geometric mean (2.15). Second, recall that to calculate real input the input quantity index (4.2) was used. Instead of (4.2) the following alternatives are considered; (*i*) all firms their own labour factor share based only on period 0 or 1; (*ii*) all firms the same labour factor share; (*iii*) labour factor shares calculated relative to value added instead of the sum of capital and labour cost. Third, there are different possibilities to define the relative size of a firm. Instead of the real input shares based on all input factors, relative size measures based on the input factor labour only and on real output are considered. In the last subsection value added based labour productivity is presented and compared with the labour productivity measures from the National Accounts.

5.1.1 Geometric mean aggregate productivity level

In almost all empirical studies aggregate productivity levels have been computed by using weighted geometric means. It is well known that $PROD_G^t \leq PROD^t$. For the productivity change between two periods such a relation does not need to hold.

Productivity changes based on weighted arithmetic and geometric means are displayed together in figure 4. Except for the periods 1993-94 and 1995-96 the productivity change based on geometric means is smaller than the productivity change based on arithmetic means. The differences themselves are not very important.

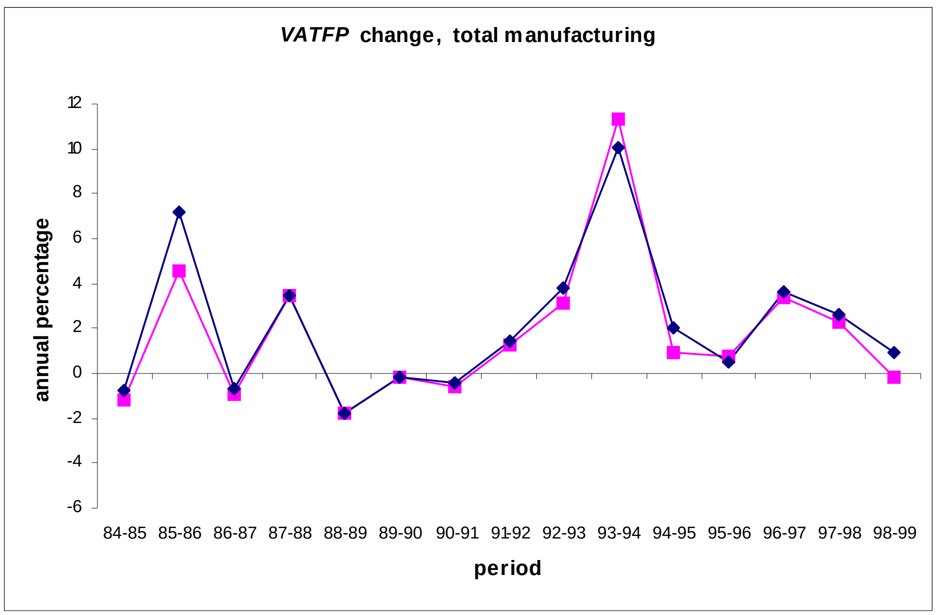


Figure 4. Annual percentage change of VATFP for total manufacturing using weighted arithmetic mean (diamonds) and geometric mean (squares) aggregate productivity level

5.1.2 Alternative input factor shares

In the initial scenario labour factor shares α^i per firm, averaged over base and comparison period, were calculated for the input quantity index number (4.2). To study the impact of this specific choice, labour factor shares either from the base period or from the comparison period are calculated:

$$\alpha^{it} = \frac{LC^{it}}{KC^{it} + LC^{it}} . \qquad (5.1)$$

It appears that aggregate productivity change does not differ much whether α^{i0}, α^{i1} or the average of both is used. Henceforth the labour factor share averaged over the base and comparison period is used.

Another alternative is to use one aggregate labour factor share α instead of labour factor shares per firm α^{i}:

$$\alpha = \frac{1}{2}\left(\frac{\sum_i LC^{i0}}{\sum_i (KC^{i0} + LC^{i0})} + \frac{\sum_i LC^{i1}}{\sum_i (KC^{i1} + LC^{i1})} \right). \qquad (5.2)$$

The summations are taken over all firms existing at periods 0 and 1 respectively. Table 5 provides per pair of adjacent years the aggregate labour factor share. Since α does not play a part in the outlier removal procedure, the numbers of continuing, entering and exiting firms remain those of table 3.

Table 5. Aggregate labour factor shares per firm

Period	α	**Period**	α
1984-85	0.84	1992-93	0.80
1985-86	0.83	1993-94	0.80
1986-87	0.83	1994-95	0.80
1987-88	0.82	1995-96	0.80
1988-89	0.81	1996-97	0.80
1989-90	0.80	1997-98	0.80
1990-91	0.80	1998-99	0.80
1991-92	0.80		

Figure 5 depicts productivity changes based on aggregate labour factor shares and those based on labour factor shares per firm. The graphs are almost the same. One may conclude that it does not matter much whether the labour factor share is calculated aggregatetively or individually. Henceforth the labour factor shares are calculated individually.

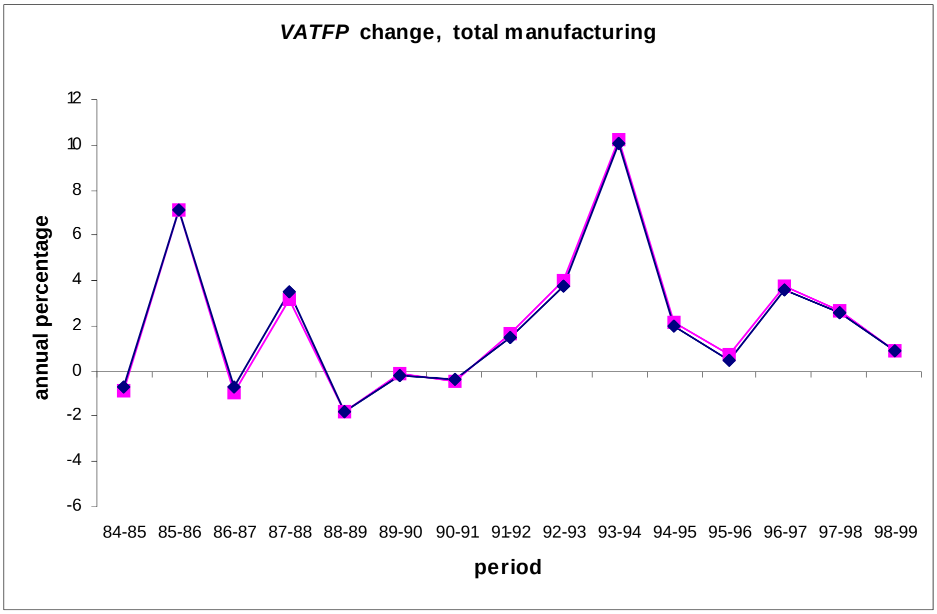


Figure 5. Annual percentage change of VATFP for total manufacturing using labour factor shares per firm (diamonds) and aggregate labour factor shares (squares)

As final alternative the labour factor share is computed as

$$\alpha^{*i} = \frac{1}{2}\left(\frac{LC^{i0}}{VA^{i0}} + \frac{LC^{i1}}{VA^{i1}}\right). \tag{5.3}$$

Instead of dividing labour cost by total cost of labour and capital, labour cost is divided by value added. These labour factor shares were used in the OECD study, and are familiar in the growth accounting approach. Only under the assumption that value added is equal to capital and labour cost, the labour factor shares α^i and α^{*i} are the same. Inaccuracies and measurement errors at the firm level could however lead to unwanted results. The ratio of labour cost to value added can easily exceed 1 in one or both periods, which then results in a negative contribution of capital. For these firms, the ratio is fixed to 1 in the periods concerned. As a consequence the labour factor shares become on average about 0.72 (see table 6) instead of 0.87, since labour cost has a smaller contribution in value added than in the sum of capital and labour cost.

In figure 6 one sees that for all periods the productivity change is smaller when using the ratio of labour cost to value added than using the ratio of labour cost to total capital and labour cost.

Table 6. Mean of the labour factor shares per firm calculated as ratio of labour cost to value added

Period	**Mean of α^{*i}**	**Period**	**Mean of α^{*i}**
1984-85	0.76	1992-93	0.75
1985-86	0.75	1993-94	0.75
1986-87	0.74	1994-95	0.73
1987-88	0.74	1995-96	0.72
1988-89	0.73	1996-97	0.71
1989-90	0.72	1997-98	0.71
1990-91	0.72	1998-99	0.71
1991-92	0.73		

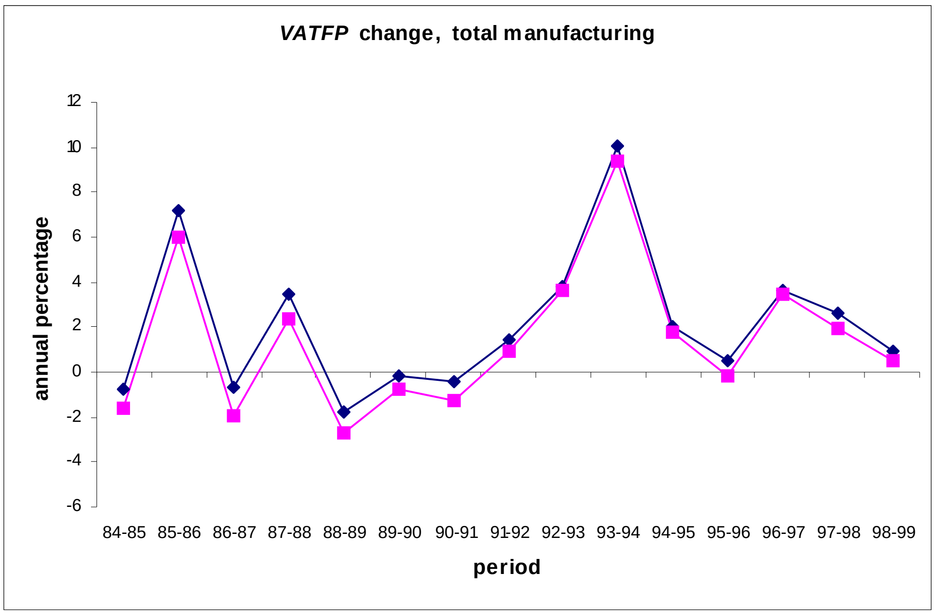


Figure 6. Annual percentage change of VATFP for total manufacturing using labour factor shares calculated as the ratio of labour cost to cost of labour and capital (diamonds) and as the ratio of labour cost to value added (squares)

As shown in section 4.1 however, the ratio of labour cost to the sum of capital and labour cost appears to be the 'natural' labour factor share.

