Are Dutch Services Industries Becoming More Productive? Explorations on Micro-data

Discussion paper 03002

Jacco Daalmans

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Statistics Netherlands

Voorburg/Heerlen, 6 May 2003

Explanation of symbols

.	= data not available
*	= provisional figure
x	= publication prohibited (confidential figure)
–	= nil or less than half of unit concerned
–	= (between two figures) inclusive
0 (0,0)	= less than half of unit concerned
blank	= not applicable
2002–2003	= 2002 to 2003 inclusive
2002/2003	= average of 2002 up to and including 2003
2002/’03	= crop year, financial year, school year etc. beginning in 2002 and ending in 2003

Due to rounding, some totals may not correspond with the sum of the separate figures.

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ARE DUTCH SERVICES INDUSTRIES BECOMING MORE PRODUCTIVE? EXPLORATIONS ON MICRO-DATA

Summary: Statistics Netherlands is planning to set up a system of productivity statistics. An innovative approach is to directly build up productivity indices from data at the level of the individual firm. To study the feasibility of this approach, several exercises have been carried out, using micro-data on trade services, transport services and business services. It will be shown how sensitive productivity indices are with respect to the method. Some recommendations about the method will be given.

Keywords: Productivity change, decomposition methods, micro-data, trade services, transport services, business services, firm mutation.

1. Introduction

Who does not want to work less and get more wealth at the same time? This is not an utopia, it can be achieved by an increase of productivity. Productivity is the amount of work that can be done in some given amount of time by one person or one factory. Productivity growth leads to better standards of living. For instance: if public transport becomes faster, a baker who uses the public transport has more time available for producing bread so that he can earn more money, or alternatively he has more time available to go to the casino to spend his money.

Productivity growth will more and more become an important instrument to achieve economic growth, i.e. the growth of the number of goods and services that can be consumed by some country. Economic growth can namely be achieved in two ways: by an increase of productivity, or by the use of more labour or machines. In practice it is not always feasible to increase the number of working persons. This problem is very relevant to our times, due to the ageing population. Growth of productivity is therefore very important to increase our standards of living.

Where does productivity growth come from? It does not come from working harder, since this may increase output, but it also increases labour input. Productivity growth comes from working smarter. That means adopting new technologies, a more efficient use of machines, and upgrading the skill of the workers. The greatest increase in productivity has historically been associated with important inventions, for instance the steam engine.

A lot of research has been done to explain productivity growth, for instance to study whether new firms are more productive than existing firms, or whether high productive firms attract more new employees than less productive firms. The results can be used to efficiently set out policy that improves productivity. The trend is to use firm-level data, rather than to focus on higher level aggregates, such as the manufacturing industry as a whole, since these micro-data are more appropriate to explain aggregate productivity change.

Currently, Statistics Netherlands is planning to set up new productivity indices. It considers to directly build up these statistics from micro-data. For the Netherland's manufacturing industry Balk and Hoogenboom-Spijker (2003) computed such productivity indices and they studied the sensitivity with respect to the method.

In this paper for three Netherlands services industries: trade services, transport services and business services, productivity indices are studied, that are directly built from micro-data. The aim of this is to find out whether it is feasible for Statistics Netherlands to publish such indices. Furthermore it will be shown what happens to the results if different methods are applied. This leads to some recommendations with respect to the choice of the specific index.

In section 2 some characteristics of the services industries are presented. The theory on measuring productivity change is presented in section 3. Some characteristics of the data sets and the method are described in section 4. Initial results are discussed in section 5. Several extensions to the method are considered in section 6. Section 7 concludes.

2. Characteristics of the industries

Three services industries: trade services, transport services and business services, are topic of this paper. Trade services captures wholesale services and retail services, transport services involves a diversity of transport services as well as post and telecommunication and business services involves seven main branches.[1]

Productivity indices for services industries would be of great importance. One reason is the large share of GDP: the contributions of value added of trade, transport and business services added up to 42% of Netherlands GDP in 1999, while the part of manufacturing industries accounted for only 17%. This means that productivity change of services industries is an important factor of economic growth.

Statistics Netherlands publishes a labour productivity index at the meso level, i.e. at the level of industries. For instance one productivity index is published that involves retail trade services, wholesale trade services, repair services, restaurants and hotels. In this paper the focus is on less comprehensive branches of industry. For these branches productivity changes have been computed from other statistics that are published by Statistics Netherlands.[2] As shown in Figure 1, for trade services and business services labour productivity changes increased during the 90s, while the reverse picture can be seen for business services.

For business services Van der Wiel (1998), Audretsch et al. (1997) and CPB (2002) gave several explanations for labour productivity index numbers, that were based on insights from micro-data. One of these is that new firms are relatively unproductive. This problem is especially important, since an increasing number of new firms enter the market.

Other characteristics are presented in Table A.2 and Table A.3. One of these is that business services are small on average. As mentioned by Audretsch et al. (1997), “the Dutch are an economy of small shopkeepers when it comes to services”. Thus it would be interesting to study productivity change of small firms. This cannot be done from the currently published indices. Micro-data have to be used instead. Thus, further research could benefit from new productivity indices which are directly built from micro-data.

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[1] Renting of movables, computers and related activities, legal and economic activities, architectural services, engineering activities, advertising and activities of employment agencies.

[2] Computed by the ratio of gross value added at the price level of 1995 and the number of persons employed.

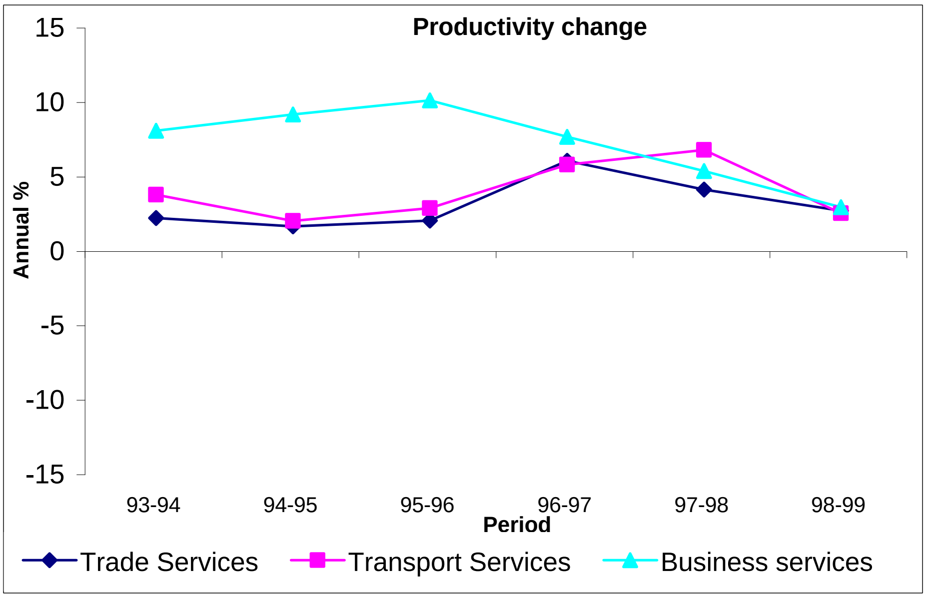

Figure 1. Labour productivity change for three services industries. Source: Statistics Netherlands (2003).

3. The theory of productivity measurement

In section 3.1 it is explained how productivity can be measured for individual firms, as well as for any aggregate of firms. Furthermore it is discussed how aggregate productivity change can be computed and decomposed into contributing factors of entering, continuing and exiting firms. Two types of decompositions are discussed in section 3.2.

3.1 Concepts of productivity change

The productivity *level* at a period is defined as the amount of real output per unit of real input, where the word real means: computed at some standard price level. While it is easy to define, it is notoriously difficult to measure, especially for services industries.

Traditionally five types of input are distinguished: capital (hereafter referred to as *K*), labour (*L*), energy (*E*), materials (*M*) and services (*S*). A measure of labour ideally reflects the actual time worked of all employees and the quality of labour. Capital is ideally measured by its user cost. Labour and capital are called primary input factors. Energy, materials and services are intermediate inputs. Firms purchase these from other firms, or they are imported.

Output is not just the number of breads produced by a baker, or the number of statistics published by a statistical office, but rather the real value that is created. This value depends on product quality, timeliness etcetera. Output measures that are widely used are: gross output and value added. Gross output is defined as the sum of total turnover, change in stocks, margins on trading and other revenues. Value added is defined as the difference between gross output and cost of intermediate inputs.

An aggregate productivity level for some period *t*, denoted by $PROD^t$, can be computed by weighting together productivity levels of single firms. It is natural to use a weighted arithmetic mean, that is:

$$PROD^t = \sum_i q^{it} PROD^{it} , \quad (3.1)$$

where the summation is taken over all firms existing at period *t*, $PROD^{it}$ denotes the productivity level of firm *i* at period *t* and q^{it} denotes a measure of relative size of firm *i* at period *t*, which means that:

$$\sum_i q^{it} = 1 \quad (3.2)$$

Productivity *change* can be calculated in any pairwise comparisons by subtracting the aggregate productivity *level* of the *base* period (chronologically the first period) from the aggregate level of the comparison period (chronologically the second period), that is:

$$DPROD^{10} = PROD^{1} - PROD^{0}\ , \tag{3.3}$$

where $DPROD^{10}$ denotes aggregate productivity change and $PROD^{1}$ and $PROD^{0}$ denote aggregate productivity levels of the comparison period and the base period, respectively. By combining (3.1) and (3.3) we obtain:

$$DPROD^{10} = \sum_i q^{i1} PROD^{i1} - \sum_i q^{i0} PROD^{i0}\ , \tag{3.4}$$

where the first summation is taken over all firms existing at period 1 and the second over all firms existing at period 0. Aggregate productivity change as a percentage can be computed as:

$$\frac{DPROD^{10}}{PROD^{0}} = \frac{\sum_i q^{i1} PROD^{i1} - \sum_i q^{i0} PROD^{i0}}{\sum_i q^{i0} PROD^{i0}}\ . \tag{3.5}$$

Other definitions are also used: often aggregate productivity levels are computed as weighted geometric means:

$$PROD^{t} = \prod_i (PROD^{it})^{q^{it}}\ , \tag{3.6}$$

where the product is taken over all firms existing at period *t*.

Instead as a difference, productivity change is often defined as a ratio:

$$IPROD^{10} = \frac{PROD^{1}}{PROD^{0}}\ . \tag{3.7}$$

If (3.6) and (3.7) are combined we obtain:

$$IPROD^{10} = \frac{\prod_i (PROD^{i1})^{q^{i1}}}{\prod_i (PROD^{i0})^{q^{i0}}}\ , \tag{3.8}$$

where the product in the numerator is taken over all firms existing at period 1 and the product in the denominator is taken over all firms existing at period 0. Taking natural logarithms leads to:

$$D\ln IPROD^{10} = \sum_i q^{i1} \ln PROD^{i1} - \sum_i q^{i0} \ln PROD^{i0}\ , \tag{3.9}$$

which is approximately equal to the percentage of aggregate productivity change, if this percentage is small. Note that expression (3.4) and (3.9) have the same structure. It is preferred to use the first, since it is more intuitive.

3.2 Decompositions of aggregate productivity change

In order to get more insight, aggregate productivity change is often decomposed into four contributing factors. Two factors capture dynamics in the population of firms, i.e. the process that new firms appear in the population and that other firms close down. The first is the contribution of entering firms. In any bilateral comparisons these are firms that are active at the comparison period only. Aggregate productivity increases (decreases) if entering firms have above-average (below-average) productivity levels.

The second belongs to exiting firms. That is: firms that were in operation during the base period, but no more during the comparison period. The contribution to aggregate productivity change is positive, if productivity levels of exiting firms are below average.

The third and fourth contributing factors capture changes of continuing firms, i.e. firms that were active, both at the base period and at the comparison period. These firms can contribute positively to aggregate growth in two ways: by an increase of productivity levels, or by an increase (decrease) of relative size of above (below) average productive firms.

In the literature several results of decompositions have been published. Thus, there is a lot of need for decompositions results. Consequently it is worthwhile to publish these.

The decomposition of aggregate change into contributions of entering, continuing and exiting firms is not unique. Of the decompositions reviewed by Balk (2001), two are especially important. The first is expressed by:

$$\begin{aligned} DPROD^{10} = & \sum_{i\in N} q^{i1}(PROD^{i1} - a) + \\ & \sum_{i\in C} \left(\frac{q^{i0}+q^{i1}}{2}\right)(PROD^{i1} - PROD^{i0}) + \\ & \sum_{i\in C} (q^{i1} - q^{i0})\left(\frac{PROD^{i0}+PROD^{i1}}{2} - a\right) - \\ & \sum_{i\in X} q^{i0}(PROD^{i0} - a), \end{aligned} \qquad \text{(D.1)}$$

where $a = \frac{PROD^{0} + PROD^{1}}{2}$, i.e. the average productivity level, C, N and X denote the sets of continuing, entering and exiting firms respectively, $PROD^{it}$ denotes the productivity level of firm i at period t and $PROD^{t}$ denotes the aggregate productivity level at period t. This decomposition was proposed by Griliches and Regev (1995) and will therefore be called the GR-decomposition. The first term refers to the contribution of entering firms, called the *entrants term*, the second and third add up to the contribution of continuing firms and the fourth is related to the contribution of exiting firms, which is referred to as the *exiters term*. The second term is a weighted average of firm-level productivity changes, holding relative sizes fixed and is called the *within term*. The third term captures shifts in relative size and is called the *between term*. Note that weights are averaged over base periods and comparison periods.

The second decomposition is expressed by:

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

where a denotes an arbitrary scalar.

The within term and between term are represented by the second and the third term, respectively. Both use base period weights. Therefore a natural choice for a seems to be $PROD^0$, the base period aggregate productivity level. This leads to the decomposition proposed by Foster et al. (1998), which will be called the FHK-decomposition hereafter.

The main difference between the GR-decomposition and the FHK-decomposition is the appearance of the fourth term in decomposition (D.2). This so-called *covariance* or *cross term* tells us something about the interaction between change of relative size and productivity. It is positive if firms that increase (or decrease) relative size also increase (decrease) productivity level. Haltiwanger (2000) noted that this term is sensitive to random measurement error. Moreover Balk (2001) mentions that one should be careful with reifying this term, since it can be considered as an artifact arising from the specific decomposition chosen. Another disadvantage of (D.2) is its asymmetry: the exiters term reflects deviation of productivity levels from the average level at the same period (i.e. the base period), while the entrants term reflects deviation of comparison period productivity levels from the base period average. Thus both terms cannot appropriately be compared. For these reasons the GR-decomposition is preferred.

The choice of the decomposition does matter. In section 5 it will be shown that the outcomes of any decomposition exercise will depend on the particular expression that is chosen.

4. Data and method

As the data available determine what methods can be implemented, in section 4.1 some characteristics of the data sets are described. Section 4.2 explains how the data sets were created. The method that was used as starting point is explained in section 4.3.

4.1 Characteristics of the data available

The production surveys

Data on the input and output of firms came from several *production surveys* (PS). A PS is an annual survey that includes information about economic activity, revenue, cost, employment and branch specific information.

The statistical unit is the *firm*. Its main characteristics are autonomy with respect to the production process, the possibility to describe it in a statistical way and external orientation.[3] One or more firms form an *enterprise*, which is autonomous with respect to the financial process.

Firms with more than 20 employees are completely covered by the PS, whereas smaller firms are sampled. Production surveys include records of responding firms, but may also include imputed data. Moreover raising factors are included that can be used to derive population estimates from sample data.[4] Definitions of key variables in the PS are given in Table A.4. All variables required for productivity change analysis can be obtained from the PS. Some variables are not directly included; they can be derived from other variables. For example gross output can be computed as the sum of total net turnover and other revenues.[5] Another variable, value added, can

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[3] The definition of the firm corresponds to the kind of activity unit (KAU) of the EU and the establishment of the United Nations.

[4] The population of all firms was stratified into classes, according to size and main economic activity. For business services and wholesale trade services stratum-specific raising factors were computed by the volume of firms in the stratum divided by the volume of firms in the sample, where the volume of firms is determined by the total number of months of registration in the ABR. However, raising factors were set to 0 for firms that did not report any activity in the PS. For retail services stratum-specific raising factors were set to equal the total net turnover of the firms in the stratum divided by total net turnover of all firms in the PS sample, where data on net turnover came from a different survey. For transport services raising factors of outliers in the PS sample were set equal to 1. For the other firms raising factors were set equal to: (Total number of firms in the stratum minus the number of outliers in the PS sample) divided by (Total number of firms in the PS sample minus the number of outliers in the PS sample).