5.1.3 Alternative measures of relative size

From the definition of the aggregate productivity level (2.11) the real input share was found to be the 'natural' measure of relative size. All input factors are included in this measure. In the literature, among others in Griliches and Regev (1995) and Barnes et al. (2001), measures only based on employment levels are found. Therefore, the consequences of using employment shares are explored. The employment shares are defined as

$$\theta^{it} = \frac{L^{it}}{\sum_i L^{it}} . \qquad (5.4)$$

Figure 7 compares the results. The differences are appreciable.

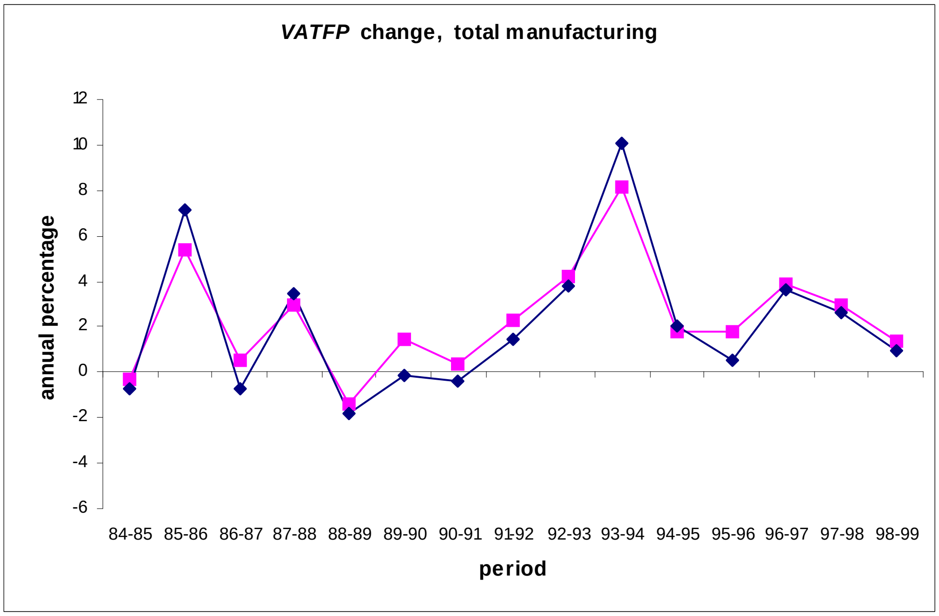


Figure 7. Annual percentage change of VATFP for total manufacturing using real total input weights (diamonds) and real labour input weights (squares)

In other empirical studies, for example Baily et al. (1992) and Haltiwanger (1997), instead of real input based relative size measures output based size measures are being used, especially gross output based. For value added based total factor productivity the following output shares seem appropriate:

$$\theta^{i0} = \frac{VA^{i0}}{\sum_i VA^{i0}} \qquad (5.5)$$

$$\theta^{i1} = \frac{VA^{i1} / P_{out}^{i1}}{\sum_i VA^{i1} / P_{out}^{i1}} .$$

This results in a different distribution of the importance of individual firms and therefore a somewhat different pattern of aggregate productivity change, see figure 8. The productivity change between 1985 and 1986 is very high with 14.9%. It appears that some firms with a relatively high output share have a high change of relative size and productivity. Ignoring these firms results in a more moderate productivity change of 7.1%.

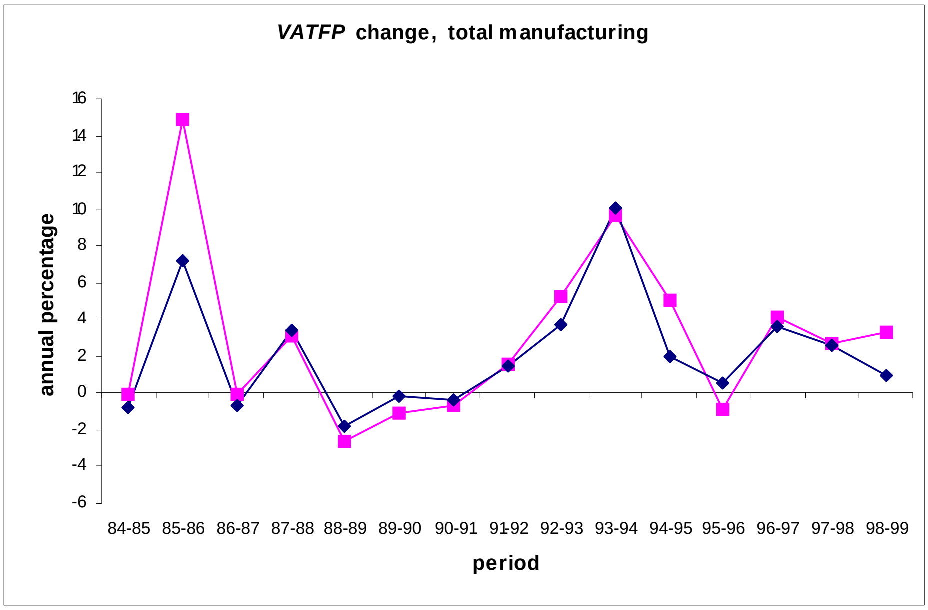


Figure 8. Annual percentage change of VATFP for total manufacturing using real total input weights (diamonds) and real output weights (squares)

5.1.4 Value added based labour productivity

In table 1 labour productivity levels and index numbers from the Netherlands' National Accounts have been presented. Labour productivity was defined as the amount of nominal value added (at basic prices) per full-time equivalent job. The productivity figures concern aggregates of firms. In this section a comparison is made between the figures at the macro level and those calculated from the micro data.

To compare the figures directly, the same variables should be observed. However, with respect to labour the production surveys of the manufacturing industry cover only the number of employees and the labour cost. There is no information about the number of full-time equivalent jobs.

The value added based labour productivity, *VALP*, is calculated as

$$VALP^{i0} = \frac{VA^{i0}}{LC^{i0}} \qquad \text{for } i \in C \cup X \tag{5.6}$$

$$VALP^{i1} = \frac{VA^{i1} / P_{out}^{i1}}{LC^{i0}(L^{i1} / L^{i0})} \qquad \text{for } i \in C$$

$$= \frac{VA^{i1}}{LC^{i1}} \qquad \text{for } i \in N$$

where VA^{it} is the value added of firm *i* at period *t*, LC^{it} is the labour cost of firm *i* at period *t* and L^{it} is the number of employees of firm *i* at period *t*. Again, P_{out}^{i1} is a producer output price index for the industry class to which firm *i* belongs.

The aggregate productivity level, $VALP^t$, is defined as the arithmetic mean of the individual productivity levels, see expression (2.12), with real input shares

$$\theta^{i0} = \frac{LC^{i0}}{\sum_i LC^{i0}} \qquad for\ i \in C \cup X \tag{5.7}$$

$$\theta^{i1} = \frac{LC^{i0}(L^{i1}/L^{i0})}{\sum_{i\in C} LC^{i0}(L^{i1}/L^{i0}) + \sum_{i\in N} LC^{i1}/P_{out}^{i1}} \quad for\ i \in C$$
$$= \frac{LC^{i1}/P_{out}^{i1}}{\sum_{i\in C} LC^{i0}(L^{i1}/L^{i0}) + \sum_{i\in N} LC^{i1}/P_{out}^{i1}} \quad for\ i \in N.$$

Since the input variable has been changed, the outlier removal procedure marks other firms as outliers. In table 7 the numbers of continuing, entering and exiting firms are given. Figure 9 contains the results and compares the microdata-based outcomes to those published in the National Accounts. The graphs show a remarkable similarity. Comparing the development of labour productivity to that of total factor productivity in figure 1, one observes the same pattern. Percentage changes of *VALP* tend to be higher than those of *VATFP*.

Table 7. Total numbers of continuing, entering and exiting firms corresponding to VALP

Period	**C**	**N**	**X**
1984-85	4802	506	476
1985-86	4750	476	494
1986-87	4701	545	458
1987-88	4545	926	668
1988-89	5190	506	211
1989-90	5328	446	301
1990-91	5339	745	360
1991-92	5617	667	390
1992-93	5646	518	449
1993-94	5520	545	448
1994-95	5473	543	577
1995-96	5326	489	653
1996-97	5282	516	520
1997-98	5390	565	373
1998-99	5485	569	420

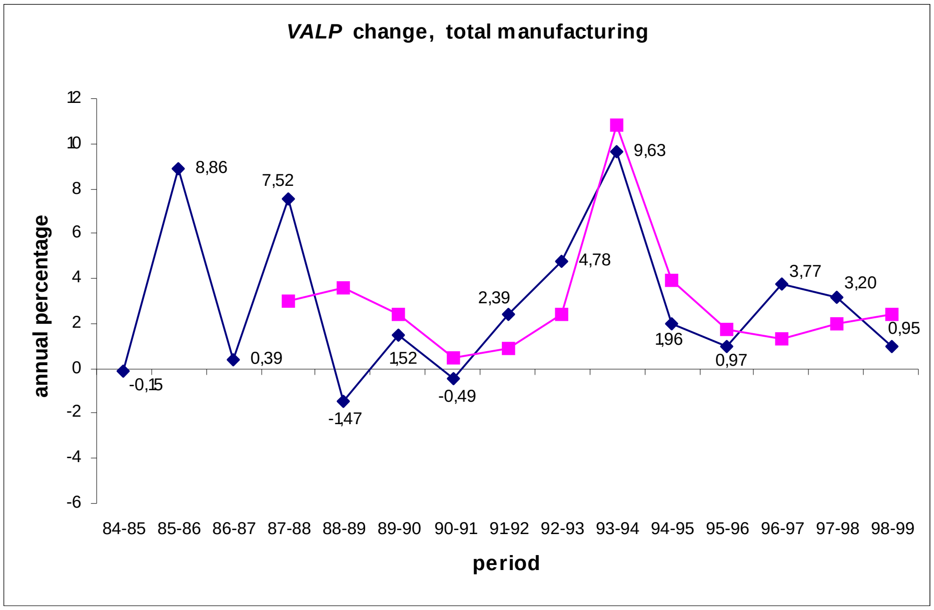


Figure 9. Annual percentage change of VALP for total manufacturing using micro data (diamonds) and using macro data (squares)

5.2 Gross output based productivity concepts

Besides the value added based productivity measures there are gross output based productivity measures. Note that gross output consists of deliveries to final demand and intermediate products. The split between those two categories depends very much on the level of aggregation. In contrast, value added enables one to compare firms belonging to different industries. Ignoring the complications of intra-industry deliveries, aggregate productivity change for the total manufacturing sector will be calculated. In appendix E the focus is on aggregates at the two-digit level of the SBI classification.