[5] ‘Other revenues’ includes revenues with respect to subsidies, received damages benefits, received rental payments, received payments for personal lent out, revenues related to private

be computed in different ways, depending on the variables available.[6] Energy cost appears as a specification of car cost and accommodation cost.

Comparisons problems

Several changes in the PS occurred in the course of time. One of these is a radical change of the classification system of economic activity. Prior to 1993 SBI74 was used, from 1993 onwards SBI93. All data were recoded to the last system.[7]

In 1993 new firm identifiers were introduced. Original identification codes were recoded. However, this was impossible for firms that ceased operation in or before 1993; original codes were used for these firms.

Comparability of PS is also hampered by revisions of questionnaires in 1995 and in 1998.

The general business register

The PS are based on the General Business Register (in Dutch: Algemeen bedrijven register, ABR). This register contains information about SBI93 code, size class, legal form, location, date of first appearance, date of liquidation, and since 1993, mutation code. The latter means that the business register includes information about merger, take-over, break-up and split-off.

National Accounts

Deflators for production, intermediate use and value added were derived from the supply and use tables of the National Accounts. Deflators were available for the period 1987-1999, at a more detailed level than the official publications: 10 are related to a 2-digit SBI93-class, 45 are related to a 3-digit SBI93-class, 18 are related

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use of telephones and cars and other revenues. Only in the PS Commercial services this variable also includes change of work in process.

[6] For the PS Commercial services value added was computed by subtracting compensation for purchased materials and for work that was done by other firms from total gross output. For other production surveys it was computed by adding compensation for labour and depreciation cost to operating profit.

[7] If firm-specific data were included in the PS of both 1992 and 1993, the matching was straightforward: the original 1992 codes were replaced by the new codes of 1993. To match the codes prior to 1992 the following procedure was carried out: If original codes were the same as in 1992, they were recoded to the SBI93-code of 1993. Otherwise the original code was recoded to a corresponding SBI93-code. A complication is that some of the original codes can be matched to more than one SBI93-code; in that case one of the matching codes was selected. For firms that only appeared in the PS prior to 1993, original codes had to be matched to one of the matching SBI93-codes

to a 4-digit SBI93-class and 17 are related to a 5-digit SBI93-class. In general the most detailed deflators were available for the most recent years.

In order to harmonize price and volume measurement in European countries, Eurostat (2001) published several guidelines for constructing price indices. One of the main principles is that a deflator should be representative, i.e. based on all outputs of an industry. Current services industry deflators often do not satisfy this guideline. Three main methods can be distinguished for constructing deflators.

The first is to use a consumer price index (CPI). Services industries to which this method was applied are cleaning services and real estate services, amongst others. A CPI only covers price change on the consumer market. However, business services are mainly consumed by firms. For example, only 5 percent of the output value of building cleaning services is sold to consumers. A CPI-based deflator is not representative, since it is unclear whether price changes on the business market and on the consumer market are identical.

A second method for constructing output price indices is to divide value index numbers by indicators of volume change. Such deflators often only cover a part of the production.

A third method for constructing output price indices is to use the price change of one or more input categories. This method is often applied to services where market output prices or volumes are difficult to observe. Employment agencies, security firms and transport via pipelines are kinds of services to which a wage-based deflator is applied. These deflators are not appropriate for measuring productivity, as input-based deflators reflect assumptions on productivity change. For example, if the change of wages is used to deflate output, it is implicitly assumed that labour productivity is constant.

Like other statistical agencies Statistics Netherlands is doing research on improving price and volume measurement, especially for services industries. At this moment the current deflators have to be used.

4.2 The data set

Productivity change is ideally measured by using data that are based on the same population of firms over time. However, the population covered by production surveys fluctuates over time. Therefore parts of the populations were selected for which data were (mostly) available over some time interval. Those data sets involve:

Trade services: The data set covers the period 1988-1999, except the years 1989 and 1991, and is based on PS Retail trade and PS Wholesale trade. Data on SBI-classes 5245 and 524940 are excluded, since no data were available on depreciation cost for 1998. Firms that belong to the wholesale industry with less than 10 employees were not covered in 1996, 1998 and 1999.

Transport services: The data set covers the period 1993-1999. Transport via railways is excluded, as data were not available for the full period. Moreover, records for "PTT Post B.V", "Postkantoren BV" and "KPN Telecom" are excluded for the same reason. Data on air transport services do not cover firms with more than 20 employees.

Business services: The data set covers the period 1993-1999, for classes 711-726, 7411-74151 and 742-745. Data on other SBI-classes are excluded, since they were not available for the full period.

Both true response and imputed data were used. However, if records in which all variables were imputed (item non-response) were deleted.

Non-deflated depreciation cost was used as quantity measure of capital, since neither data on capital services nor appropriate deflators were available.

As quantity measure of labour the number of persons employed was used. This measure includes hired employees, self-employed owners and part-time employees. Each employee is counted as 1 and the quality of the work force is not taken into account. In section 6.5.1 it is studied what happens if employees are replaced by full-time equivalent jobs.

Energy is related to accommodation only, not to transport.

4.3 The method

Initially, output was measured by real value added and input by labour and capital, that is:

$$PROD^{it} = \frac{RVA^{it}}{(L^{it})^{a^t}(K^{it})^{1-a^t}}, \tag{4.1}$$

with:

RVA^{it}: Deflated value added (gross output minus cost of intermediate use) for firm i at period t;

L^{it}: Number of persons employed by firm i at period t (including hired employees, self-employed owners and part-time employees);

K^{it}: Depreciation cost of fixed assets of firm i at period t (non-deflated);

a^t: Labour factor share at period t.

Labour factor shares a^t only depend on the period t, and were computed as the share of labour cost in value added:

$$a^t = \frac{\sum_i LC^{it}}{\sum_i VA^{it}}, \tag{4.2}$$

where the summation is taken over all firms existing at period t and LC^{it} denotes labour cost of firm i at time t. For each two successive periods, base period value added was converted to comparison period prices, by multiplication by price index numbers for value added. These index numbers have been computed by double-deflation, i.e. changes of (nominal) output were deflated by an output price index and changes of (nominal) input by an input price index.

Industrial price indices are assigned to the firms. This is not straightforward, since the industrial classification of firms in the production surveys can change over time. The pragmatic solution is that in bilateral comparisons the comparison period classification is used. If no observation is available for the comparison period, the base period business industry is taken instead.

Aggregate productivity levels were computed according to expression (3.5), using employment shares as weights, i.e.:

$$q^{it} = \frac{L^{it}}{\sum_i L^{it}}, \tag{4.3}$$

where the summation is taken over all firms existing at period t. To compute representative statistics all firm data were multiplied by raising factors.

Two productivity change decompositions were applied, both of which are based on decomposition (D.2). The first is the FHK-decomposition, which sets: $a = PROD^0$, the second sets $a = \frac{PROD^0 + PROD^1}{2}$ and will be called the FHKA-decomposition. Recall that the GR-decomposition (D.1) is preferred. The reason for choosing decomposition (D.2) is that results of other decompositions can be derived from the results of this decomposition. For example, the between term (within term) of the GR-decomposition can be computed by adding 0.5 times the covariance term of the FHKA-decomposition to the between term (within term) of this decomposition.

It would be straightforward to base a definition of entering, continuing and exiting firms on availability of records in the PS. For any pairwise comparison, firms are defined as entering (exiting), if they occur with data in the PS at the comparison (base) period, but not at the base (comparison) period. However, in fact, this decomposition does not lead to clear results, since parts of the production surveys are samples. Thus, two events during the comparison (base) period will lead to the assignment of entering (exiting) firms: the start (close down) of firms and the non-occurrence of an active firm in the PS sample. A clearer decomposition is obtained, when entering, continuing and exiting firms are defined from the ABR. Since all private firms are recorded, firms are defined as entering (exiting), only if they started (finished) operation. A complication is that firms that appear in the ABR can have missing PS data. Thus, in addition to entering, continuing and exiting firms, there are two other categories: continuing firms with missing base period data and continuing firms with missing comparison period data. Since productivity changes cannot be computed for continuing firms with missing data, these records were deleted.

Records of firms with one or more non-positive values for the variables: gross output, value added, turnover, labour cost, number of employees and depreciation cost were deleted. An outlier correction procedure was applied to the remaining data. This procedure deleted the lowest 1% and the highest 1% of all productivity levels, computed per sub-industry, in a similar way as in the expressions (4.1) and (4.2), except that value added was not deflated.

In order to avoid that entering and exiting firms were spuriously created, comparison period data were not used for firms of which base period data were deleted and vice versa. There occurred few firms in the PS which do not appear in the ABR. Their records were deleted.

For the three data sets, described in subsection 4.2, annual productivity changes were computed; for trade services they were derived as the square root of bi-annual changes for the periods 1988-1990 and 1990-1992.

An outline of the method is given in appendix B.

5. Results

Total factor productivity growth of the three services industries was low in the middle of the 90s, but increased toward the end of the 90s, as is shown in Figure 2. The increase was especially large for business services.

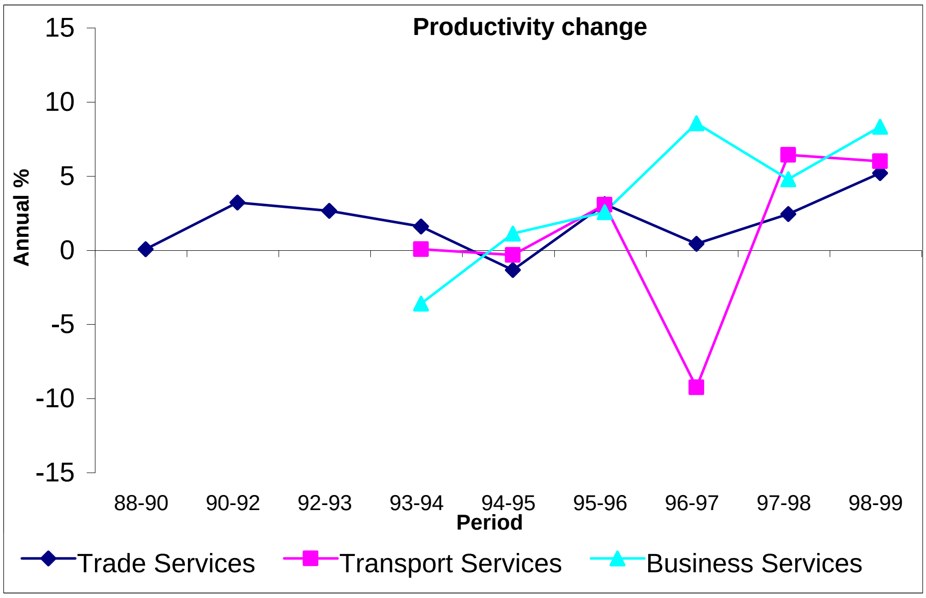


Figure 2. Annual productivity changes

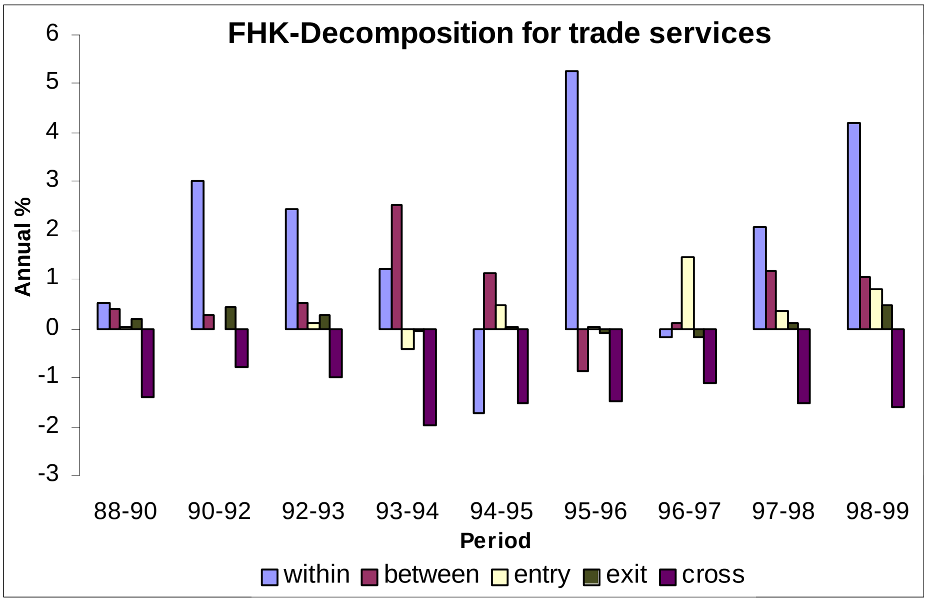
The percentages of entering and exiting firms are quite low: on average 93.1% of all firms are continuing, 5.0% entering and 1.9% exiting, as can be seen in Table 1. Higher percentages of entering and exiting firms are found in the firm demographic statistics: for trade services, transport services and business services[8] these were 10.6% and 3.5%, respectively in 1996. In section 6.7 an explanation for these low percentages is given.

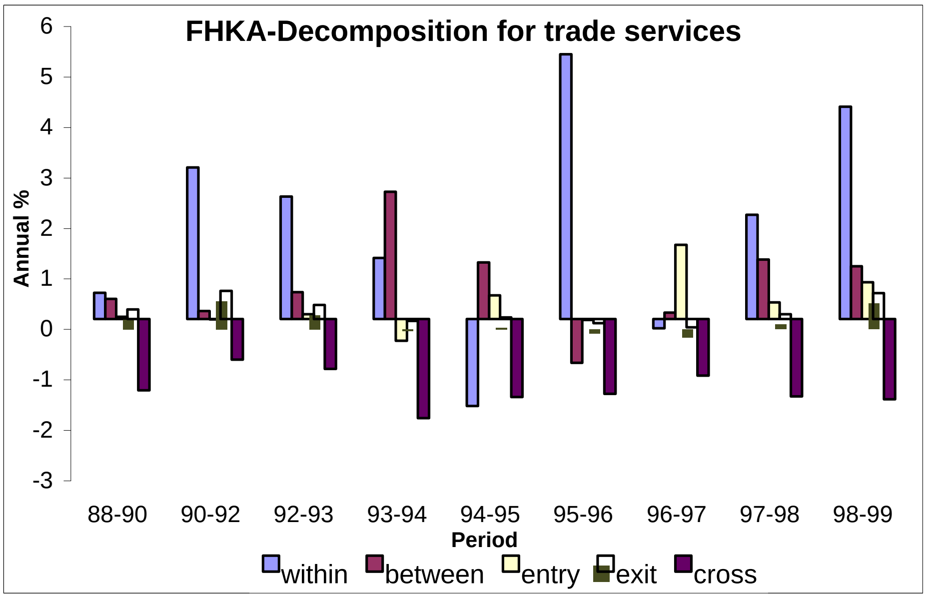
[8] Business services are related to SBI-class 74. Entry and exit due to a change of structure, for instance merger and takeover (see subsection 6.7.1), are not included in these percentages.

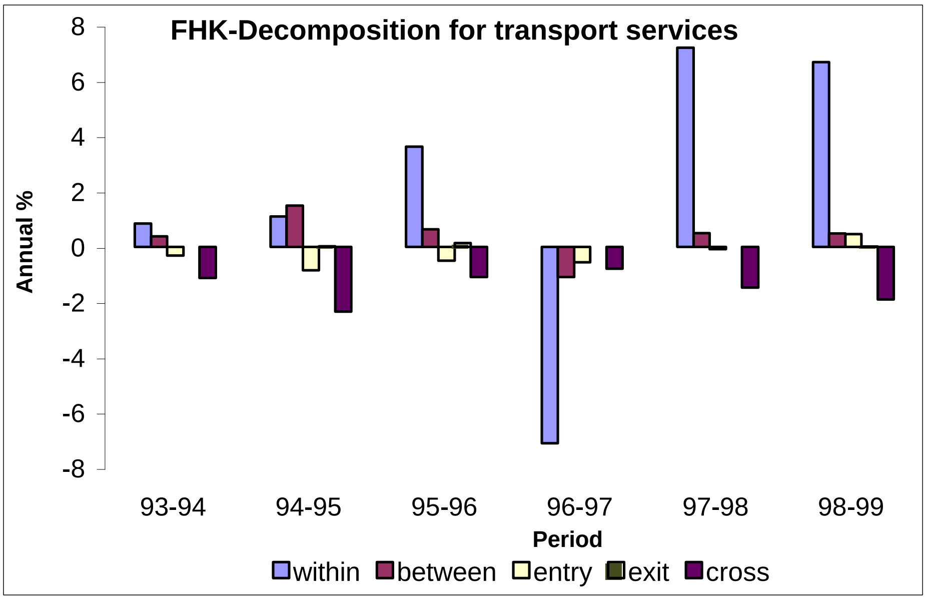
Table 1. Total number of continuing (C), entering (N) and exiting (X) firms and labour factor shares for base and comparison periods (respectively denoted by a^0 and a^1).

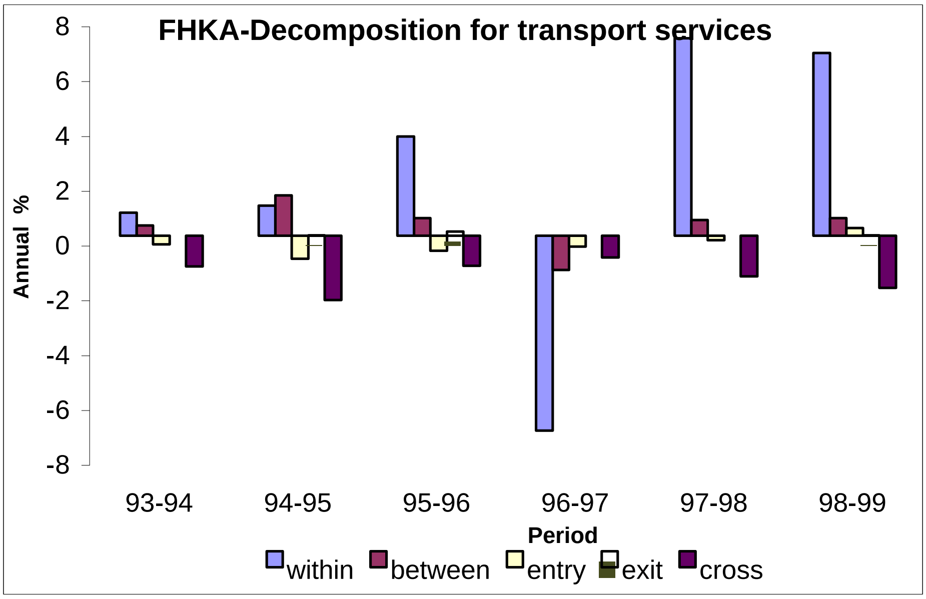
Data set	**Period**	**C**	**N**	**X**	**a^0**	**a^1**
Trade	88-90	7029	94	148	0.64	0.63
	90-92	7648	4	654	0.63	0.66
	92-93	6334	287	64	0.66	0.66
	93-94	10031	463	107	0.66	0.66
	94-95	11337	338	213	0.66	0.63
	95-96	9165	108	179	0.63	0.66
	96-97	8033	170	99	0.66	0.64
	97-98	8499	98	183	0.64	0.67
	98-99	8195	307	238	0.66	0.67
Transport	93-94	1480	87	0	0.72	0.70
	94-95	1666	134	1	0.70	0.72
	95-96	2353	108	15	0.72	0.73
	96-97	2214	105	0	0.73	0.70
	97-98	2311	110	6	0.69	0.71
	98-99	2195	151	44	0.71	0.72
Business	93-94	2663	304	57	0.71	0.70
	94-95	2985	363	20	0.70	0.66
	95-96	3755	531	19	0.65	0.73
	96-97	4186	559	31	0.72	0.74
	97-98	4557	599	72	0.75	0.75
	98-99	4892	1035	109	0.75	0.75
Average	88/00	5311	284	108	0.69	0.69
Average (%)	88/00	93.1	5.0	1.9		

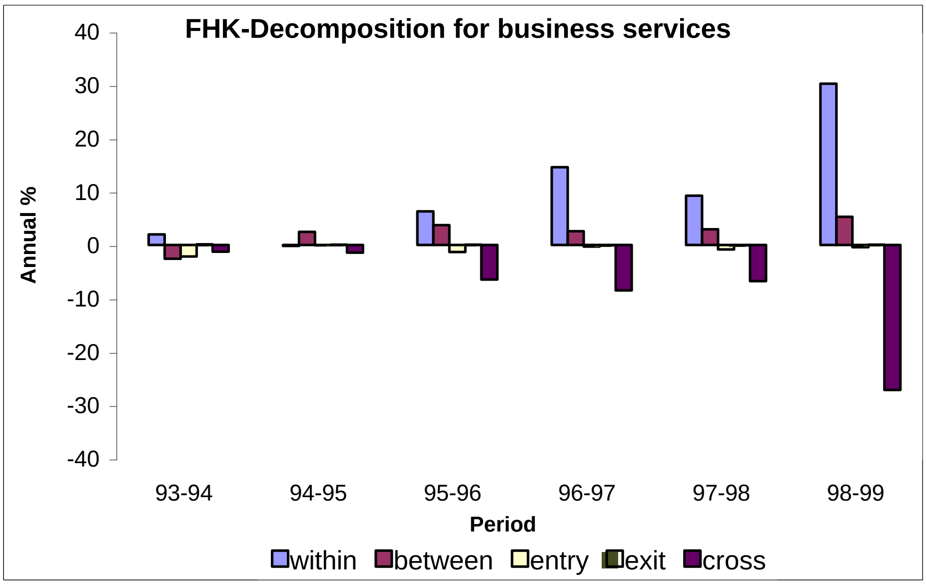
It does not matter much whether the FHK-decomposition is used, or the FHKA-decomposition; results in Figure 3 hardly differ.


FHK-Decomposition for trade services
Annual %
6
5
4
3
2
1
0
-1
-2
-3
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHKA-Decomposition for trade services
Annual %
6
5
4
3
2
1
0
-1
-2
-3
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHK-Decomposition for transport services
Annual %
8
6
4
2
0
-2
-4
-6
-8
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHKA-Decomposition for transport services
Annual %
8
6
4
2
0
-2
-4
-6
-8
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross



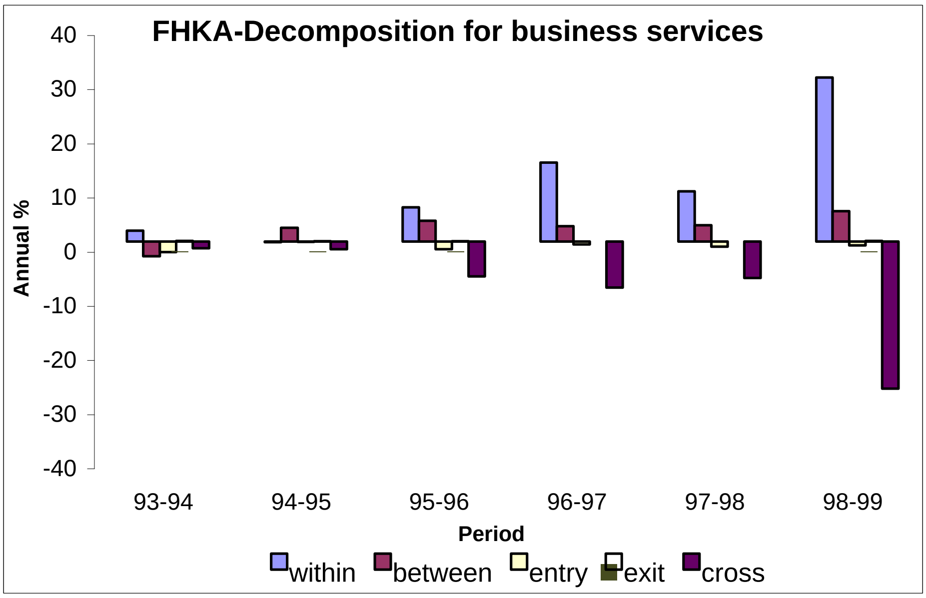


Figure 3. FHK and FHKA-decompositions.

In both decompositions the covariance-term is negative for all periods, which means that on average firms with decreasing employment share exhibit productivity increase. This result is consistent with findings of Barnes et al. (2001), amongst others. In absolute terms the covariance term is quite large. Recall that no covariance term appears in the GR-decomposition, discussed in section 3. Therefore results of the GR-decomposition will be appreciably different; the within term and the between term will be smaller.

The contribution of the within-term was substantial for the three services industries, but fluctuated considerably over successive periods. It was relatively unimportant in 93-94 and 94-95, periods in which the economy was slowing down, as is shown in Figure 4.

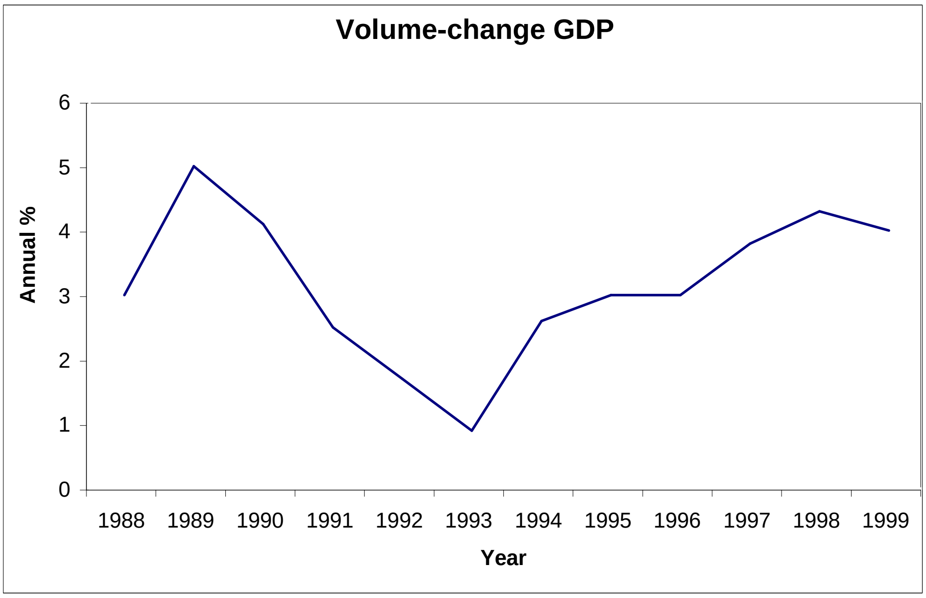


Figure 4. Volume-change in % of the Netherlands GDP; Source: National Accounts, Statistics Netherlands.

This result is consistent with the observation of a pro-cyclical within-term, observed by Foster et al. (1998) amongst others. This means that productivity growth within firms was not only an important component of aggregate productivity growth, but also of economic growth. In order to achieve some level of economic growth, productivity growth within continuing firms seems to be necessary.

For transport services and business services, the contribution of entering firms was negative and the contribution of exiting firms positive. That is: productivity levels of both entering and exiting firms were below the average level of all firms. For the manufacturing industry Balk and Hoogenboom-Spijker (2003) found a similar result for recent years.

The between-term was small but positive for most periods, which means that on average labour moved to more-than-average productive firms. Since positive between-terms are offset by large negative covariance terms, in decompositions without a covariance term most between terms will be negative.

6. Several extensions

After having presented results for an initial scenario, in this section it will be shown what happens to the results if changes are introduced to the methods and the concepts: *(i)* aggregate productivity changes are broken down into contributions of small and large firms; *(ii)* raising factors are fixed; *(iii)* gross-output based, turnover-based and labour productivity measures are computed; *(iv)* labour factor shares are defined in different ways; *(v)* alternative measures of labour are used; *(vi)* varying measures of relative size are used; *(vii)* a clear distinction of firm mutation will be made by linking production data to the business register.

6.1 Small firms and large firms

It will be discussed what happens to aggregate productivity change if small firms are omitted from the data sets. Firms with less than 20 employees are considered as small, all other firms as large.

Recall that productivity levels of individual firms were weighted together by employment shares. On average the employment share of small firms was considerable; i.e. 40.7% for trade services, 35.6% for transport services and 37.8% for business services. This tells us that small firms contribute appreciably to aggregate productivity change.

Productivity changes of small firms are quite different from those of large firms; compare Figure 5 with Figure 6. It can be seen that on average large firms exhibit higher productivity growth. This reflects that effects of scale are present.

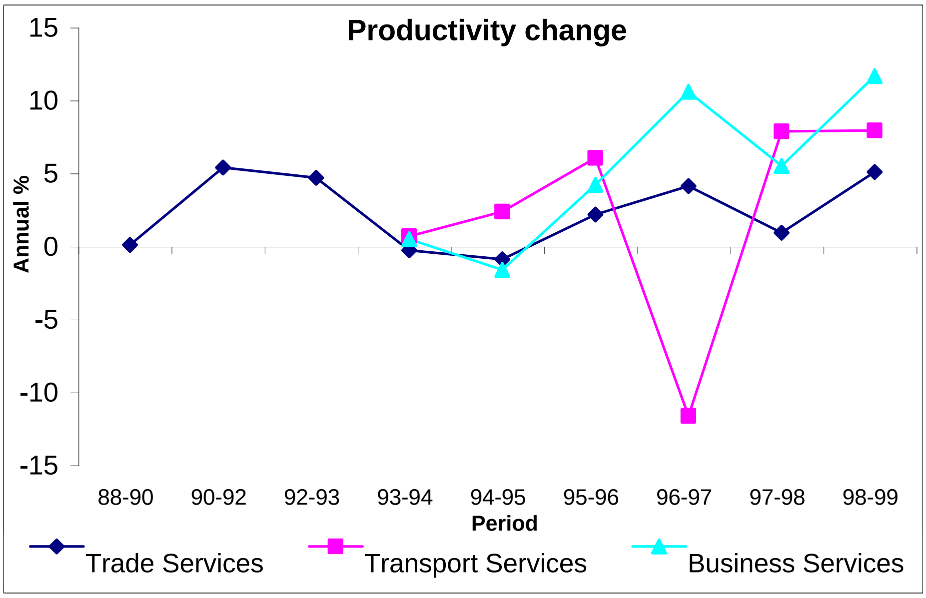


Figure 5. Productivity change; large firms.

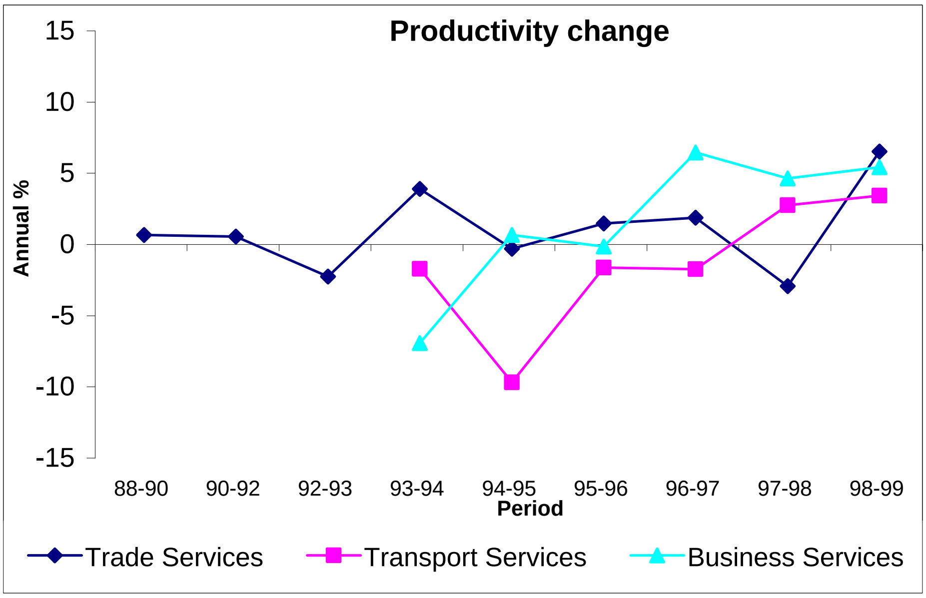


Figure 6. Productivity change; small firms.

From Table C.1 compared to Table C.2 can be seen that small firms have relatively low labour cost shares. This means that these firms are less labour-intensive than large firms. Another characteristic is that entering and exiting firms are small on average; compare Figure C.1 to Figure C.2.