We calculate for each firm *i* the total factor productivity level, *GOTFP*, as

$$GOTFP^{i0} = \frac{GO^{i0}}{KC^{i0} + LC^{i0} + MC^{i0}} \qquad for \quad i \in C \cup X \tag{5.8}$$

$$GOTFP^{i1} = \frac{GO^{i1} / P_{out}^{i1}}{(KC^{i0} + LC^{i0} + MC^{i0})Q_{in}^{i1}} \qquad for \quad i \in C$$

$$= \frac{GO^{i1}}{(KC^{i1} + LC^{i1} + MC^{i1})} \qquad for \quad i \in N$$

where GO^{it} is the value of gross output of firm *i* at period *t*, KC^{it} is the depreciation cost of firm *i* at period *t*, LC^{it} is the labour cost of firm *i* at period *t*, and $MC^{it} = GO^{it} - VA^{it}$ is the intermediate input cost of firm *i* at period *t*. Furthermore,

$$Q_{in}^{i1} = \left(\frac{L^{i1}}{L^{i0}}\right)^{\alpha^i} \left(\frac{KC^{i1}}{KC^{i0}}\right)^{\beta^i} \left(\frac{MC^{i1}/P_{in}^{i1}}{MC^{i0}}\right)^{\gamma^i} \tag{5.9}$$

is a Törnqvist type input quantity index with L^{it} being the number of employees of firm *i* at period *t*,

$$\alpha^i = \frac{1}{2}\left(\frac{LC^{i0}}{KC^{i0}+LC^{i0}+MC^{i0}} + \frac{LC^{i1}}{KC^{i1}+LC^{i1}+MC^{i1}}\right) \tag{5.10}$$

being the average labour factor share of firm *i*,

$$\gamma^i = \frac{1}{2}\left(\frac{MC^{i0}}{KC^{i0}+LC^{i0}+MC^{i0}} + \frac{MC^{i1}}{KC^{i1}+LC^{i1}+MC^{i1}}\right) \tag{5.11}$$

being the average intermediate input factor share of firm *i*, and $\beta^i = 1 - \alpha^i - \gamma^i$.

Since the production surveys do not contain volume data on the capital stock, depreciation cost is used in the input quantity index. Finally, P_{in}^{i1} is a producer input price index for the industry class to which firm *i* belongs, and P_{out}^{i1} is a producer output price index for the industry class to which firm *i* belongs.

The aggregate productivity level, $GOTFP^t$, is defined as the arithmetic mean of the individual productivity levels, see expression (2.12), with real input shares being

$$\theta^{i0} = \frac{KC^{i0}+LC^{i0}+MC^{i0}}{\sum_i (KC^{i0}+LC^{i0}+MC^{i0})} \quad \text{for } i \in C \cup X \tag{5.12}$$

$$\begin{aligned}\theta^{i1} &= \frac{(KC^{i0}+LC^{i0}+MC^{i0})Q_{in}^{i1}}{\sum_{i\in C}(KC^{i0}+LC^{i0}+MC^{i0})Q_{in}^{i1} + \sum_{i\in N}(KC^{i1}+LC^{i1}+MC^{i1})/P_{out}^{i1}} \quad \text{for } i \in C \\ &= \frac{(KC^{i1}+LC^{i1}+MC^{i1})/P_{out}^{i1}}{\sum_{i\in C}(KC^{i0}+LC^{i0}+MC^{i0})Q_{in}^{i1} + \sum_{i\in N}(KC^{i1}+LC^{i1}+MC^{i1})/P_{out}^{i1}} \quad \text{for } i \in N.\end{aligned}$$

Due to the change of the industry classification it appeared to be difficult to obtain reliable results for the years prior to 1992. Therefore we consider only the period 1992-1999. The means of the labour and intermediate input factor shares per firm are presented in table 8. Since the output and input variables have been changed, the outlier removal procedure marks other firms as outliers. The numbers of continuing, entering and exiting firms are also given in this table.

Table 8. Mean of the labour and intermediate input factor shares per firm and total numbers of continuing, entering and exiting firms corresponding to GOTFP

Period	**Mean of** α^i	**Mean of** γ^i	**C**	**N**	**X**
1992-93	0.33	0.62	5472	501	433
1993-94	0.33	0.62	5353	530	427
1994-95	0.32	0.63	5290	529	559
1995-96	0.31	0.65	5149	488	626
1996-97	0.30	0.65	5104	499	499
1997-98	0.29	0.66	5203	545	363
1998-99	0.29	0.66	5303	557	396

Figure 10 shows the development of *GOTFP*. Notice that the percentage changes of *GOTFP* are lower than the corresponding ones of *VATFP* in figure 1.

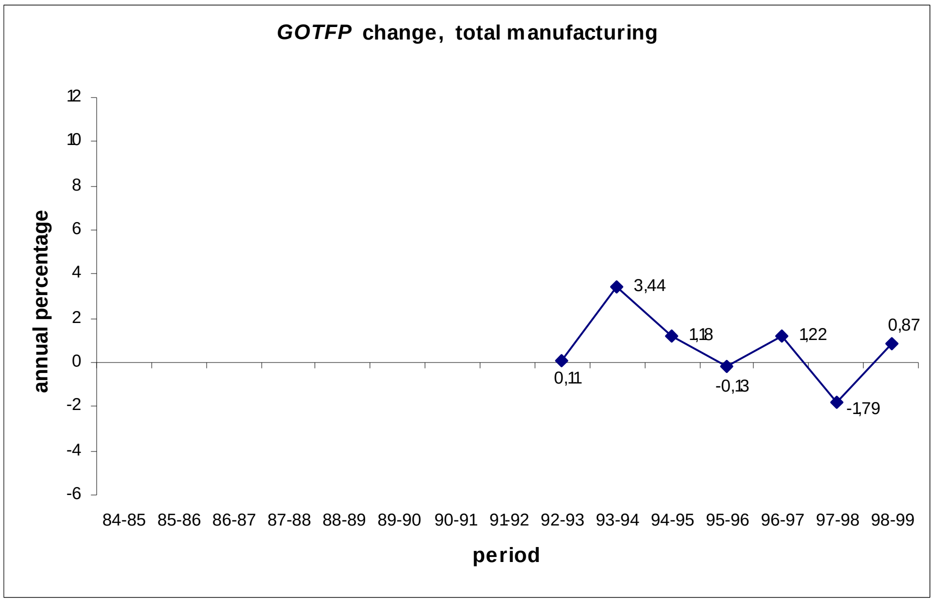


Figure 10. Annual percentage change of GOTFP for total manufacturing

5.2.1 Gross output excluding changes in inventories

Instead of taking the total production value to measure output, we could also take the value of total turnover, which means that the change in inventories is excluded. In some industries and periods it is likely that large quantities of produced goods were stocked. In those cases a productivity measure based on total production would be economically less relevant.

Table 9 presents the mean of the factor shares per firm and the numbers of observations for this approach. The results as depicted in figure 11 give no reason to suppose that at this level of aggregation the influence of inventory behaviour is large. Although the percentages differ, the trend is almost the same.

Table 9. Mean of labour and intermediate input factor shares per firm and total number of continuing, entering and exiting firms corresponding to GOTFP with total turnover as output

Period	Mean of α^i	Mean of γ^i	C	N	X
1992-93	0.33	0.62	5439	490	426
1993-94	0.33	0.62	5322	509	423
1994-95	0.32	0.63	5270	525	541
1995-96	0.31	0.65	5139	474	625
1996-97	0.30	0.65	5100	493	486
1997-98	0.30	0.66	5189	541	362
1998-99	0.29	0.66	5299	552	390

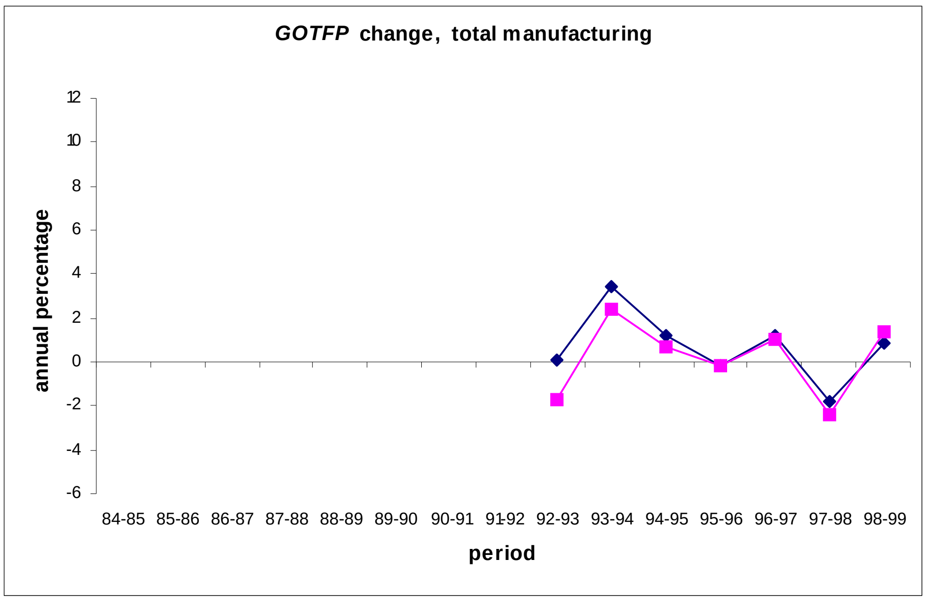


Figure 11. Annual percentage change of GOTFP for total manufacturing using gross output (diamonds) and total turnover (squares) as output

5.3 Entries and exits defined from the business register

Until now, the entry or exit status of a firm was determined from the production survey data. In any bilateral comparison, if there was an observation of a firm in the base (comparison) year and not in the comparison (base) year this firm was automatically defined as an exiting (entering) firm. Large, unreal numbers of entrants and exiters are due to a number of causes:

- If a firm temporarily falls below the observation threshold, there is no observation during this period.
- If a firm temporarily does not respond, there is no observation.

An alternative is to use a business register to define the entry and exit status. The Netherlands' business register is continuously updated and comprehensive. It is simple to extract a subregister of all firms existing during a certain year. This register contains information on the mutations that have taken place. It is known whether a firm has been 'born' or has 'died', but also whether there has been a restructuring due to, for example, a merger or a take-over. Firms without exhibiting mutations we will call continuing firms (C). Firms exhibiting a mutation can be divided into three groups: entering firms (N), exiting firms (X), and firms with mutation other than entry or exit (H)[6].