6.2 Fixed raising factors

Recall that firm-level data were multiplied by raising factors. These factors vary over time. To study the effect on aggregate productivity change, it would be interesting to see what happens if raising factors are fixed at 1.

It can be expected that aggregate productivity change will be similar to productivity change of large firms, since small firms have relatively large raising factors. When all raising factors are set to 1 the average labour share of small firms was only 11.7% for trade services, 9.4% for transport services and 9.7% for business services.

Figure 7 corroborates the expectation; the patterns of aggregate productivity change are very similar to these of large firms (see Figure 5). This fact implies that changes of firm specific raising factors over time are not an important component of aggregate productivity change.

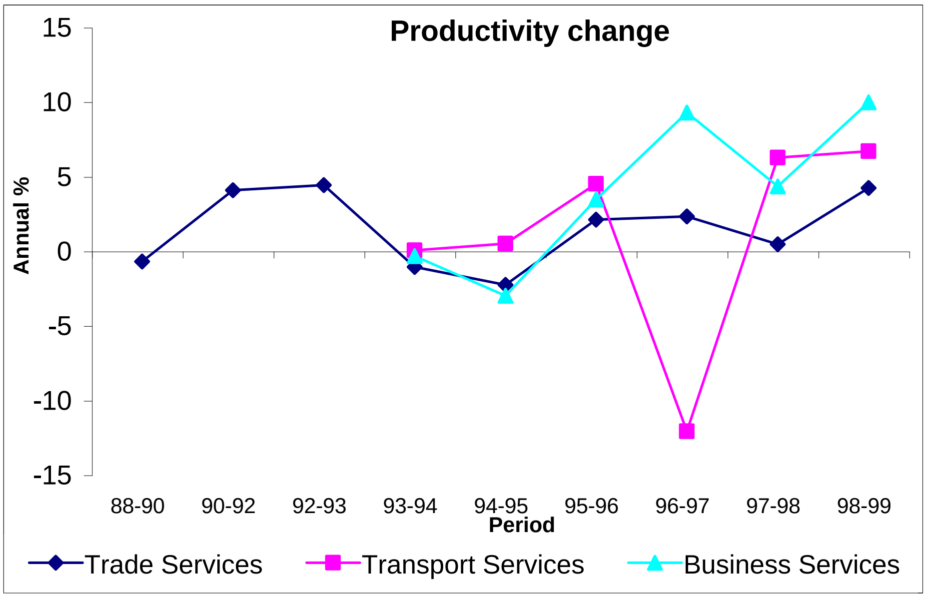


Figure 7. Annual productivity change; raising factors fixed at 1.

6.3 Alternative concepts

6.3.1 TFP: Gross output

Besides value added, gross output is often used as a measure of output in productivity measures. Recall that gross output is the sum of value added and intermediate consumption. Gross output is more intuitive than value added, since it is more closely related to the actual production of goods and services. However a complication is the double counting of intermediate products in aggregate measures.

Gross-output based productivity changes are presented in this subsection. The productivity measure of firm *i* at period *t* is defined as:

$$PROD^{it} = \frac{RGO^{it}}{(L^{it})^{a^t}(K^{it})^{1-a^t-b^t-g^t}(RE^{it})^{b^t}(RM^{it})^{g^t}}, \tag{6.1}$$

with:

RGO^{it}: Deflated gross output of firm *i* at period *t* (total net turnover plus other revenues).

L^{it}: Number of persons employed by firm *i* at period *t* (including hired employees, self-employed owners and part-time employees).

RE^{it}: Deflated energy cost of firm *i* at period *t* (energy cost as specification of accommodation cost only).

K^{it}: Depreciation cost of fixed assets of firm *i* at period *t* (non-deflated).

RM^{it}: Deflated materials cost of firm *i* at period *t* (computed as: gross output – value added + energy cost).

a^t: Labour factor share at period *t* (computed as aggregate labour cost relative to aggregate gross output, non-deflated).

b^t: Energy factor share at period *t* (computed as aggregate energy cost relative to aggregate gross output, non-deflated).

g^t: Materials factor share at period *t* (computed as aggregate materials cost relative to aggregate gross output, non-deflated).

In bilateral comparisons, base period energy cost and materials cost was converted to comparison period prices, by multiplication by price index numbers for intermediate use. Records in which materials cost and energy cost are positive, both at the base period and at the comparison period were used only.

Labour factor shares, materials factor shares and energy factor shares are given in Table D.1. From this table it can be seen that change in materials cost plays an important role in aggregate productivity change. For trade services materials factor shares were approximately 0.85, for transport services about 0.55. Large materials factor shares are not a peculiarity of services sectors; for the manufacturing industry Balk and Hoogenboom-Spijker (2003) computed shares of about 0.65, on average.

Energy factor shares were very low, i.e. smaller than 0.01 on average. Therefore energy cost seems to be an unimportant factor. However, one must bear in mind that energy cost data are related to accommodation cost only, not to transport cost. Obviously, energy cost related to transport is very important for transport services.

Productivity changes of Dutch manufacturing services were on average lower and less volatile when gross output was used instead of value added. As Figure 8 shows, the same applies to trade services and transport services. The increasing trend in productivity growth that was observed in Figure 2 (the initial scenario) does not appear in Figure 8. This implies that intermediate use grew faster than output.

Lower productivity change is consistent with the theoretical point of view (see for example Schreyer et al. (2001)). For the manufacturing industry, Balk and Hoogenboom-Spijker (2003) found the same phenomenon.

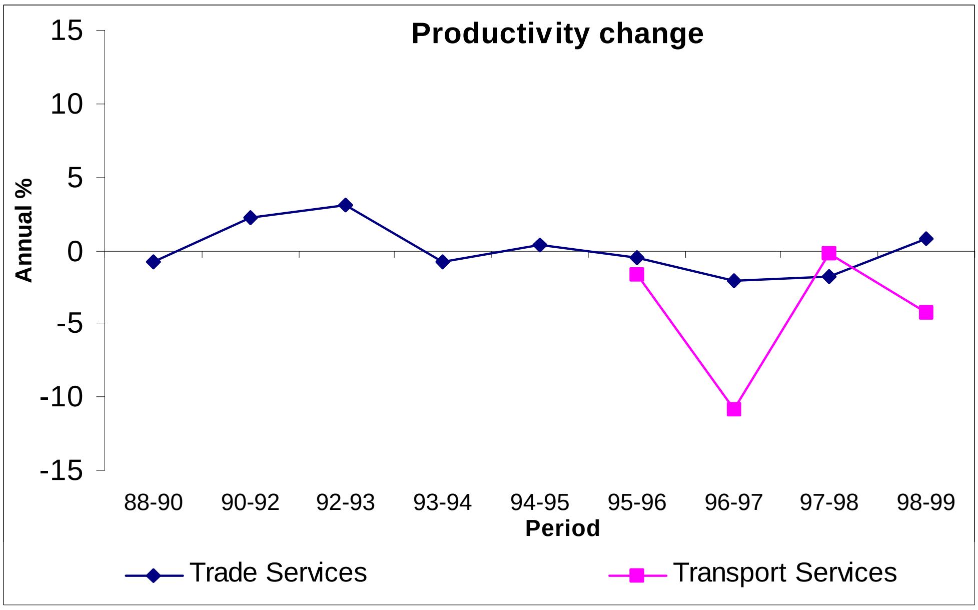


Figure 8. Annual productivity change; gross output/ capital, labour, energy and materials.

Since for business services data on energy cost were not available, Figure 8 only reports results for trade services and transport services.

6.3.2 TFP: Turnover

In this section it is studied what happens if gross output at the numerator of expression (6.1) is replaced by turnover. A reason for studying this case is that turnover partly includes revenues that are irrelevant to the production process, for example received subsidies. However, in practice the difference between turnover and gross output is only small; the contribution of aggregate turnover to aggregate gross output is 94.7% for trade services, 99.4% for transport services and 98.9% for business services.[9]

Since energy cost appeared to be a relatively unimportant factor, a labour-capital-materials based input measure was used. Figure 9, compared to Figure 8, shows that it does matter whether in the numerator of the productivity level turnover instead of gross output is placed: most productivity changes are somewhat larger.

[9] Aggregated over all records available in the production survey, in which gross output and turnover were positive.

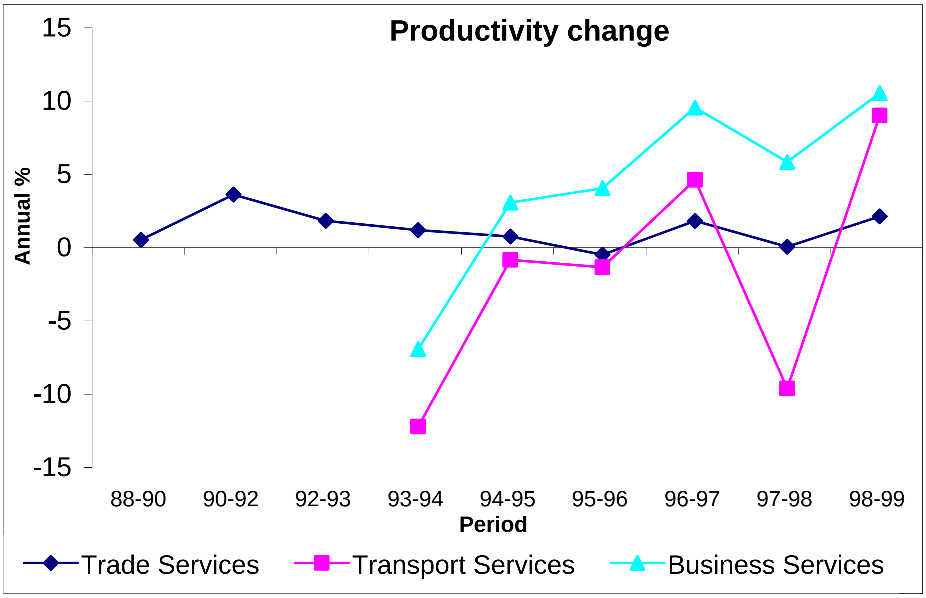


Figure 9. Annual productivity change; turnover/capital and labour

6.3.3 Labour productivity

Labour productivity is probably the concept of productivity that is most often used. It is somewhat easier to interpret than multifactor productivity and the problem of computing a measure of capital is avoided. Presently Statistics Netherlands only publishes a labour productivity index.

The question may arise whether it is useful to publish indices of other concepts of productivity change. This depends on the purpose of the index. When a measure of productivity is used with the purpose to say something about welfare (the amount of goods that can be purchased per person) labour productivity is the most appropriate concept. But if change of technology is the subject of research, a multifactor measure is more appropriate. There is a strong need for these measures since technological change has been the subject of a lot of research.

The main reason to compute labour productivity indices, directly built from micro-data is to compare them with the labour productivity indices published by Statistics Netherlands. Ideally, the results should be the same. However, differences may appear because the statistics published have been obtained by integrating production data with other sources of statistical information. These differences are quite important; compare Figure 1 to Figure 10.[10] This could be caused by the low quality of the micro-data. Further research on this quality is welcome.

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[10] Labour productivity has been defined as the ratio of real value added to the number of persons employed.

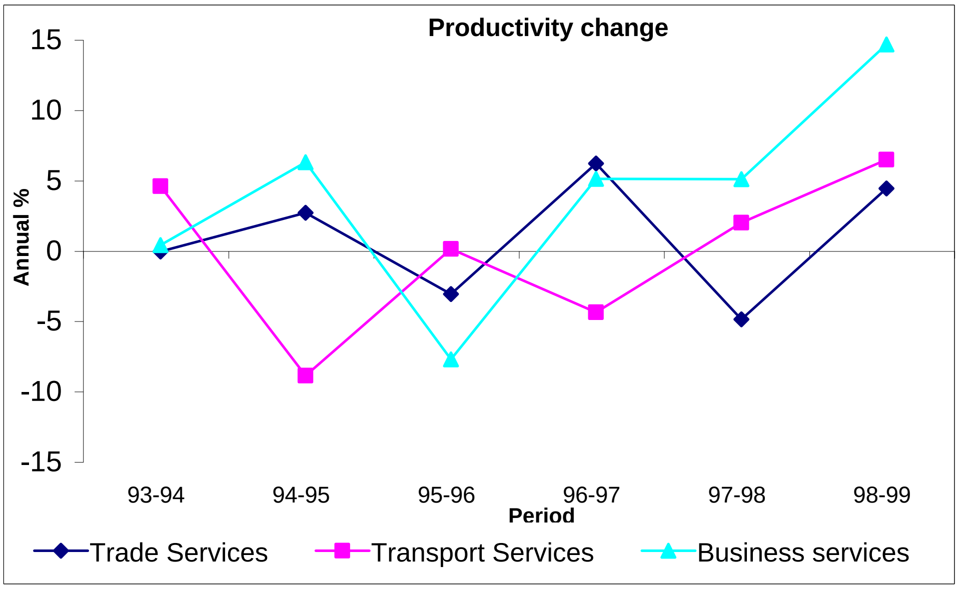

Figure 10. Labour productivity changes

Note that the labour productivity changes are very different from the value added, labour and capital based measure; compare Figure 10 to Figure 2. This implies that capital plays an important role in the latter index. However one must bear in mind that capital is measured by cost, whereas labour is measured by a number. Since numbers will be lower than cost, the contribution of capital to aggregate changes will automatically be more important than that of labour. In section 6.5.2 a productivity measure will be used in which the contributions of labour and capital are better comparable.

6.4 Different factor shares

6.4.1 A cost-based definition

Recall that the labour factor share was defined in (4.2) as aggregate labour cost relative to aggregate value added. It was used to construct a measure of real input. In the literature a similar measure is also often used.

A complication is that this measure partly depends on the output variable value added. This can lead to unexpected results. For instance: suppose that in bilateral comparisons value added increased and that labour and capital were constant for each continuing firm, both in nominal and in real terms. One would expect an increase of the corresponding productivity levels. However, this does not necessarily have to be true for firms that used more capital than labour. The reason for this is that there was a decline in the labour factor share, so that capital became more important as input factor. Consequently there was an increase to the measure of real input, which could lead to a decrease of productivity.

Therefore it is more straightforward to define the labour factor share a as the part of labour cost in the sum of labour cost and depreciation cost. That is:

$$a^t = \frac{\sum_i LC^{it}}{\sum_i (LC^{it} + K^{it})}, \tag{6.2}$$

where LC^{it} represents labour cost of firm i at period t, K^{it} denotes depreciation cost of firm i at period t and summations are taken over all firms existing at period t. From a theoretical point of view expression (6.2) is consistent with the assumption of imperfect market power, which implies that value added exceeds the sum of the factor costs of labour and capital, as is mentioned by Braun (2000). In the literature this definition is also often used and it should be preferred above the one expressed by (4.2).

Labour factor shares, presented in Table E.1, are higher than in the baseline model (see Table 1), since the sum of labour cost and depreciation cost is smaller than value added for most firms. This implies that changes of the input factor labour are more important than in the initial scenario.

It can also be seen from Table E.1 that labour factor shares are very stable over time, as compared to the initial scenario (see Table 1). This implies that value added is more volatile than the sum of labour and capital. This emphasises the preference of expression (6.2) above (4.2).

To the results it matters much whether labour factor shares are defined by (4.2), or by (6.2); compare Figure 11 to Figure 2.