As an example we consider the period 1997-98. We consider the initial scenario described in section 4.1. Thus productivity change is based on value added as output and capital and labour as input. The two sets of production survey observations were linked to the business register to enhance the observations with mutation codes. After pooling and matching, the deletion of incomplete records, and the application of the outlier removal procedure, there are 6113 firms left in the pooled dataset. These firms can be classified in a number of distinct groups. Table 10 displays the result.

Table 10. Firms in 1997-98 with the business register mutation codes

Code 1997	Code 1998	Code 1997-1998	Number of firms
.	H	-	119
.	N	N	14
.	C	-	409
.	X	-	9
H	H	H	27
H	C	H	278
H	X	H	1
N	H	H	2
N	C	C	20
N	X	C	1
C	H	H	219
C	N	-	13
C	C	C	4619
C	X	C	17
C	.	-	219
X	.	X	14
H	.	-	131
N	.	-	1
Total			6113

The first four lines apply to firms with an observation in 1998 but without a corresponding observation in 1997. Data-driven, these 551 firms would be classified as entering firms. However, the mutation code reveals that only 14 of them are really new firms.

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[6] Note that there are firms with a mutation code that only occurs for administrative reasons. Another point of attention is the delay between the occurrence of a mutation in the real world and the registration of that mutation in the business register.

A similar story applies to the last four lines of table 10. These lines apply to what data-driven would be called exiting firms, of which there were 365. However, only 14 of them were exiters according to the business register mutation code.

A third category is formed by the firms with a conflicting pair of mutation codes. In particular, the 13 firms with codes (C, N) were deleted from the analysis.

The remaining 5184 firms were classified either as continuing firms (C) or as firms that have undergone some kind of restructuring (H). The final number of firms used in the analysis turned out to be 5212, of which 4657 were continuing firms, 527 restructured firms, 14 entrants, and 14 exiters.

Table 11 contains the corresponding numbers of firms for all the pairs of years for which this procedure could be applied.

Table 11. Mean of labour factor shares per firm and total numbers of continuing, restructured, entering, and exiting firms

Period	**Mean of** α^i	**C**	**H**	**N**	**X**
1993-94	0.86	5223	128	12	15
1994-95	0.86	4822	455	8	13
1995-96	0.86	4599	527	17	33
1996-97	0.86	4580	505	11	12
1997-98	0.86	4657	527	14	14
1998-99	0.86	4834	455	14	28

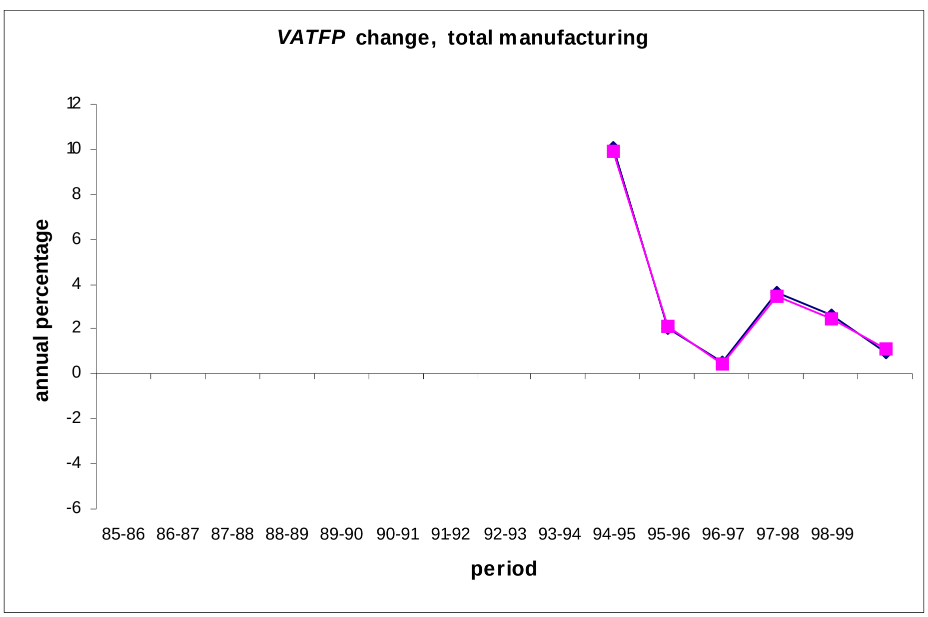

Figure 12. Annual percentage change of VATFP for total manufacturing where entry and exit is based on the business register (squares) and based on the data (diamonds)

Figure 12 depicts the aggregate productivity change percentages. The difference with the corresponding part of the initial scenario where no use was made of the business register is not large.

The decomposition results, however, change dramatically. Notice that there is now also a within and a between component for the restructured firms (coded H). Figure 13 contains the results for (D.5) with a = 0. Compared with figure 2, the entry and exit components have become very small. The between component of the restructured firms is mostly negative. This means that for most of these firms the relative size has declined. The between component of the continuing firms is mostly positive, which means that the relative size of these firms has increased. The within component is overall the largest one.

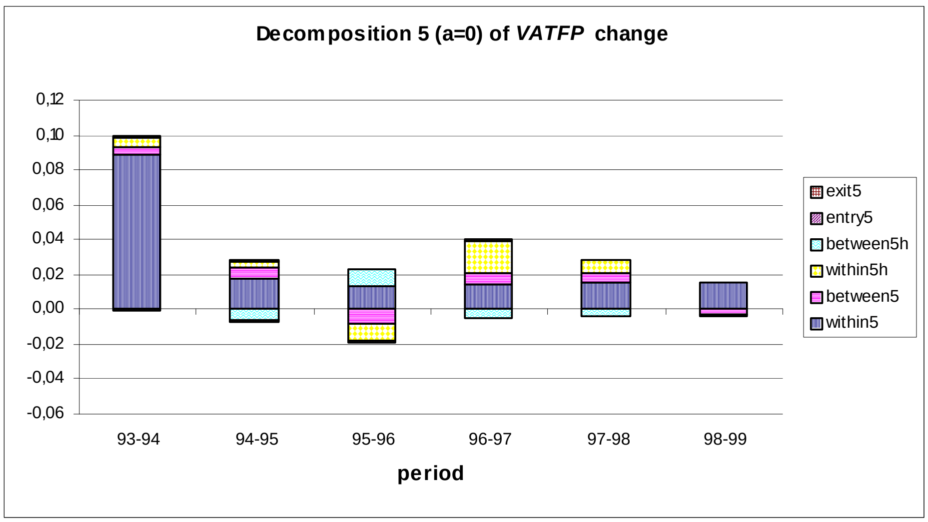

Figure 13. Decomposition (D.5) (a=0) of the annual percentage change of VATFP for total manufacturing where entry and exit is based on the business register

For decomposition (D.6) the within component was already the most important one. Now this is magnified. The between, entry, and exit components are hardly visible in figure 14.

We may conclude that the precise definition of entry and exit is an important issue. Judged from the production survey data there are lots of entries and exits, but most of them appear to be artificial. Especially when it comes to decomposition of the aggregate productivity change the consequences are important.

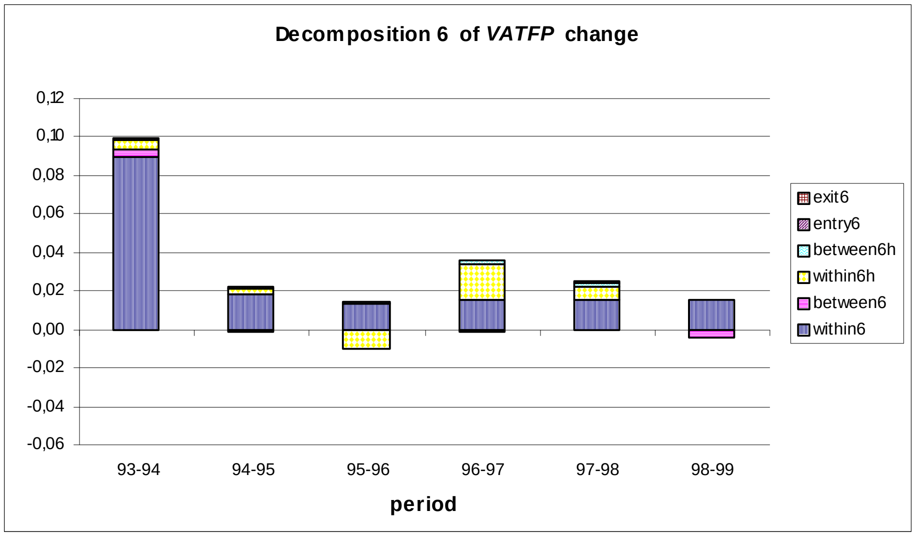

Figure 14. Decomposition (D.6) of the annual percentage change of VATFP for total manufacturing where entry and exit is based on the business register

6. Some conclusions

We summarize our findings. To some extent our point of departure was the Netherlands' part of the study on productivity and firm dynamics carried out by the OECD. In particular we study the dependency of the outcomes on the firm-level productivity measure used, the decomposition method, and the definition of entry and exit of firms.

It appears that the decomposition methods can be grouped into two sets, between which the results differ remarkably. Using one set of methods, the continuing firms appear to account for most of the aggregate productivity change. Using the other set, the entering and exiting firms appear to be the most important players.

The percentages of productivity change do not differ much whether a weighted arithmetic mean or a weighted geometric mean is used for calculating the aggregate productivity levels.

The outcomes are quite insensitive to the input quantity index which is used for the calculation of real input. In particular the way the labour factor shares are defined does not matter much.

Total factor productivity change can be based on value added or on gross output. The percentages derived with gross output are lower than those derived with value added.

We checked the sensitivity with respect to the definition of entry or exit of a firm. Supplementing production survey data with information from the business register leads to a more precise definition of the entry and exit process. This in turn appeared to lead to a significantly lower contribution of entering and exiting firms to aggregate productivity change.

The appropriate measurement of capital input remains a topic for further research.

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Appendix A

Variables used from Production Surveys Manufacturing Industry 1984-1999 (eps84set t/m eps99set):

Variable description		*Variable in eps..set*
Gross output	*GO*	eps78pw
Turnover		eps78iv
Value added	*VA*	eps78btw
Capital input	*KC*	eps84afs
Number of employees	*L*	eps78wkn
Labour cost	*LC*	eps78ak
Intermediate input cost	*MC*	eps78pw-eps78btw

Deflators used from Statistics of Prices:

Nominal value added and gross output were deflated by producer price indices for total turnover. Where available, the indices at the three-digit level of the SBI classification were used, otherwise those at the two-digit level.

The intermediate input cost was deflated by producer price indices for total expenditures at the two-digit level of the SBI classification.

Appendix B

Table 12. 2-digit SBI '93 industries

SBI industry	Description
15	Food products and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Wood and products of wood and cord, except furniture; articles of straw and plaiting materials
21	Pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastic products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c.
30	Office machinery and computers
31	Electrical machinery and apparatus n.e.c
32	Radio, television and communication equipment and apparatus
33	Medical, precision and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; manufacturing n.e.c (excluding SBI 36631, social job creation).
37	Preparation for recycling

Appendix C

Summary overview of the analysis of value added based total productivity change:

The code consists of two parts. During the first phase the database with all the data is prepared for use. This means among others that the classification hierarchy is constructed and outliers are identified. At the end of this step we have a database, which can be used for measuring productivity change. So, in the second phase the data for the time periods considered are filtered from the database and used to calculate productivity change and various components of decomposition methods.

The industrial classification SBI has been changed in 1993. Since we consider annual changes we split the database in two parts; first production data for 1984-1992 according to the classification SBI 1974, second production data for 1992-1999 according to SBI 1993. So, for 1992 we have two different datasets, because the number of firms belonging to the manufacturing industry according to the old classification is somewhat different from the number of firms according to the new classification.

Preparation of the datasets:

- Merge the production data with the classification hierarchy.
- Delete the records that have a classification falling outside the manufacturing industry.
- Mark incomplete records.
- Observe only the complete records. Define records as outliers falling in the first and ninety-ninth percentile of the distribution of nominal output divided by nominal input at the most detailed level of the STAN industry classification.
- Optional: use the business register ABR to construct the entry and exit status.

Calculating productivity change between period $t-1$ and t and the components of the decomposition methods:

- Filter production data for period $t-1$ and period t from the production database.
- Filter price data for period $t-1$ and period t from the price database.
- Merge production data of the two periods by using the firm identification number.
- Delete records that are incomplete in one of the periods or are outlier in one of the periods. (Doing this prevents the occurrence of spurious entry and exit).
- To combine price data with the production data we take the SBI Industry belonging to period t. If there is no observation in period t, the SBI Industry of period $t-1$ is taken.
- Merge price data with production data.

- Define the status of the firm. Is it an entry, exit or a stayer?
- Define input factor shares[1].
- Calculate the productivity level per firm in period $t-1$ and t. Nominal values are expressed at prices of period $t-1$.
- Define the relative size of the firm in period $t-1$ and t[2].
- Calculate with the relative size and the productivity level per firm aggregate productivity level of the manufacturing industry in period $t-1$ and t[3].
- Calculate aggregate productivity change between period $t-1$ and t.
- Calculate the various components of the decomposition methods and some general descriptives of the analysis.

1) Methods to calculate input factor shares:

- Input factor share per firm averaged over base and comparison period
- Input factor share per firm from either the base or comparison period
- One aggregate input factor share averaged over base and comparison period (for each firm the same factor share)
- Input factor share per firm calculated as a ratio of labour cost to value added instead of labour cost to total capital and labour cost.

2) Methods to calculate relative size of a firm:

- Based on all input factors, the real input shares
- Based on employment, the number of employees
- Based on real output.

3) Methods to calculate aggregate productivity level:

- arithmetic
- geometric.

Appendix D

Table 13. Change of VATFP, total manufacturing

Period	*VATFP* change	Within	Between	Net entry	Entry	Exit
1984-85	-0.0074	-0.0079	0.0195	-0.0190	0.0941	-0.1131
1985-86	0.0716	0.0851	-0.0242	0.0107	0.0923	-0.0816
1986-87	-0.0071	0.0048	0.1110	-0.1228	0.0611	-0.1839
1987-88	0.0346	0.0205	0.0150	-0.0009	0.2436	-0.2445
1988-89	-0.0179	-0.0178	-0.0059	0.0058	0.0576	-0.0518
1989-90	-0.0017	0.0035	-0.0153	0.0101	0.0372	-0.0271
1990-91	-0.0039	-0.0061	-0.0110	0.0133	0.0579	-0.0446
1991-92	0.0146	0.0131	-0.0121	0.0136	0.0806	-0.0670
1992-93	0.0377	0.0243	0.0163	-0.0028	0.0513	-0.0541
1993-94	0.1009	0.0941	-0.0100	0.0167	0.0563	-0.0396
1994-95	0.0201	0.0255	-0.0085	0.0030	0.0533	-0.0503
1995-96	0.0052	0.0058	0.0002	-0.0008	0.0353	-0.0361
1996-97	0.0361	0.0349	-0.0024	0.0036	0.0361	-0.0326
1997-98	0.0260	0.0241	0.0035	-0.0015	0.0414	-0.0429
1998-99	0.0093	0.0201	-0.0029	-0.0079	0.0345	-0.0424
average	0.0212	0.0216	0.0049	-0.0053	0.0688	-0.0741
st deviation	0.0309	0.0301	0.0307	0.0327	0.0503	0.0598

VATFP is calculated by (4.1). Decomposition (D.1) with *a* = 0. Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

Table 14. Change of VATFP, total manufacturing

Period	*VATFP* change	Within	Between	Net entry	Entry	Exit
1984-85	-0.0074	-0.0121	0.0237	-0.0190	0.0941	-0.1131
1985-86	0.0716	0.0802	-0.0193	0.0107	0.0923	-0.0816
1986-87	-0.0071	0.0024	0.1134	-0.1228	0.0611	-0.1839
1987-88	0.0346	0.0182	0.0174	-0.0009	0.2436	-0.2445
1988-89	-0.0179	-0.0243	0.0006	0.0058	0.0576	-0.0518
1989-90	-0.0017	0.0000	-0.0118	0.0101	0.0372	-0.0271
1990-91	-0.0039	-0.0129	-0.0043	0.0133	0.0579	-0.0446
1991-92	0.0146	0.0089	-0.0079	0.0136	0.0806	-0.0670
1992-93	0.0377	0.0220	0.0185	-0.0028	0.0513	-0.0541
1993-94	0.1009	0.0862	-0.0020	0.0167	0.0563	-0.0396
1994-95	0.0201	0.0149	0.0022	0.0030	0.0533	-0.0503
1995-96	0.0052	0.0016	0.0044	-0.0008	0.0353	-0.0361
1996-97	0.0361	0.0301	0.0024	0.0036	0.0361	-0.0326
1997-98	0.0260	0.0192	0.0084	-0.0015	0.0414	-0.0429
1998-99	0.0093	0.0088	0.0084	-0.0079	0.0345	-0.0424
average	0.0212	0.0162	0.0103	0.0688	-0.0741	-0.0053
st deviation	0.0309	0.0298	0.0297	0.0503	0.0598	0.0327

VATFP is calculated by (4.1). Decomposition (D.2) with *a* = 0. Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

Table 15. Change of VATFP, total manufacturing

Period	***VATFP* change**	**Within**	**Between**	**Net entry**	**Entry**	**Exit**
1984-85	-0.0074	-0.0100	0.0216	-0.0190	0.0941	-0.1131
1985-86	0.0716	0.0827	-0.0217	0.0107	0.0923	-0.0816
1986-87	-0.0071	0.0036	0.1122	-0.1228	0.0611	-0.1839
1987-88	0.0346	0.0193	0.0162	-0.0009	0.2436	-0.2445
1988-89	-0.0179	-0.0211	-0.0026	0.0058	0.0576	-0.0518
1989-90	-0.0017	0.0018	-0.0135	0.0101	0.0372	-0.0271
1990-91	-0.0039	-0.0095	-0.0076	0.0133	0.0579	-0.0446
1991-92	0.0146	0.0110	-0.0100	0.0136	0.0806	-0.0670
1992-93	0.0377	0.0231	0.0174	-0.0028	0.0513	-0.0541
1993-94	0.1009	0.0901	-0.0060	0.0167	0.0563	-0.0396
1994-95	0.0201	0.0202	-0.0031	0.0030	0.0533	-0.0503
1995-96	0.0052	0.0037	0.0023	-0.0008	0.0353	-0.0361
1996-97	0.0361	0.0325	0.0000	0.0036	0.0361	-0.0326
1997-98	0.0260	0.0216	0.0059	-0.0015	0.0414	-0.0429
1998-99	0.0093	0.0144	0.0028	-0.0079	0.0345	-0.0424
average	0.0212	0.0189	0.0076	-0.0053	0.0688	-0.0741
st deviation	0.0309	0.0299	0.0302	0.0327	0.0503	0.0598

VATFP is calculated by (4.1). Decomposition (D.5) with $a = 0$. Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

Table 16. Change of VATFP, total manufacturing

Period	***VATFP* change**	**Within**	**Between**	**Cross**	**Net entry**	**Entry**	**Exit**
1984-85	-0.0074	-0.0079	0.0011	-0.0042	0.0035	0.0102	-0.0066
1985-86	0.0716	0.0851	0.0016	-0.0049	-0.0103	-0.0135	0.0033
1986-87	-0.0071	0.0048	0.0030	-0.0024	-0.0125	-0.0019	-0.0106
1987-88	0.0346	0.0205	0.0049	-0.0024	0.0116	0.0156	-0.0040
1988-89	-0.0179	-0.0178	0.0073	-0.0066	-0.0009	0.0066	-0.0075
1989-90	-0.0017	0.0035	0.0025	-0.0035	-0.0042	-0.0052	0.0010
1990-91	-0.0039	-0.0061	0.0105	-0.0068	-0.0015	-0.0019	0.0004
1991-92	0.0146	0.0131	0.0061	-0.0042	-0.0004	0.0081	-0.0085
1992-93	0.0377	0.0243	0.0118	-0.0023	0.0039	0.0027	0.0011
1993-94	0.1009	0.0941	0.0076	-0.0080	0.0071	-0.0013	0.0083
1994-95	0.0201	0.0255	0.0043	-0.0106	0.0009	-0.0035	0.0043
1995-96	0.0052	0.0058	0.0022	-0.0042	0.0014	-0.0030	0.0044
1996-97	0.0361	0.0349	0.0030	-0.0048	0.0030	0.0010	0.0020
1997-98	0.0260	0.0241	0.0044	-0.0049	0.0024	0.0004	0.0020
1998-99	0.0093	0.0201	0.0018	-0.0113	-0.0013	-0.0056	0.0043
average	0.0212	0.0216	0.0048	-0.0054	0.0002	0.0006	-0.0004
st deviation	0.0309	0.0301	0.0032	0.0027	0.0058	0.0070	0.0055

VATFP is calculated by (4.1). Decomposition (D.3). Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