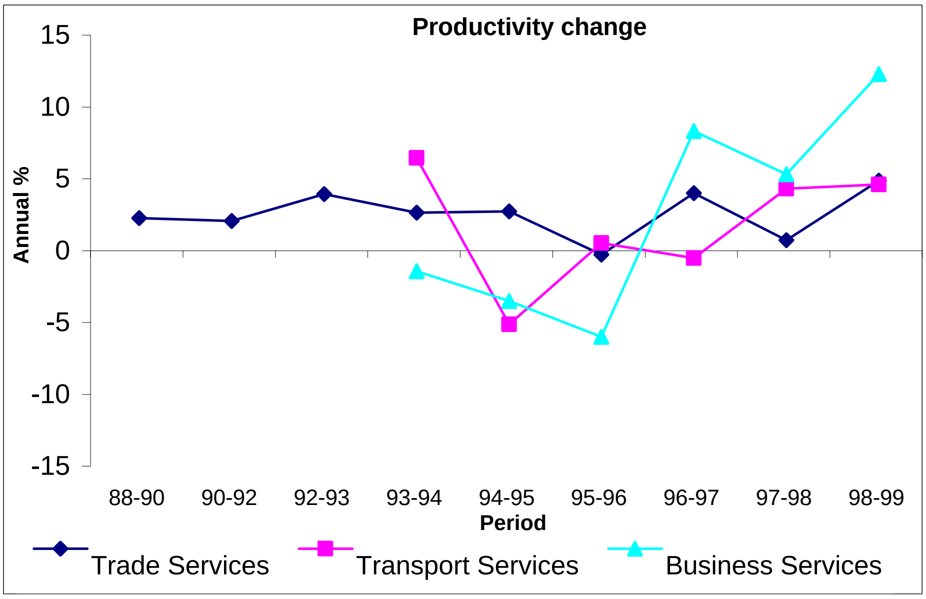

Figure 11. Annual productivity change; cost-based labour factor shares.

6.4.2 Firm-specific factor shares

Instead of computing one labour factor share that is used for all firms, in this section firm-specific shares $a^{it} = \frac{LC^{it}}{LC^{it} + K^{it}}$ will be used in (4.1). Since differences between single firms are better reflected, firm specific factor shares are preferred.

For the results this does not matter much; compare Figure 12 to Figure 2. For manufacturing industries, a similar conclusion was drawn by Balk and Hoogenboom-Spijker (2003). Average labour factor shares are given in Table E.2.

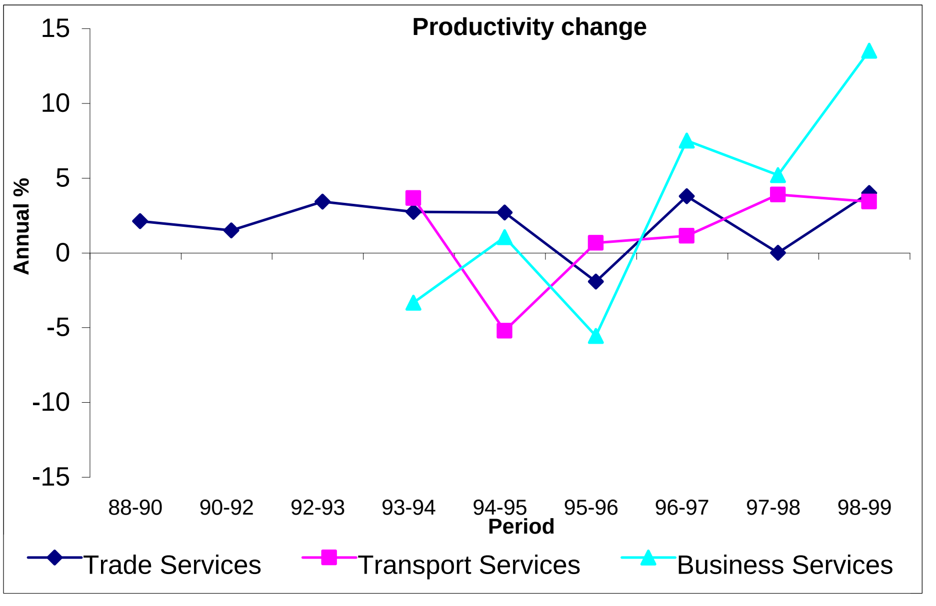

Figure 12. Annual productivity change; firm specific labour factor shares

6.4.3 Equal factor shares for base and comparison periods

Labour factor shares were computed per period. Consequently changes of labour factor shares contribute to change in productivity levels.

To study this effect in bilateral comparisons between periods 0 and 1, a^0 and a^1, as defined by expression (4.2), are replaced by the average ½$(a^0 + a^1)$. The resulting productivity changes as expressed by Figure 13, show substantially different patterns, compared to the results of the initial scenario (see Figure 2). However, differences between labour factor shares at the base period and at the comparison period are only small, see Table 1. Therefore it can be concluded that in the baseline model changes of labour factor shares are a very important contributing factor to aggregate productivity change.

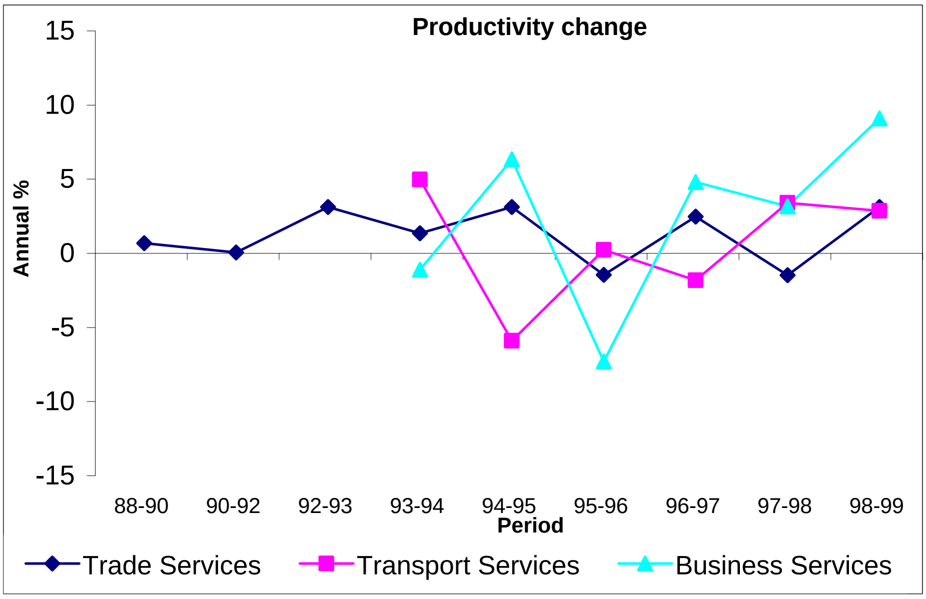

Figure 13. Annual productivity change; average labour factor shares

6.5 Alternative labour measures

6.5.1 Full-time equivalent jobs

Recall that labour was measured by persons employed. This measure is a count of the number of 'heads'. This means that differences in contract hours per employee are not taken into account.

Therefore it is better to use the full-time equivalent of jobs as a measure of labour. In this subsection it will be shown what happens to the results if this full-time equivalent replaces the original measure of labour. Due to the availability of data, comparisons could be made for recent years only.

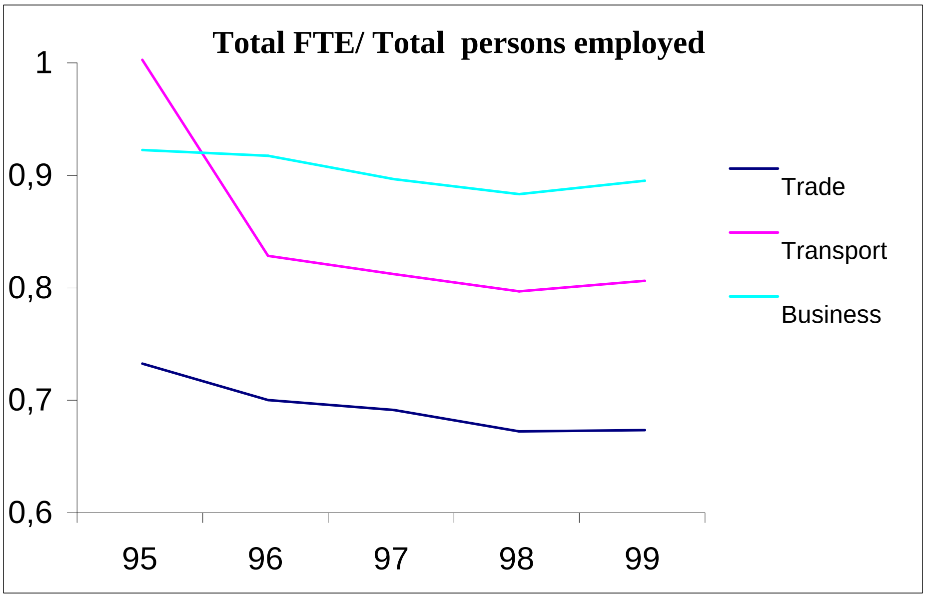

Figure 14. Ratio of aggregate full-time equivalent of jobs to the aggregate persons employed.

As shown in Figure 14, the number of contract hours per employee decreased on average, but only slightly. Thus, bilateral productivity growth can be expected to be higher, in comparison with the baseline model. This expectation is corroborated by a comparison of Figure 15 to Figure 2. However, note that the productivity changes show very similar patterns.

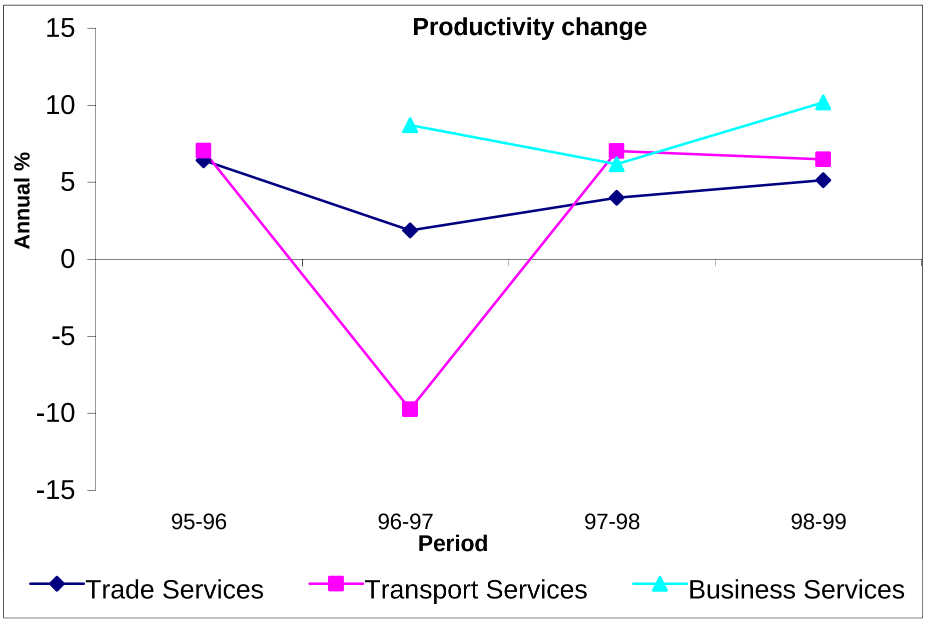

Figure 15. Annual productivity change; full-time equivalent jobs.

6.5.2 A cost-based measure

In the baseline model labour was measured by a number and capital by cost. These measures are not comparable. Thus it is unclear how productivity change depends on the choice of the measurement units. An alternative measure of the productivity level is studied in this subsection. Both labour and capital are measured by cost and nominal input is simply the sum of these costs.

In bilateral comparisons real input at the comparison period is set equal to nominal input. Real input at the base period is calculated by inflation of the nominal input at the base period by its corresponding price index. Thus, real input measures input at comparison period prices.

Recall that real output at the base period was calculated in a similar way: i.e. nominal output at the base period was inflated by its related price index. The foregoing is expressed by:

$$RINP^{i0} = (LC^{i0} + K^{i0})P^{i,10}_{input} \qquad ROUT^{i0} = VAL^{i0}P^{i,10}_{VAL}$$

$$RINP^{i1} = (LC^{i1} + K^{i1}) \qquad ROUT^{i1} = VAL^{i1} \qquad , \quad (6.3)$$

with:

LC^{i0}: Labour cost of firm *i* at period *t* (where *t=0* for the base period and *t=1* for the comparison period);

K^{it}: Depreciation cost of fixed assets of firm *i* at period *t*;

$RINP^{it}$: Real input of firm *i* at period *t*;

$ROUT^{it}$: Real output of firm *i* at period *t*;

$P^{i,10}_{input}$: Input price index of firm *i;*

$P^{i,10}_{VAL}$: Value added price index of the SBI-class to which firm *i* belongs.

Recall that the output price index was obtained from the National Accounts. As input price index an index of unit labour cost was computed:

$$P^{i,10}_{input} = \begin{cases} \left(\dfrac{LC^{i1} / L^{i1}}{LC^{i0} / L^{i0}} \right)^{a^{10}} & for\, i \notin X \\ \left(\dfrac{\sum_{i \in C} LC^{i1} / \sum_{i} L^{i1}}{\sum_{i \in C} LC^{i0} / \sum_{i} L^{i0}} \right)^{a^{10}} & for\, i \in X \end{cases} , \qquad (6.4)$$

where:

L^{it} : Number of persons employed by firm i at period t;

a^{10} : Labour factor share.

Since the PS do not involve price data on the capital stock, changes of the price of capital are not taken into account. Implicitly, it is assumed that prices of capital are constant. Thus, the change of depreciation cost is used as proxy for the change of real capital. For exiting firms, obviously no comparison period data are available. The pragmatic solution is to inflate nominal input by the index of unit labour cost of continuing firms.

The labour factor share a^{10} is defined as the average of a^0 and a^1, as defined by expression (6.2), that is:

$$a^{10} = ½ \frac{\sum_i LC^{i0}}{\sum_i (LC^{i0} + K^{i0})} + ½ \frac{\sum_i LC^{i1}}{\sum_i (LC^{i1} + K^{i0})}, \qquad (6.5)$$

where the summations in the first term are taken over all firms existing at period 0, and the summations in the second term are taken over all firms existing at period 1.

Recall that in the baseline model aggregate productivity levels are defined as weighted averages of firm-level productivity levels, with employment shares as weights. In this subsection weights will be derived from the definition of the aggregate productivity level. This definition can be written as:

$$PROD^t = \frac{\sum_i ROUT^{it}}{\sum_i RIN^{it}} = \sum_i \frac{RIN^{it}}{\sum_i RIN^{it}} \frac{ROUT^{it}}{RIN^{it}} =$$

$$\sum_i q^{it} \frac{ROUT^{it}}{RIN^{it}} \qquad (6.6)$$

where the summations are taken over all firms existing at period t.

Thus, in bilateral comparisons, the weights are given by: $q^{i0} = \frac{RIN^{i0}}{\sum_i RIN^{i0}}$ and

$q^{i1} = \frac{RIN^{i1}}{\sum_i RIN^{i1}}$, where RIN^{i0} and RIN^{i1} are computed by (6.3) and summations are taken over all firms existing at period 0 and period 1 respectively.

Productivity changes, in Figure 16, show roughly the same patterns as the results for the other case in which average labour factor shares were used (see Figure 13). The productivity measure derived in this subsection should be preferred above the measure of the baseline model, since labour and capital are measured by the same unit.

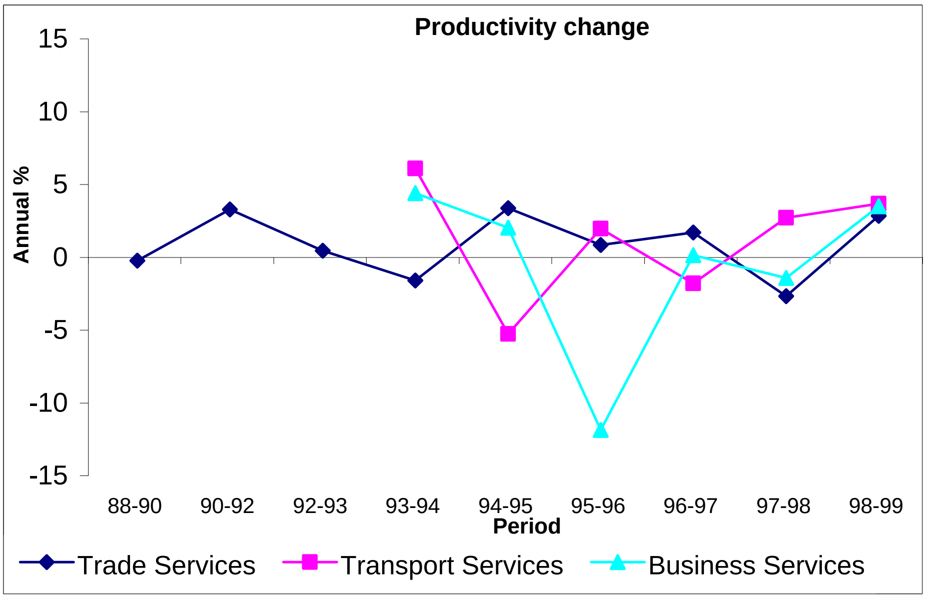

Figure 16. Annual productivity change; a cost-based definition of labour.

6.6 Alternative definitions for weights

6.6.1 Output based weights

Recall that in the initial model weights were defined as relative input shares. Sometimes relative output shares are used as weights. Therefore in this subsection weights will be defined as shares of value added:

$$q^{it} = \frac{VA^{it}}{\sum_i VA^{it}}, \qquad (6.7)$$

where the summation is taken over all firms existing at period *t*.

The results are shown in Figure 17. It shows that patterns of productivity change of trade services and transport services are quite similar to those of the baseline model (see Figure 2). For Belgian labour productivity a similar observation was made by Backer and Sleeuwaegen (2002). On average, bilateral productivity changes are somewhat larger than in the original model.

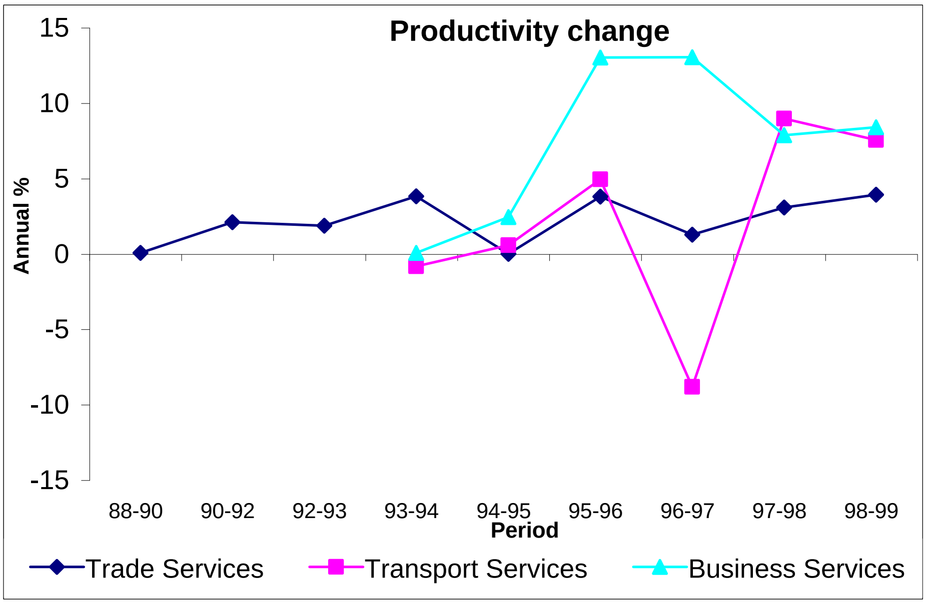

Figure 17. Annual productivity change; output based weights.

As shown by the decompositions in Figure F.1, the within term is less important than in the initial scenario (i.e. compared to Figure 3), whereas the between term and the covariance term are more important. This implies that change of output is stronger related to productivity change than change of input factors.

The covariance term is very important and positive. This means that firms with increasing value added shares, exhibit productivity growth on average. This term is much more important than in the original model, which implies that results of decomposition exercises will heavily depend on the choice of the specific decomposition method.

6.6.2 Geometric weights

In the initial scenario, firm-specific productivity levels were averaged by using arithmetic weights. In almost all empirical studies however, geometric weights are used (see for instance OECD (2001)). That is:

$$PROD^{it} = \prod_i (PROD^{it})^{q^{it}} , \tag{6.8}$$

where the product is taken over all firms existing at period t and q^{it} is defined as employment share.[11] Arithmetic weights should be preferred, since they correspond to the definition of aggregate productivity.

Does it matter to the results which type of weights is used? The answer is: not really, as appears by comparing Figure 18 to Figure 2 and Figure F.2 to Figure 3.

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[11] Productivity change was computed according to expression (3.9)

Patterns of productivity change are almost identical, but bilateral changes differ somewhat. The decomposition of productivity change does not provide new insights.

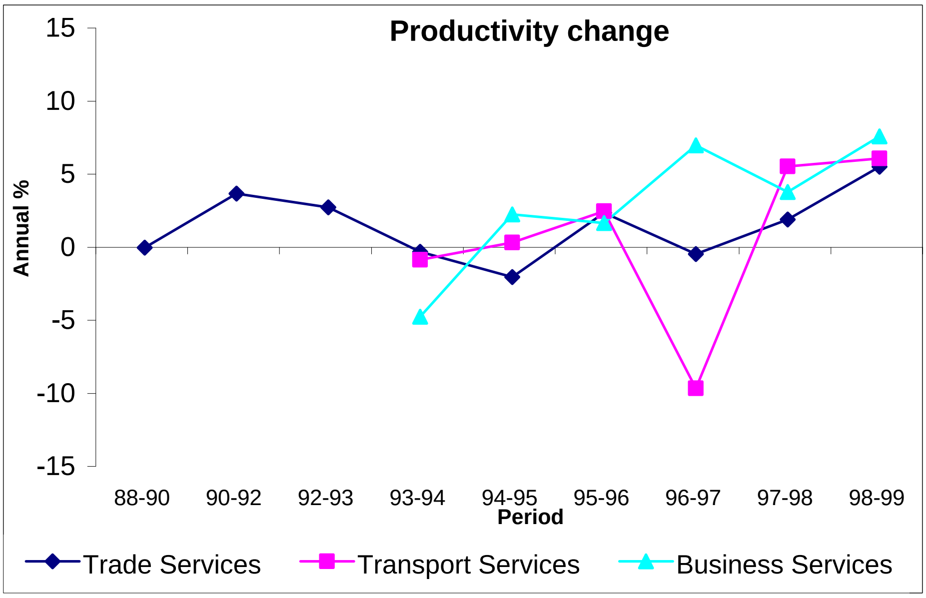

Figure 18. Annual productivity change; geometric weights.

6.7 Mutations

6.7.1 Classes of mutations

Several mutations take place to firms over time. Information on the kind of mutation and the moment of occurrence are recorded in the ABR. In bilateral comparisons production survey data of the base period and the comparison period were linked to the ABR. Information on the creation and close down of firms was used to define entering and exiting firms. However, creation and close down are not the only types of firm mutation in the ABR; in this section other types of mutations are also taken into account.

A classifications of mutations is given in Table 2.

Table 2. Basis classification of firm mutation: classes and defining criteria.

Mutation class	**Number of firms involved**[1]	**Identity Continued**[2]
1. Change of Characteristics	1:1	Yes
2. Change of Existence		
1. Birth	0:1	No
2. Death	1:0	No
3. Change of Structure		
1. Concentration		
1. Merger	x:1	No
2. Takeover	x:1	Yes
2. Deconcentration		
1. Break-up	1:y	No
2 Split-off	1:y	Yes
3. Restructuring	x:y	Yes or No

From: Struijs and Willeboordse (1995).

[1] Number of firms before and after the change: x>1 and y>1.

2 The identity of a firm is continued if at least one of the firms involved with the mutation existed before and after the mutation.

Change of characteristics and change of existence are related to one firm only. The first involves mutations within continuing firms, for instance change of industrial code (SBI-class) or size class. Since these firms predominantly remain the same, this type of firm mutation will not be taken into account in the remainder of this paper.[12]

[12] If the economic activity of firms at a certain period does not belong to trade services, transport services or business services, it does not appear in the data set with production data at that period. If such firms are appear in the ABR at the base period and at the comparison period, corresponding records are deleted in the bilateral comparison.

The second category in Table 2, change of existence, involves firms that only existed in one of the two periods that are compared and that are not (partly) emerged from, or continued in other firms. These firms will be defined as entering or exiting.[13] Recall that in the initial scenario a broader definition is used; firms are defined as entering or exiting if they appear with an identifier in only one of the two periods that are compared.

The third category, change of structure, involves more than one firm. For instance, two firms that merge into one firm. It is unclear how productivity change should be measured. Therefore records of such firms were deleted.[14]

Besides the three categories of mutation in Table 2, a fourth type occurs in the ABR: administrative corrections. The purpose of this is to correct the ABR for mutations that were overlooked at first sight. Records of firms to which an administrative correction took place were deleted, since it is unclear whether productivity levels can be compared appropriately. In the remainder of this paper administrative changes will be considered as changes of structure.

A complication of the link to the ABR is that it usually takes some time before mutations 'in the real world', are recorded in the business register.[15] The reason is that some time is needed, before the precise nature of a mutation can be ascertained. As a consequence entering firms can be firms that have already been existing for some period. For exiting firms the consequence is more serious: due to the delay of deregistration some firms that have already closed down, still figure in the ABR. Some of these inactive firms are included in the production surveys, their records must be empty or imputed.[16] Recall that records with empty fields are deleted from the data sets in the analysis. Consequently, it can be expected that exiting firms are underrepresented in the production surveys.

This problem was partly solved by using additional information on the moment of deregistration at the Chambers of Commerce. This information is recorded in the ABR, but not for all firms. Recall that in the initial scenario the definition of exiting firms was based on the moment of deregistration at the ABR, i.e. firms that are defined as exiting in any bilateral comparisons are recorded in the ABR at the base period, but not at the comparison period. This definition was replaced by a definition

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[13] These definitions are consistent with the definition of real births and real death, mentioned in Regulation Nr 2700/98 of the European Commission.

[14] In the literature the contribution of firms that underwent a change of structure is often measured by a separate term in the decomposition, see for instance Balk and Hoogenboom-Spijker (2003) and Bland and Will (2001).

[15] An expert mentioned a duration of about half a year.

[16] Bland and Will (2001) observed strong suggestions that Australian data of many exiting firms had been imputed. Therefore true deaths were defined as firms that excited the survey, and recorded a decline in employment and a limited rise in capital stock of no more than five per cent, in the year prior to death.

that is based on the moment of deregistration from the Chambers of Commerce. That is: in any bilateral comparisons a firm is exiting, if it is recorded at the Chambers of Commerce at the base period but not at the comparison period. Records in the production surveys for periods after the deregistration at the Chambers of Commerce were deleted, since they belong to inactive firms.

For firms of which the moment of deregistration from the Chambers of Commerce is not known, however, the initial definition had to be used.

To study the effect of the adaptations mentioned above, aggregate productivity changes were computed for the modified data sets. The productivity changes, presented in Figure 19, are not structurally lower or higher than in the initial model (see Figure 2). This means that there does not seem to be a clear relation between the occurrence of a change of structure and a change of productivity.

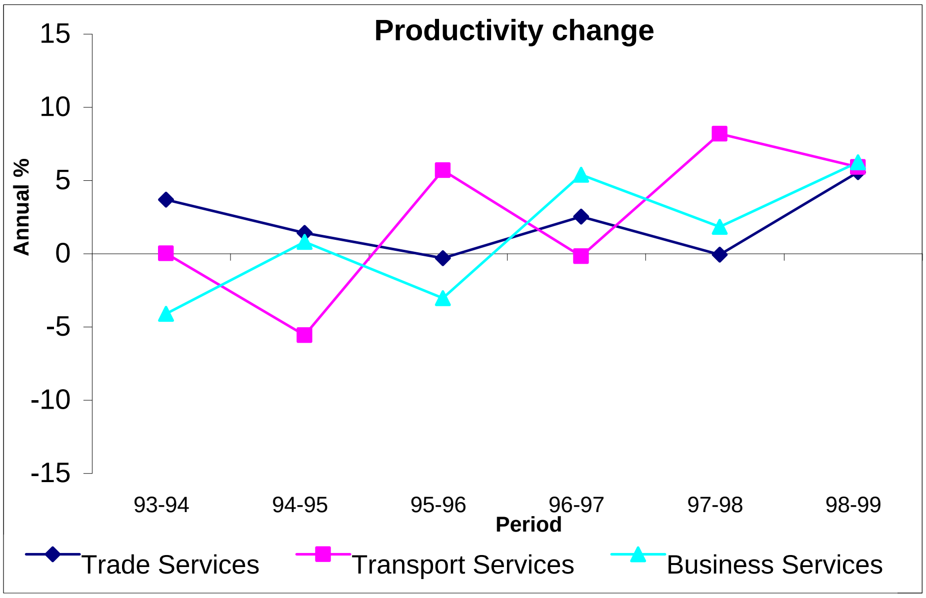


Figure 19. Annual productivity change; mutations in the ABR.

A part of the records was deleted, namely the records of firms to which a change of structure took place. As can be seen from Table G.2, on average this kind of mutation occurred to 6% of the population of all firms recorded in the ABR. However, this percentage fluctuated strongly between different periods; exceptionally high percentages were found for the periods 1996-1997 and 1997-1998. These large fluctuations were caused by the different method of data processing at Statistic Netherlands. Therefore, the changes of structure that are recorded in the ABR do not represent all changes in the real world.

Although there was a substantial decline of records in the data sets, the shares of entering, continuing and exiting firms, depicted by Table G.1, do not differ much from the initial model, as shown in Table 1. On average percentages of entering and exiting firms were 4.4 % and 1.3 %, respectively.

It would be interesting to compare these percentages with those mentioned in the ABR. As shown in Table G.2, those are much higher, i.e. 11% and 8% on average. That is: entering and exiting firms are under-represented in the production surveys. As mentioned before, an explanation for the low percentage of exiting firms is that there is a lag between the closedown of the firm in the real world and its deregistration from the ABR.

Consequently one can argue that contributions of entering and exiting firms to aggregate productivity change are understated. Two opposite solutions are discussed in the next two subsections to solve this problem. The first is to raise the weights of the entering and exiting firms. Thus, the contributions of these firms to the aggregate results become larger. The second is to ignore the first and last period of occurrence in the ABR; that is the period prior to deregistration from the ABR will be considered as the last period of activity.

6.7.2 Adapting raising factors

As mentioned in last subsection, contribution of entering and exiting firms to aggregate productivity change is understated.

A solution to this problem is to increase the raising factors of entering and exiting firms. Thus, the contributions of these firms to aggregate productivity change become more larger. Raising factors are multiplied by factors, such that the contributions of entering, continuing and exiting firms in the sum of all raising factors, become similar to the proportion of the number of these firms in the ABR. The idea is that entering and exiting firms in the production survey sample are representative of all of the population. This leads to:

$$MF(N_Y) = \begin{cases} \dfrac{|N_{ABR,Y}| \Big/ \left(|N_{ABR,Y}| + |C_{ABR,Y}| + |X_{ABR,Y}|\right)}{\sum_{i \in N_Y} RF^i \Big/ \left(\sum_{i \in N_Y} RF^i + \sum_{i \in C_Y} RF^i + \sum_{i \in X_Y} RF^i \right)} & \text{if } \sum_{i \in N_Y} RF^i > 0 \\ 0 & \text{else} \end{cases} \qquad (6.9)$$

$$MF(C_Y)=\begin{cases}\dfrac{|C_{ABR,Y}| / \left(|N_{ABR,Y}|+|C_{ABR,Y}|+|X_{ABR,Y}|\right)}{\sum_{i\in C_Y} RF^i \Big/ \left(\sum_{i\in N_Y} RF^i+\sum_{i\in C_Y} RF^i+\sum_{i\in X_Y} RF^i\right)} & if \sum_{i\in C_Y} RF^i > 0 \\ 0 & else\end{cases}$$

$$MF(X_Y)\ \begin{cases}\dfrac{|X_{ABR,Y}| / \left(|N_{ABR,Y}|+|C_{ABR,Y}|+|X_{ABR,Y}|\right)}{\sum_{i\in X_Y} RF^i \Big/ \left(\sum_{i\in N_Y} RF^i+\sum_{i\in C_Y} RF^i+\sum_{i\in X_Y} RF^i\right)} & if \sum_{i\in X_Y} RF^i > 0 \\ 0 & else\end{cases}$$

where:

$MF(N_Y)$: Multiplication factor for raising factors of entering firms in the production survey sample which belong to SBI-class *Y*.

$MF(C_Y)$: Multiplication factor for raising factors of continuing firms in the production survey sample which belong to SBI-class *Y*.

$MF(X_Y)$: Multiplication factor for raising factors of exiting firms in the production survey sample which belong to SBI-class *Y*.

C_Y: Set of continuing firms in the production survey sample which belong to SBI-class *Y*.

N_Y: Set of entering firms in the production survey sample which belong to SBI-class *Y*.

X_Y: Set of exiting firms in the production survey sample which belong to SBI-class *Y*.