Table 17. Change of VATFP, total manufacturing

Period	*VATFP* change	Within	Between	Cross	Net entry	Entry	Exit
1984-85	-0.0074	-0.0121	-0.0028	0.0042	0.0034	0.0108	-0.0074
1985-86	0.0716	0.0802	-0.0017	0.0049	-0.0118	-0.0211	0.0093
1986-87	-0.0071	0.0024	0.0014	0.0024	-0.0133	-0.0014	-0.0118
1987-88	0.0346	0.0182	0.0021	0.0024	0.0120	0.0077	0.0043
1988-89	-0.0179	-0.0243	0.0006	0.0066	-0.0008	0.0075	-0.0083
1989-90	-0.0017	0.0000	-0.0010	0.0035	-0.0042	-0.0051	0.0010
1990-91	-0.0039	-0.0129	0.0037	0.0068	-0.0014	-0.0016	0.0002
1991-92	0.0146	0.0089	0.0021	0.0042	-0.0006	0.0071	-0.0077
1992-93	0.0377	0.0220	0.0093	0.0023	0.0041	0.0009	0.0032
1993-94	0.1009	0.0862	0.0006	0.0080	0.0061	-0.0071	0.0132
1994-95	0.0201	0.0149	-0.0063	0.0106	0.0008	-0.0046	0.0054
1995-96	0.0052	0.0016	-0.0020	0.0042	0.0014	-0.0032	0.0046
1996-97	0.0361	0.0301	-0.0017	0.0048	0.0030	-0.0002	0.0032
1997-98	0.0260	0.0192	-0.0006	0.0049	0.0026	-0.0006	0.0032
1998-99	0.0093	0.0088	-0.0095	0.0113	-0.0012	-0.0060	0.0048
average	0.0212	0.0162	-0.0004	0.0054	0.0000	-0.0011	0.0011
st deviation	0.0309	0.0298	0.0042	0.0027	0.0061	0.0076	0.0068

VATFP is calculated by (4.1). Decomposition (D.4). Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

Table 18. Change of VATFP, total manufacturing

Period	*VATFP* change	Within	Between	Net entry	Entry	Exit
1984-85	-0.0074	-0.0100	-0.0009	0.0034	0.0105	-0.0070
1985-86	0.0716	0.0827	-0.0001	-0.0110	-0.0173	0.0063
1986-87	-0.0071	0.0036	0.0022	-0.0129	-0.0017	-0.0112
1987-88	0.0346	0.0193	0.0035	0.0118	0.0117	0.0001
1988-89	-0.0179	-0.0211	0.0039	-0.0008	0.0071	-0.0079
1989-90	-0.0017	0.0018	0.0007	-0.0042	-0.0052	0.0010
1990-91	-0.0039	-0.0095	0.0071	-0.0015	-0.0018	0.0003
1991-92	0.0146	0.0110	0.0041	-0.0005	0.0076	-0.0081
1992-93	0.0377	0.0231	0.0106	0.0040	0.0018	0.0022
1993-94	0.1009	0.0901	0.0041	0.0066	-0.0042	0.0108
1994-95	0.0201	0.0202	-0.0010	0.0009	-0.0040	0.0049
1995-96	0.0052	0.0037	0.0001	0.0014	-0.0031	0.0045
1996-97	0.0361	0.0325	0.0006	0.0030	0.0004	0.0026
1997-98	0.0260	0.0216	0.0019	0.0025	-0.0001	0.0026
1998-99	0.0093	0.0144	-0.0039	-0.0013	-0.0058	0.0046
average	0.0212	0.0189	0.0022	0.0001	-0.0003	0.0004
st deviation	0.0309	0.0299	0.0034	0.0060	0.0071	0.0060

VATFP is calculated by (4.1). Decomposition (D.6). Total manufacturing is defined as the 2-digit SBI industries 15 to 37. Net entry = Entry + Exit. Figures may not add up due to rounding.

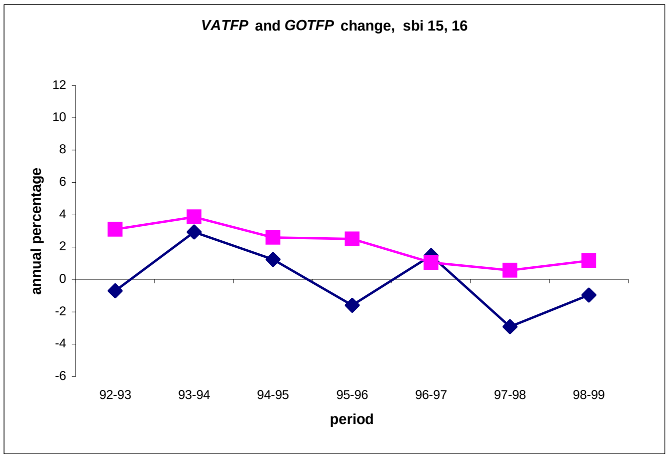
Appendix E

Table 19. Change of GOTFP and VATFP, 2-digit level of SBI

Period	SBI	Number of observations	*GOTFP* change	*VATFP* change	SBI	Number of observations	*GOTFP* change	*VATFP* change
92-93	15,16	878	-0.70	3.11	23	16	-1.78	21.58
93-94	15,16	873	2.93	3.87	23	15	1.28	8.12
94-95	15,16	891	1.24	2.60	23	15	-0.49	-9.40
95-96	15,16	882	-1.59	2.50	23	14	3.23	4.98
96-97	15,16	871	1.48	1.04	23	16	-4.07	-3.53
97-98	15,16	854	-2.92	0.57	23	17	-7.26	25.04
98-99	15,16	849	-0.97	1.16	23	16	8.60	-8.57
92-93	17	219	-0.88	1.50	24	277	2.24	9.82
93-94	17	210	1.56	4.55	24	290	6.14	29.87
94-95	17	225	0.77	-0.61	24	292	1.17	12.23
95-96	17	213	1.68	8.44	24	296	-0.19	-10.51
96-97	17	188	1.65	4.82	24	303	1.50	3.93
97-98	17	174	0.55	0.96	24	311	-3.78	-3.25
98-99	17	172	0.47	1.61	24	313	5.48	3.57
92-93	18	117	-2.22	3.59	25	336	-0.98	-1.37
93-94	18	107	-0.75	-2.26	25	345	5.87	11.63
94-95	18	103	-0.99	-6.94	25	346	0.82	-3.00
95-96	18	92	0.76	4.78	25	335	0.24	8.01
96-97	18	73	0.04	0.47	25	328	1.83	2.86
97-98	18	73	-5.11	-1.76	25	333	0.14	5.45
98-99	18	69	-1.74	0.70	25	331	-1.58	-0.60
92-93	19	71	1.03	1.09	26	282	-0.33	2.38
93-94	19	59	0.64	-0.84	26	273	3.85	10.44
94-95	19	55	0.46	7.65	26	276	0.25	-0.53
95-96	19	48	2.62	7.70	26	267	-0.70	-0.32
96-97	19	43	4.10	5.09	26	258	3.77	6.13
97-98	19	44	-4.13	0.06	26	262	-0.75	-0.36
98-99	19	42	-4.14	-5.40	26	263	1.58	4.83
92-93	20	187	1.85	1.12	27	79	1.43	8.38
93-94	20	189	2.42	1.88	27	87	3.93	14.13
94-95	20	190	-1.70	1.36	27	88	-1.80	2.28
95-96	20	192	1.52	3.26	27	80	1.25	-1.99
96-97	20	174	1.84	1.32	27	83	0.89	6.22
97-98	20	185	0.60	3.42	27	81	-0.10	0.64
98-99	20	193	0.61	1.83	27	84	2.50	0.38
92-93	21	163	2.35	5.59	28	1026	-1.40	-2.48
93-94	21	162	0.18	2.71	28	1022	3.41	5.82
94-95	21	158	-4.12	-7.77	28	1023	2.33	1.10
95-96	21	160	5.70	11.62	28	1010	-0.97	3.90
96-97	21	166	1.00	5.17	28	1005	1.76	3.59
97-98	21	192	0.07	1.34	28	1031	0.04	1.06
98-99	21	198	0.09	1.72	28	1077	-2.73	0.51
92-93	22	737	-1.01	1.68	29	919	-1.49	-0.68
93-94	22	708	3.98	7.46	29	896	2.73	6.30
94-95	22	702	4.46	0.29	29	911	3.35	5.13
95-96	22	682	-0.98	4.31	29	895	0.30	3.69
96-97	22	657	0.98	4.95	29	839	1.32	3.39
97-98	22	631	1.13	3.58	29	853	-1.64	-3.64
98-99	22	632	-0.30	0.74	29	892	-0.95	1.02

Period	SBI	Number of observations	*GOTFP* change	*VATFP* change	SBI	Number of observations	*GOTFP* change	*VATFP* change
92-93	30	32	-2.64	-6.47	34	137	-1.40	-2.68
93-94	30	29	7.67	19.96	34	142	4.88	26.37
94-95	30	28	6.16	6.93	34	145	0.92	-1.13
95-96	30	24	10.84	15.19	34	143	-1.91	-0.88
96-97	30	25	3.98	15.26	34	143	-0.02	3.01
97-98	30	22	7.05	33.29	34	146	0.58	4.26
98-99	30	23	0.07	0.48	34	150	-0.91	-4.11
92-93	31	151	-0.59	0.11	35	163	-4.60	-6.61
93-94	31	149	1.37	3.53	35	154	0.63	4.37
94-95	31	153	-1.24	-1.04	35	157	1.32	0.13
95-96	31	161	2.91	9.68	35	162	-0.23	0.80
96-97	31	166	-1.03	-0.20	35	162	0.54	3.03
97-98	31	160	0.65	2.93	35	151	0.02	5.66
98-99	31	161	1.16	2.75	35	148	-2.39	-1.61
92-93	32	47	6.79	13.60	36,37	392	1.20	4.95
93-94	32	41	3.93	6.18	36,37	381	0.94	2.50
94-95	32	43	0.51	1.24	36,37	393	0.48	0.84
95-96	32	40	-4.13	-12.55	36,37	390	-0.36	1.87
96-97	32	39	5.23	13.69	36,37	385	2.38	4.12
97-98	32	43	0.02	3.71	36,37	374	-0.66	1.55
98-99	32	57	1.05	4.28	36,37	404	-0.96	-0.89
92-93	33	177	0.47	2.79				
93-94	33	177	3.17	5.73				
94-95	33	184	8.38	20.16				
95-96	33	177	5.67	9.54				
96-97	33	178	0.53	-0.58				
97-98	33	174	0.44	4.72				
98-99	33	182	1.33	2.58				

The next pages report these results in graphical form. In each panel the gross output based productivity change is represented by diamonds, and the value added based productivity change by squares. The two graphs are based on the same observations. Outliers are observations with their *GO*/*PC* ratio in the 1^{st} or 99^{th} percentile of the distribution at the most detailed level of the STAN industry classification.