$|N_{ABR,Y}|$: Number of entering firms in the ABR which belong to SBI-class *Y*.

$|C_{ABR,Y}|$: Number of continuing firms in the ABR which belong to SBI-class *Y*.

$|X_{ABR,Y}|$: Number of exiting firms in the ABR which belong to SBI-class *Y*.

Y: SBI-class to which firm *i* belongs.

RF^i: Original raising factor of firm *i* in the production survey.

Note that if all multiplication factors which belong to a certain industry become higher than all multiplication factors that are computed for an other industry, the relative importance of the first industry increases compared to that of the second industry. To prevent this unwanted effect, the multiplication factors are multiplied by a normalisation constant *c*, in such a way that the contribution to aggregate productivity change of each industry remains constant.

That is:

$$c\Big(\sum_{i\in N_Y} MF(N_Y)RF^i + \sum_{i\in C_Y} MF(C_Y)RF^i + \sum_{i\in X_Y} MF(X_Y)RF^i\Big) = \sum_{i\in N_Y\cup C_Y\cup X_Y} RF^i \quad , \tag{6.10}$$

which leads to:

$$c = \frac{\sum_{i\in N_Y\cup C_Y\cup X_Y} RF^i}{MF(C_Y)\sum_{i\in C_Y} RF^i + MF(N_Y)\sum_{i\in N_Y} RF^i + MF(X_Y)\sum_{i\in X_Y} RF^i} \ . \tag{6.11}$$

The foregoing implies that new raising factors are computed as:

$$\overline{RF^i} = \begin{cases} c * MF(N_Y) * RF^i & i\in N_Y \\ c * MF(C_Y) * RF^i & i\in C_Y \\ c * MF(X_Y) * RF^i & i\in X_Y \end{cases} \tag{6.12}$$

with:

$\overline{RF^i}$: New raising factor of firm *i*.

RF^i : Original raising factor of firm *i*.

Since the proportion of the number of entering, continuing and exiting firms is different in detailed classes of industries, multiplication factors were computed at the 6-digit level of the SBI-classification. A complication is that no entering and exiting firms appear in the production surveys for some detailed classes of industry. Consequently the proportion of entering and exiting firms would still be too low, after rescaling the raising factors.

To solve this problem three phrases were carried out. First, raising factors were computed at the 6-digit level of the SBI. Second, these raising factors were multiplied by factors that were computed at the 3-digit level of the SBI. Third, the resulting raising factors were multiplied by factors that were computed at the overall level of trade services, transport services and business services.

As a result the contributions of entering, continuing and exiting firms to the sum of the sum of all raising factors became on average 10.7 %, 80.8 % and 8.4%, which closely resemble the percentage of the number of firms in the ABR (see Table G.2).

As is shown in Figure 20, compared to Figure 19, the adaptations to the raising factors hardly affect the patterns of aggregate productivity change. However, on average the contributions to productivity change of entering and exiting firms became more important, as can be seen from Table G.3, compared to Table G.1.

Moreover, the contributions of entering, continuing and exiting firms fluctuated more over time, than in the initial scenario.

For business services it can be seen from these tables that the contribution to productivity of entering firms became large in the new scenario (expressed by Table G.3), whereas the contribution of exiting firms became smaller, compared to the initial scenario (Table G.1). On average the contribution of entering firms was negative and that of exiting firms positive. As a consequence, all bilateral productivity changes for business services are larger in Figure 20, compared to Figure 19.

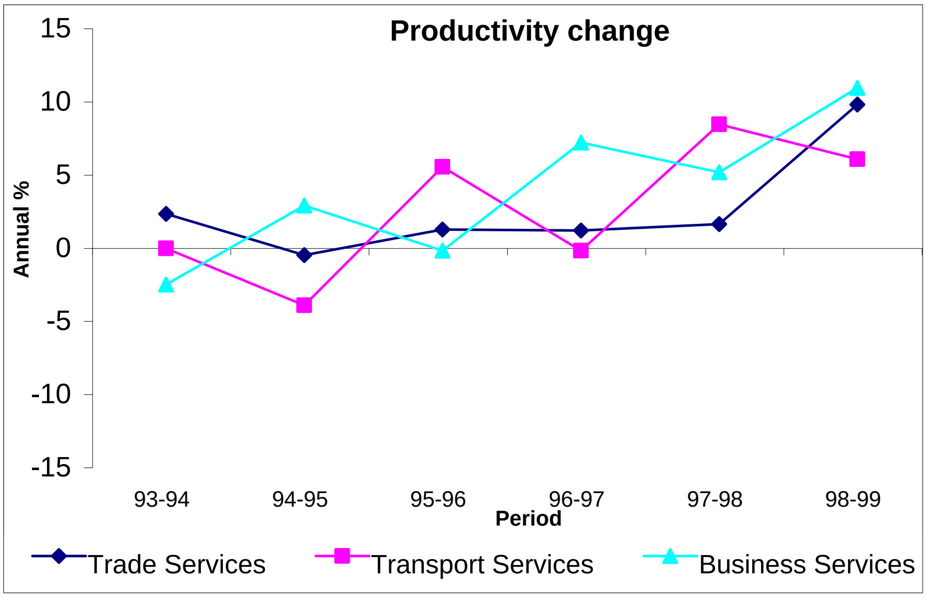


Figure 20. Annual productivity change; adapted raising factors

6.7.3 Entry and exit differently defined

In this subsection an other definition of entry and exit is discussed. The reason for this is that in the initial scenario the number of entering and exiting firms is understated. Recall that firms which are classified as exiting are recorded in the ABR at the (beginning of the) base period, but no longer at the (beginning of the) comparison period. Put differently: exiting firms closed down during the base period. As mentioned before, often there is a lag between the moment of close-down and the deregistration from the ABR. Therefore it makes sense to ignore the last period in which firms appear in the ABR, i.e. the period that contains the moment of deregistration. That is: in any bilateral comparison firms will be defined as exiting, if the base period is the last entire period of registration at the ABR. In any pairwise comparison, production survey records of firms at periods that involve the moment of deregistration at the ABR were deleted, since it was assumed that these firms had already been closed-down.

The definition of entering firms was adapted in a similar way: in any bilateral comparison firms are defined as entering, if they were recorded in the ABR during the entire comparison period, but not during the entire base period. Production survey records of firms at periods that involve the moment of registration in the ABR, were deleted.

As Figure 21 shows, aggregate productivity changes are not much affected by the adapted definitions of entry and exit (compared with Figure 19). As shown in Table G.4, the contributions of entering and exiting firms are not quite large. However, the average percentages of entering and exiting firms are higher than in Table G.1, being 4.5% and 2.5%, respectively. The contributions of entering and exiting firms to the sum of the raising factors are somewhat larger: 8.5 % and 4.7 % respectively. That is: entering and exiting firms have relatively large raising factors.

These percentages are quite similar to the average percentages of entering and exiting firms in the ABR (see Table G.2).

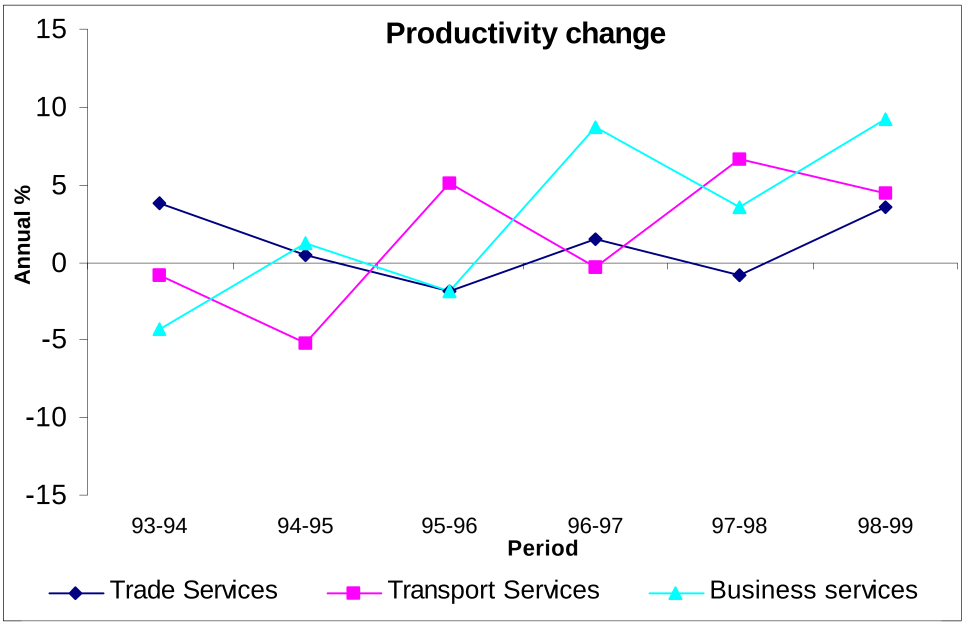


Figure 21. Annual productivity change; alternative definition of entering/ exiting firms.

The method discussed in this subsection has one important advantage above the method discussed in subsection 6.7.2. That is all firm-level data are related to periods of the same duration, i.e. one year. In any bilateral comparison, the records of entering and exiting firms are related to a duration of one year. However, in the original model of subsection 6.7.1, data for entering and exiting firms are related to a duration of less than one year, depending on the period of activity, Another advantage, compared to the method proposed in last subsection is that the lag of the removal of firms from the ABR is taken into account. Therefore the method of this subsection is preferred above the one discussed in the previous subsection.

7. Conclusions

In this report micro-data were used to calculate productivity change of Netherlands' trade services, transport services and commercial services over the period 1988-1999. Results of several methods were compared. These can be used to study whether it is useful for Statistics Netherlands to publish an index of aggregate productivity, directly built up from micro-data. If so, the results of this paper could help to find out the preferred method.

The reason for using micro-data is that insight can be obtained into the contributions of different types of firms to aggregate productivity change. Several methods are used in the literature to decompose aggregate productivity change into contributions of entering, continuing and exiting firms. The contribution of continuing firms is further decomposed into two components: a within-term that reflects intra-firm productivity changes and a between-term that reflects reallocation of production factors among firms. Since there is much need for decomposition results it worthwhile to publish these.

Two decompositions were discussed: one was described by Foster *et al.* (1998) and the other was described by Griliches and Regev (1995). The latter is preferred, since it is easier to interpret. However results have been calculated by using the decomposition of Foster *et. al.* (1998). The reason is that a remainder term appears in this decomposition, that tells us to what extent results of various decompositions differ.

In an initial scenario productivity levels were defined as ratios of deflated value added to a geometric mean of persons employees and (undeflated) depreciation cost. Such measures are often used in the literature.

Several extensions and adaptations of the initial scenario were discussed. For instance it was found that aggregate productivity changes of small firms were quite different than aggregate productivity changes of large firms.

Besides value added-based productivity measures, gross-output based and turnover-based productivity changes were computed. A drawback of these two measures is that intermediate flows between firms in the same population are doubly counted, i.e. the output of one firm is the input of another firm. Consistent with the theoretical point of view, gross output based productivity changes are small and show less fluctuation, compared to the results of the value added-based measure.

Another adaptation is to average firm-level productivity measures geometrically rather than arithmetically. The differences in the results are negligible. Arithmetic weights are preferred, since they are more intuitive. The weights that were used in the initial scenario were relative labour shares. Results do not change much, if the initial weights are replaced by value added shares, or by real input shares. The latter alternative is preferred, since input weights can be derived from the definition of aggregate productivity change, i.e. it does not matter whether aggregate productivity levels are computed as ratio of aggregate output to aggregate input, or as a weighted product of firm-level productivity levels.

Several alternative measures of real input are considered. The most important is to replace the number of employees in the initial scenario by real labour cost. Since capital is also measured by cost, both input factors are better comparable.

In the initial scenario, a measure of input was calculated as a geometric mean of labour and capital. Several methods to compute the labour factor share have been compared. For instance: whether it makes a difference whether labour factor shares are computed at the firm-level or at a more aggregate level. All alternatives lead to quite similar patterns of aggregate productivity change. Firm-specific labour factor shares are preferred, since firm-specific characteristics are better reflected. The most preferable definition of the labour factor share is labour cost relative to the sum of labour cost and capital cost.

In the original model the labour was measured by persons employed. It is better to replace this by the full-time equivalent of jobs. Productivity change using this measure is somewhat larger than in the original model. However similar patterns are obtained.

The key question is whether Statistics Netherlands can publish an index of productivity change that is built up from micro-data. One of the criteria that should be met is that small adaptations to the method do not lead to substantially different results. Results in this report indeed show that most of the different methods lead to quite similar patterns of productivity growth. Bilateral percentages, however, are appreciably different.

A complication of the indices that were computed, is the lack of data on some of the variables. For instance volume data of capital are not available at the firm level. Depreciation cost was used as a proxy. A lot of research has been done in the literature to estimate firm-level capital. The perpetual inventory method estimates capital by using investment data. This method can be applied, since data on investment are available. It was not studied in this paper, since it is more complicated than using depreciation cost. Solutions can probably be found in further research.

Another complication is that firm-level output deflators are not available. Industry-level deflators were used as a proxy. For services industries it is especially difficult to measure price change. The current price indices are being improved. For a productivity index this is very important. In further research it can be investigated whether firm-level price changes can be used.

Very important for the feasibility of an index, directly built up from micro-data is the quality of the micro-data. Low quality of the micro-data may explain deviations of the labour productivity index numbers, directly built up from micro-data, from the labour productivity index numbers that are currently published. Further research on the quality of the data seems to be necessary. Moreover, it can be studied whether other data sources can be used.

References

Audretsch, D. B., Klomp, L. and Thurik, A.R. (1997), *Do Services Differ from Manufacturing? The Post-entrants Performance of Firms in Dutch Services*. Discussion Paper, No 1718. Centre for Economic Policy Research, www.tinbergen.nl/discussionpapers/ 98012.pdf.

Backer, K. de, and Sleuwaegen, L. (2002), *Foreign Ownership and Productivity dynamics*. Vlerick Working Papers 2002/13. Vlerick Leuven Gent Management School, www.vlerick.be/research/workingpapers/2002-13.pdf.

Balk, B. M. (2001), *The Residual: On Monitoring and Benchmarking Firms, Industries, and Economies with respect to Productivity*. Inaugural Addresses Research in Management Series EIA-2001-07-MKT. Erasmus Research Institute of Management, Erasmus University Rotterdam, www.eur.nl/webdoc /doc/ iarm/erima20020909150511.pdf.

Balk, B. M. and Hoogenboom-Spijker, E. (2003), *The Measurement and Decomposition of Productivity Change: A Study of the Netherlands Manufacturing Sector*. Draft. Statistics Netherlands, Voorburg.

Barnes, M.D., Haskel, J.E. and Maliranta, M. (2001), *The Sources of Productivity Growth: Micro-level Evidence for the OECD*. Draft, paper prepared for the OECD Workshop on Firm-Level Statistics. Queen Mary University of London, http://alpha.qmul.ac.uk/~ugte193/papers/.

Bland, S. and Will, L. (2001), *Resource Movements and Labour Productivity, an Australian Illustration: 1994-95 to 1997-98*. Productivity Commission Staff, Research Paper. Ausinfo, Canberra, http://netec.mcc.ac.uk/wopec/data/papers/ wpawuwpla0105001.

Braun, N. (2000), *Construction of Adjusted Total Factor Productivity in the G-7*. Economic and Social Research Council, www.gla.ac.uk/economics/ tfp/braunfinal.pdf.

CPB (Centraal Planbureau) (2002), *Centraal Economisch Plan 2002*. Hoofdstuk 4 Zakelijke dienstverlening op de productiviteitsagenda. The Hague, www.cpb.nl/nl/cepmev/cep/2002/h4.pdf.

Eurostat (2001), *Handbook on Price and Volume Measures in National Accounts*. Draft, prepared for the seminar on price and volume measures 14-16 March Voorburg, www.cbs.nl/nl/publicaties/macro-economie/nationale-rekeningen.

Foster, L., Haltiwanger, J. and Krizan, C.J. (2001), Aggregate Productivity Growth, Lessons from Microeconomic Evidence. In *New Developments in Productivity Analysis*. Edited by Hulten C.R., Dean E.R. and Harper M.J., Studies in Income and Wealth Volume 63. Chicago and London: The University of Chicago Press.

Griliches, Z. and Regev, H. (1995), Firm Productivity in Israeli Industry, 1979-1988. *Journal of Econometrics* 65, 175-203.