VATFP and GOTFP change, sbi 15, 16
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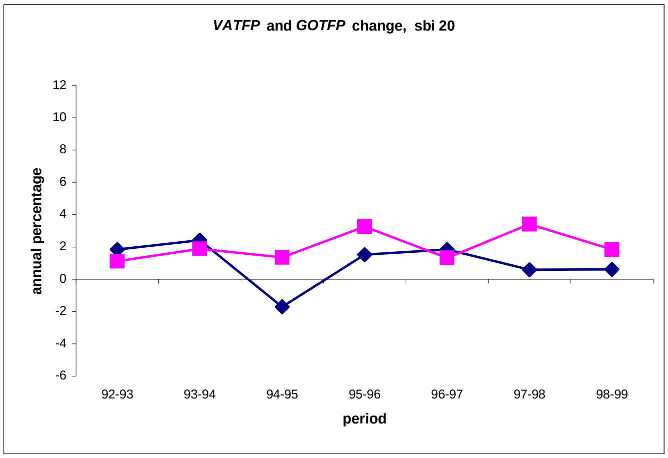
92-93
93-94
94-95
95-96
96-97
97-98
98-99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annual percentage
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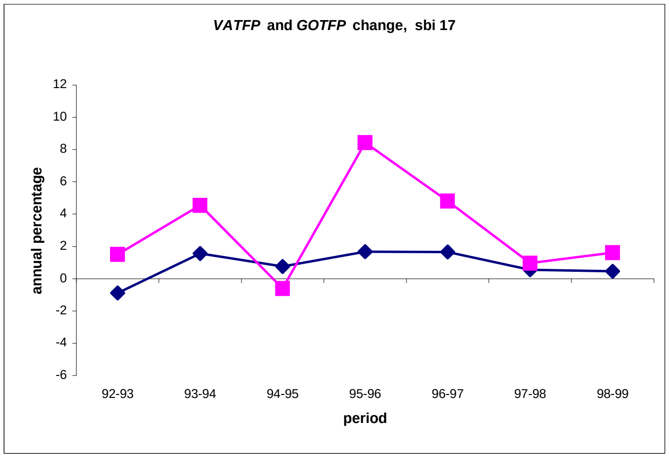
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annual percentage
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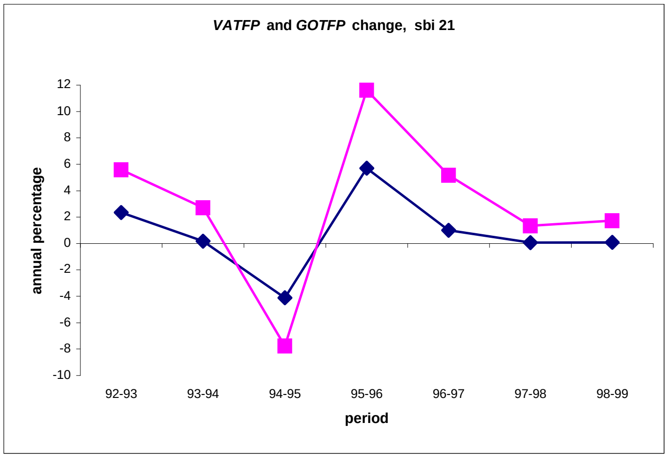
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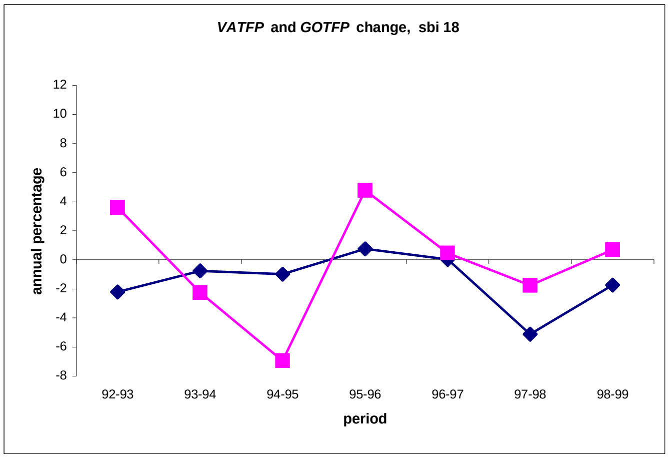
annual percentage
period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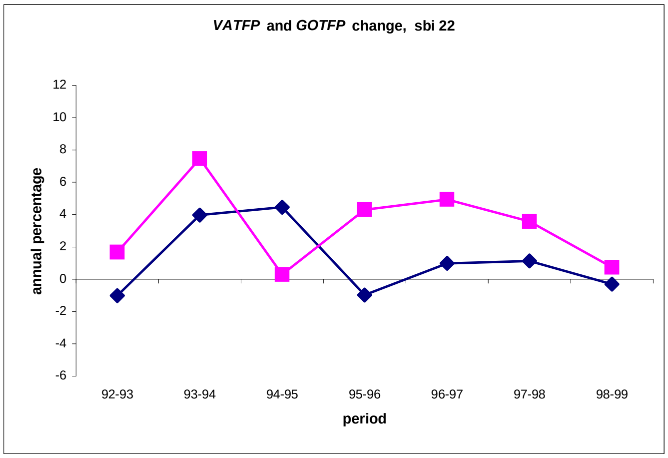
period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annual percentage
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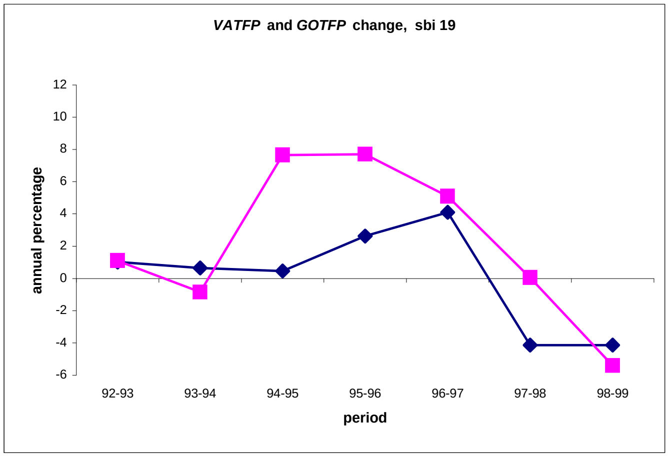
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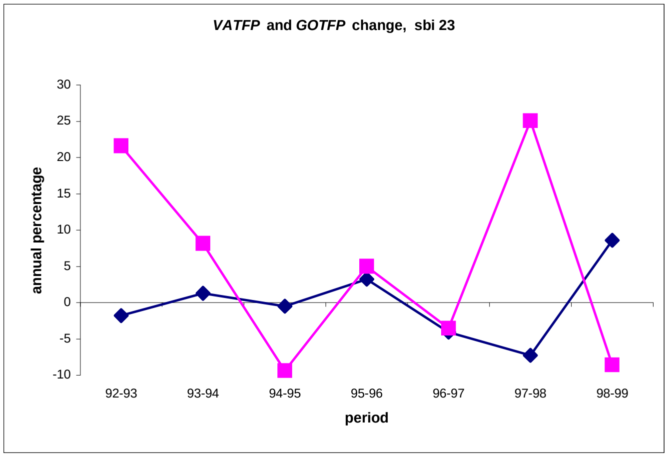
annual percentage
period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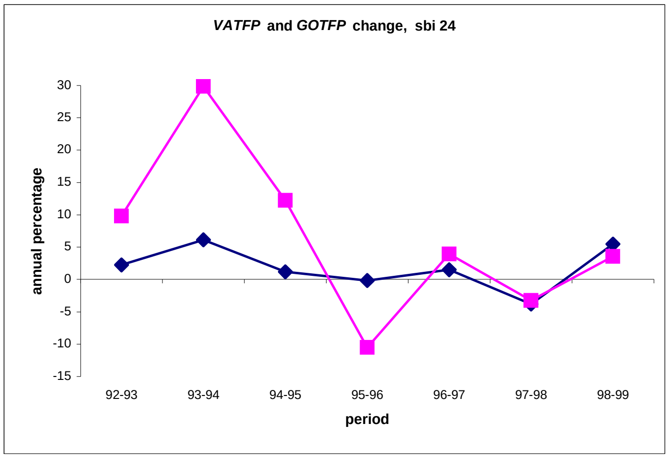
annual percentage
period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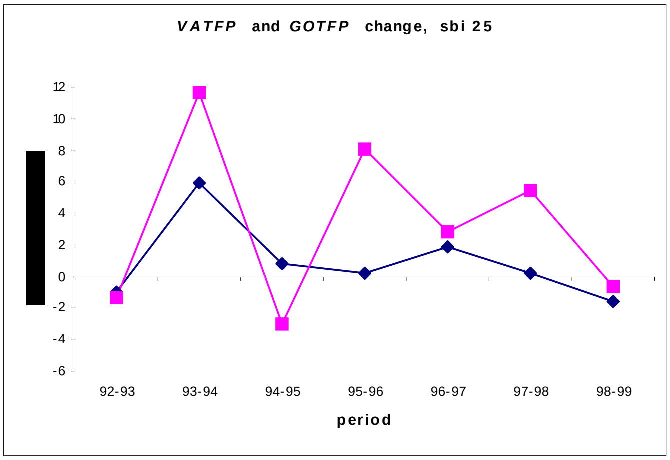
92-93 93-94 94-95 95-96 96-97 97-98 98-99
period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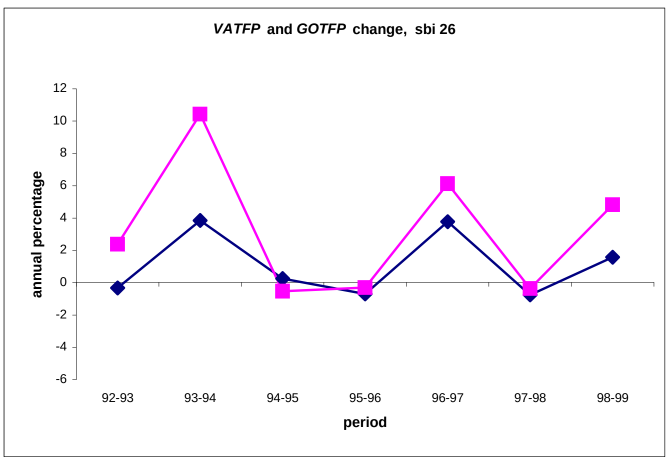
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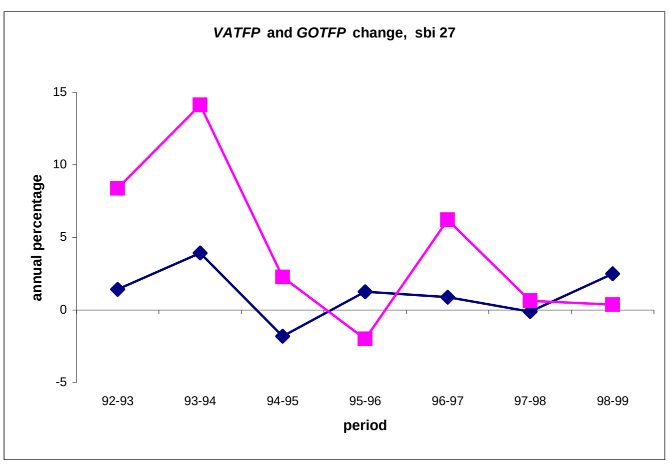
period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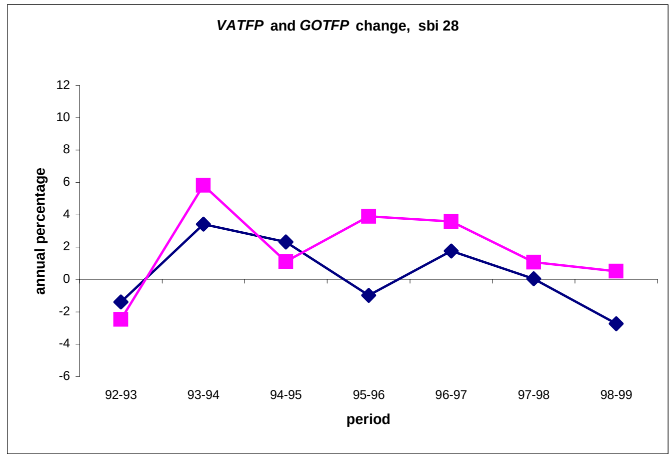
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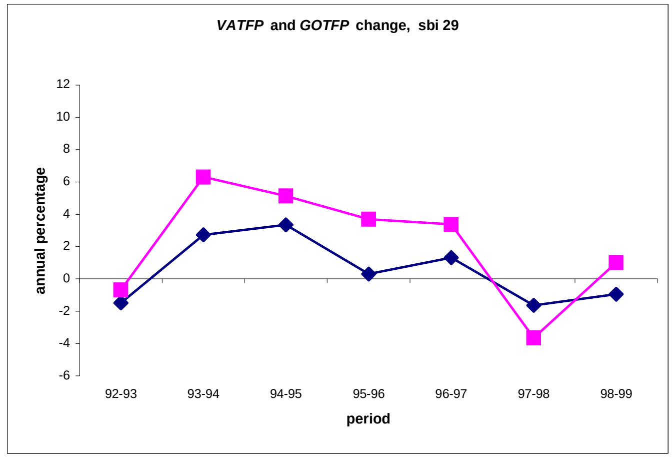
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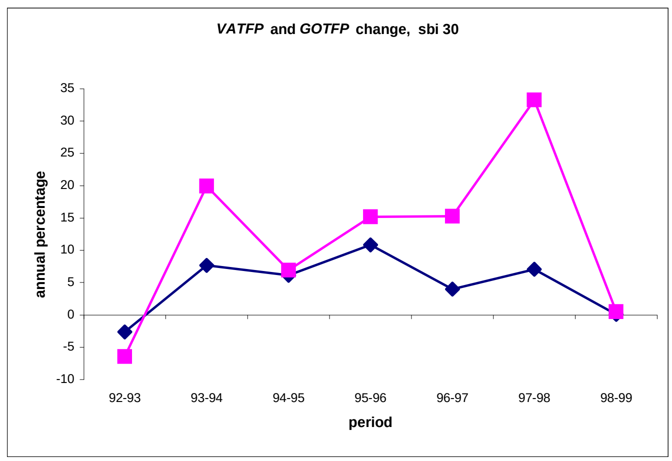
period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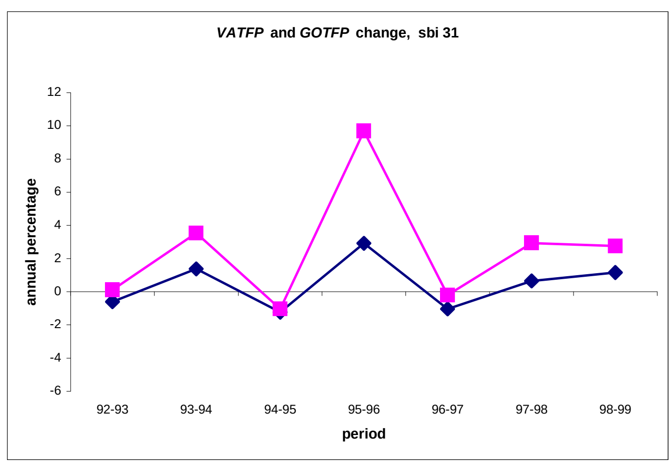
period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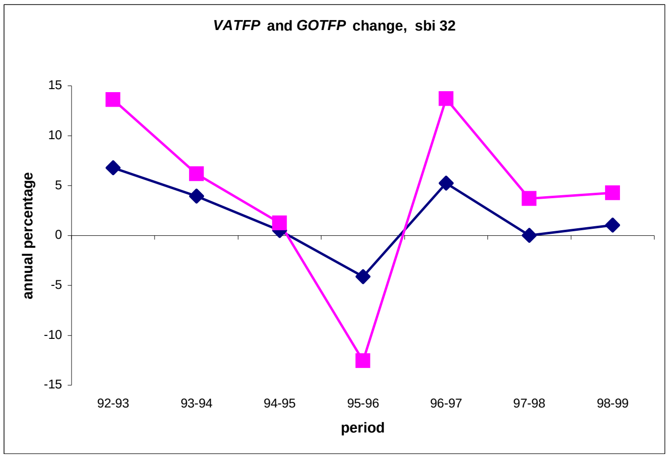
period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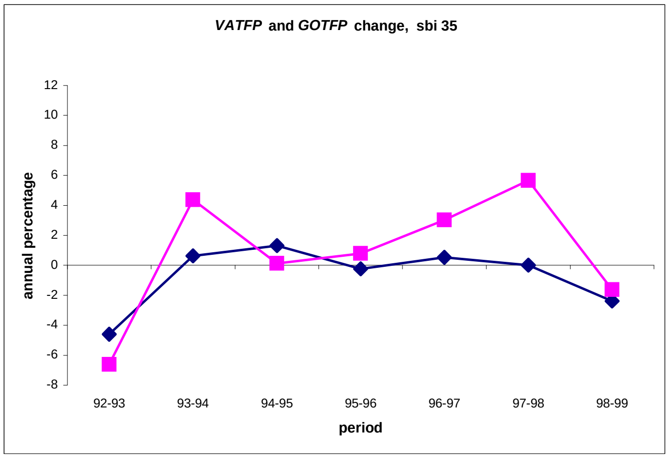
96-97
97-98
98-99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94-95
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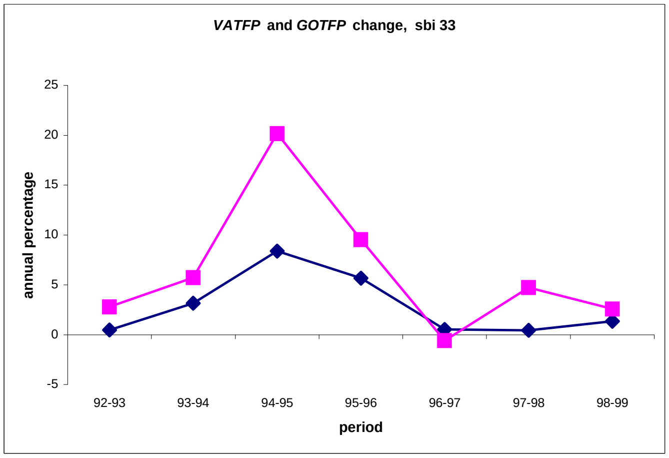
97-98
98-99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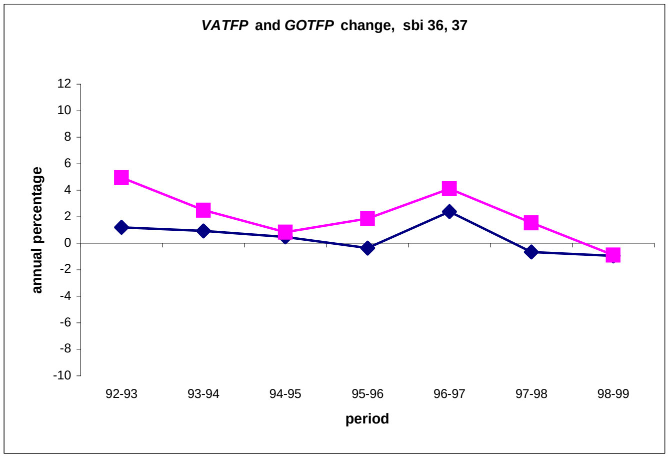
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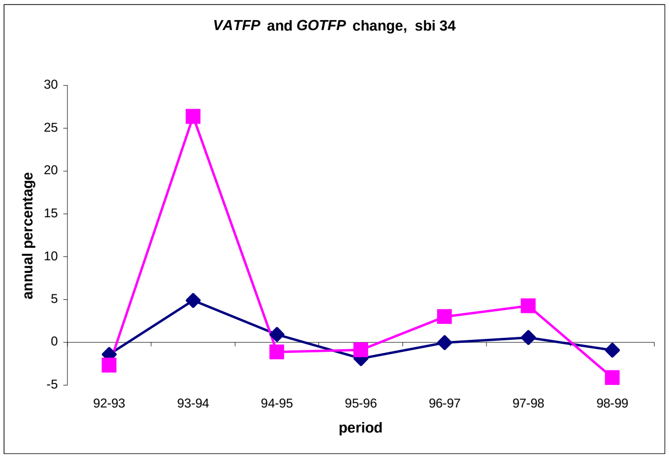
VATFP and GOTFP change, sbi 34
annual percentage
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93-94
94-95
95-96
96-97
97-98
98-99