Haltiwanger, J. (1997), *Measuring an Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence*, Federal Reserve. Bank of St. Louis. Economic Review 79, no. 3, 55-77.

Haltiwanger, J. (2000), *Aggregate Growth: What have we Learned from Microeconomic Evidence?* Working Paper No. 267, Economics Department, OECD, Paris, www.bsos.umd.edu/econ/haltiwanger/ oecd2000.pdf.

OECD (2001a), *Productivity and Firm Dynamics: Evidence from Microdata*. Chapter VII. OECD Economic Outlook No. 69.

OECD (Organisation for Economic Co-operation and Development) (2001b), *Measuring Productivity: Measurement of Aggregate and Industry-Level Productivity Growth*. OECD Manual, Paris.

Schreyer, P. and Pilat, D. (2001), Measuring Productivity. *OECD Economic studies* No.33, 2001/II, OECD Paris.

Struijs, P. and Willeboordse, A.J. (1995), Changes in Populations of Statistical Units. In: *Business Survey Methods*. Edited by Cox B., Binder D., Chinnappa B., Christianson A., Colledge M., Kott P.. John Wiley & Sons, Inc., New York.

Wiel, H.P. van der (1998), *Productivity Slowdown in Commercial Services*. CPB Report 98/1. Centraal Planbureau, The Hague.

Appendix A.

Table A.1 Descriptions of relevant 2-digit levels of SBI93

SBI93-class	Description
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55	Hotels and restaurants
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer and related activities
73	Research and development
74	Other business activities

Table A.2: Some characteristics of trade services, transport services and business serivices. Source: Statistics Netherlands

Industry	Year	Gross output	Value added	Labour cost	Deprecia-tion cost	Persons employed
		Million euro				**1000*
Trade	1993	47,258	29,910	15,322	.	1,024
	1994	49,054	30,831	15,890	.	1,021
	1995	51,399	32,196	16,458	.	1,054
	1996	53,521	32,690	17,125	.	1,075
	1997	56,732	34,694	18,008	.	1,103
	1998	61,553	37,688	18,090	.	1,131
	1999	65,578	40,530	19,523	.	1,182
Transport	1993	33,611	18,579	8,949	4,540	401
	1994	35,378	19,543	9,124	4,662	397
	1995	37,167	20,317	9,425	4,771	401
	1996	39,048	20,790	9,735	4,933	403
	1997	43,064	22,804	10,294	5,178	411
	1998	46,760	24,545	10,361	5,537	425
	1999	49,939	24,974	11,181	6,030	444
Business	1993	64,763	43,611	14,582	.	797
	1994	68,936	46,422	15,696	.	850
	1995	72,796	48,706	17,259	.	937
	1996	80,588	53,686	19,199	.	1,040
	1997	88,427	58,453	21,596	.	1,124
	1998	96,502	63,446	22,471	.	1,196
	1999	105,496	69,131	24,776	.	1,242

Table A.3: Percentages of new firms, firms that closed down and firms with 0-4 employees, taken over all firms registered in the ABR in 1996. Source: Statistics Netherlands

Industry	New firms	Firms, Closed down	Firms <5 employees
Economy	8	3	84
Trade services	7	3	84
Transport services	8	3	75
Business services	14	4	87

Table A.4 Definitions of variables in the PS of 1999

Variable	Definition
Total net turnover	Invoice value of sales to third parties of goods and services net of discounts, refunded packaging and related rebates, exclusive value added tax (VAT).
Number of persons employed	Total number of persons on the payroll, including part-timers, working owners and hired employees, minus the number of employees sent out (all measured at the end of September).
Total labour cost	The sum of gross wages and salary payments, employer's social contributions, employer's pension contributions, cost for hiring employees and other expenses (for example working clothes) minus revenues for employees sent out.

Appendix B.

An outline of the data and the method

DATA

Production surveys:

- PS Wholesale Trade 1988, 1990, 1992-1999.
- PS Retail Trade 1988, 1990, 1992-1999.
- PS Transport services 1993-1999.
- PS Business services 1993-1999.

Price index numbers:

- Industrial price index numbers for production, intermediate use and value added.

ABR

- Abstracts from the ABR at the end of each year for 1988-2000.

METHOD

- Construct data sets for trade services, transport services and business services that include production data on all relevant variables.
- Delete records that have a classification falling outside the relevant classes.
- Delete records in which all fields have been imputed.
- Link the records in the data sets to the ABR of the corresponding year by using firm identifiers.
- Link the records in the data set to the price index numbers on the basis of year and classification of economic activity.
- For each year drop records with non-positive, or missing production data.
- Determine outliers:

    For each year and branch of industry:

        Compute labour factor shares and capital factor shares to calculate nominal input.

        Define records as outliers falling in the first and ninety-ninth percentile of the distribution of nominal output divided by nominal input.

        Delete outliers from the data set

- Delete records that do not appear in the ABR.
- Compute productivity changes:

  For each two successive periods 0 and 1:

  Filter production data and price data for period 0 and period 1 from the production database.

  Merge production data of the two periods by using the firm identification number.

  Optional: Delete all records to which some kind of change of structure (take-over, split off etc.) occurred.

  Delete records that appear in the ABR at both periods, but for which production data are available at one period only.

  Determine entering, continuing and exiting firms

  Compute output price changes on the basis of the price index numbers, by using the SBI industry belonging to period 1. If there is no observation in period 1, the SBI industry of period 0 is taken.

  Deflate value added, i.e. express the nominal values that belong to period 0 to the prices of period 1, by using the output price changes.

  Compute factor shares for the input categories.

  Calculate the productivity levels per firm in period 0 and 1.

  Compute the weights of the firms

  Calculate aggregate productivity levels from the productivity levels per firm and firm-level weights.

  Compute aggregate productivity changes and contributing terms.

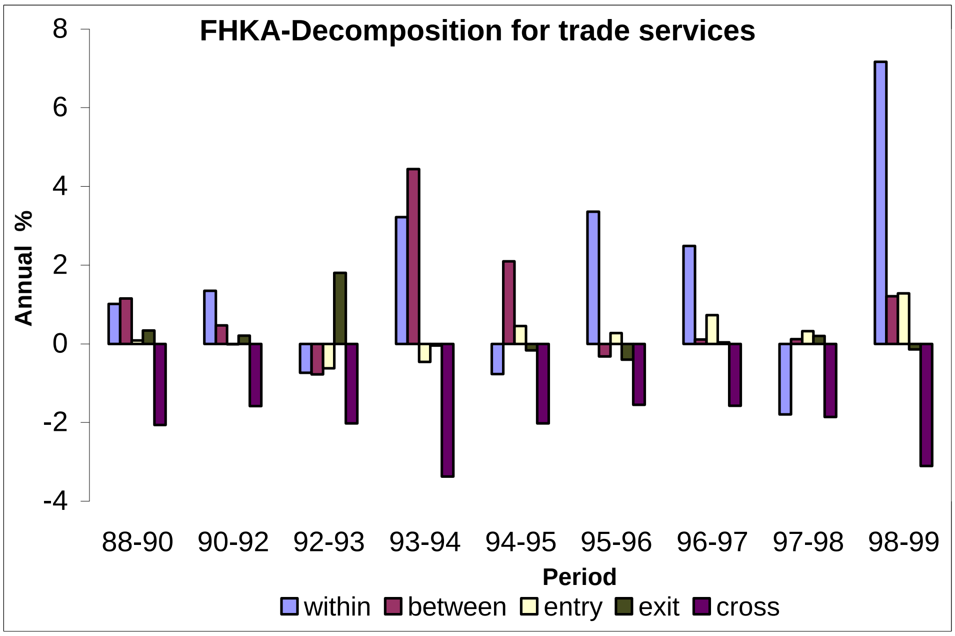
Appendix C.

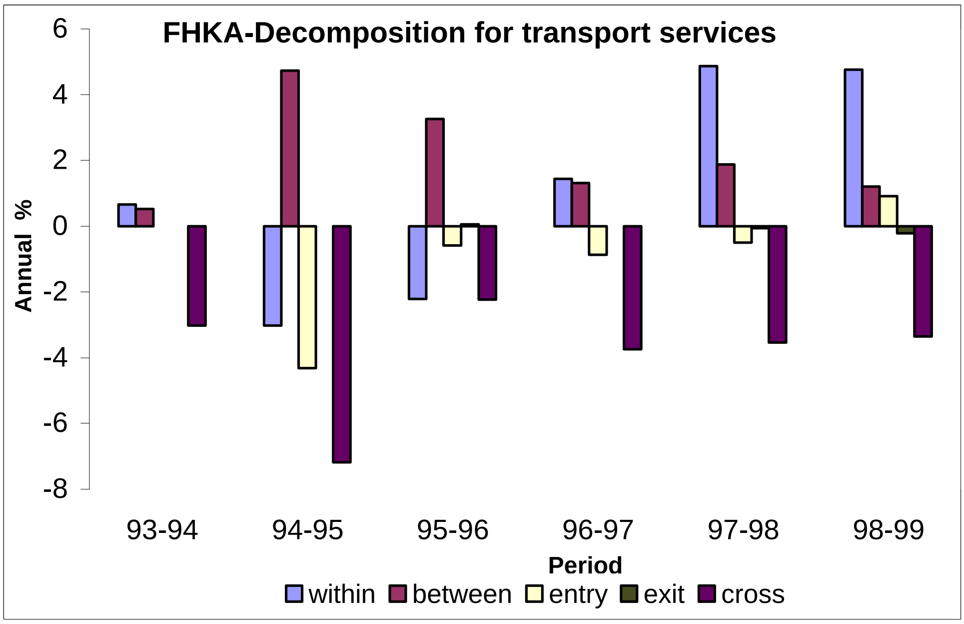
Table C.1: Total number of continuing (C), entering (N) and exiting (X) firms and labour factor shares for base period (a^0) and comparison period (a^1); small firms

Data set	Period	C	N	X	a^0	a^1
Trade	88-90	4295	88	119	0.56	0.55
	90-92	4380	3	454	0.54	0.57
	92-93	2567	249	64	0.57	0.57
	93-94	6041	403	80	0.57	0.58
	94-95	7202	250	188	0.59	0.55
	95-96	4973	27	119	0.55	0.56
	96-97	3915	110	60	0.56	0.57
	97-98	4260	38	149	0.57	0.56
	98-99	3776	218	163	0.56	0.57
Transport	93-94	686	65	0	0.66	0.64
	94-95	702	99	0	0.64	0.65
	95-96	1109	75	6	0.65	0.64
	96-97	1191	84	0	0.64	0.64
	97-98	1392	84	6	0.64	0.64
	98-99	1253	122	40	0.64	0.63
Business	93-94	1501	256	43	0.63	0.60
	94-95	1714	313	10	0.60	0.57
	95-96	2449	470	12	0.58	0.63
	96-97	2807	478	22	0.62	0.63
	97-98	3062	543	64	0.63	0.64
	98-99	3212	965	93	0.63	0.63

Table C.2: Total number of continuing (C), entering (N) and exiting (X) firms and labour factor shares for base periods (a^0) and comparison periods (a^1); large firms

Data set	**Period**	**C**	**N**	**X**	**a^0**	**a^1**
Trade	88-90	2478	7	31	0.71	0.69
	90-92	2857	1	199	0.69	0.72
	92-93	3494	40	5	0.72	0.72
	93-94	3773	63	27	0.72	0.71
	94-95	3805	87	26	0.71	0.68
	95-96	3865	81	61	0.69	0.70
	96-97	3891	60	39	0.69	0.69
	97-98	3983	59	33	0.69	0.71
	98-99	4133	90	70	0.70	0.71
Transport	93-94	740	20	0	0.74	0.72
	94-95	891	37	1	0.72	0.74
	95-96	1155	33	8	0.74	0.76
	96-97	949	21	0	0.76	0.71
	97-98	844	26	0	0.71	0.72
	98-99	855	30	4	0.72	0.74
Business	93-94	1082	48	15	0.76	0.75
	94-95	1172	56	10	0.75	0.69
	95-96	1220	64	7	0.68	0.77
	96-97	1273	83	9	0.76	0.79
	97-98	1367	55	9	0.80	0.80
	98-99	1532	69	17	0.80	0.79


FHKA-Decomposition for trade services
Annual %
8
6
4
2
0
-2
-4
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHKA-Decomposition for transport services
Annual %
6
4
2
0
-2
-4
-6
-8
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross

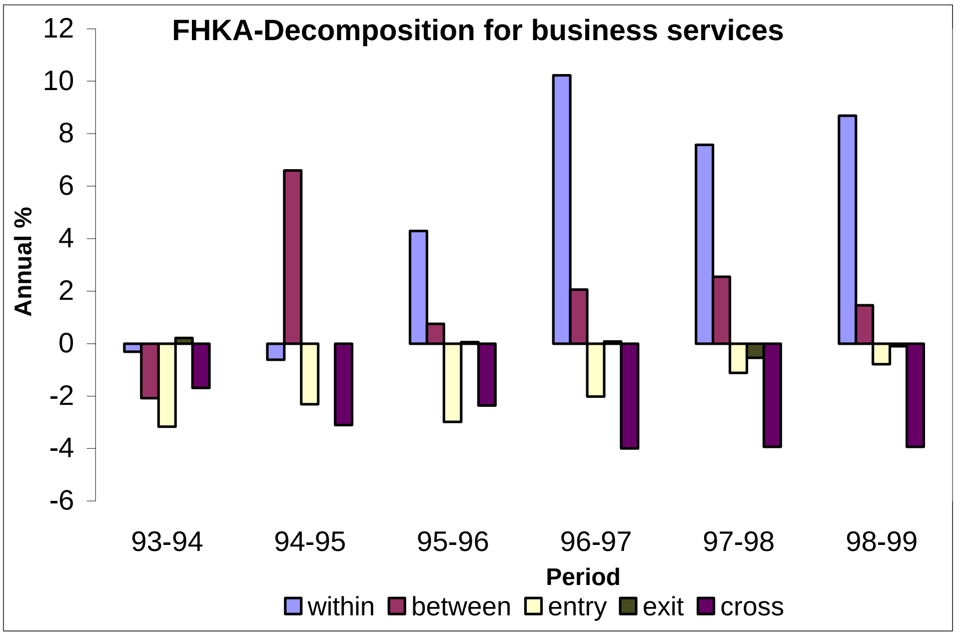
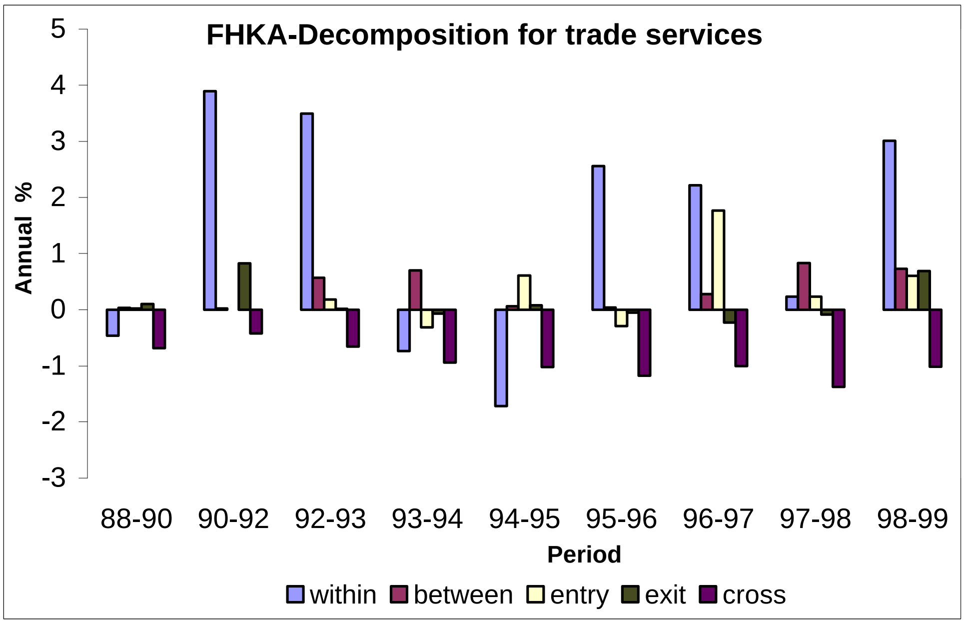
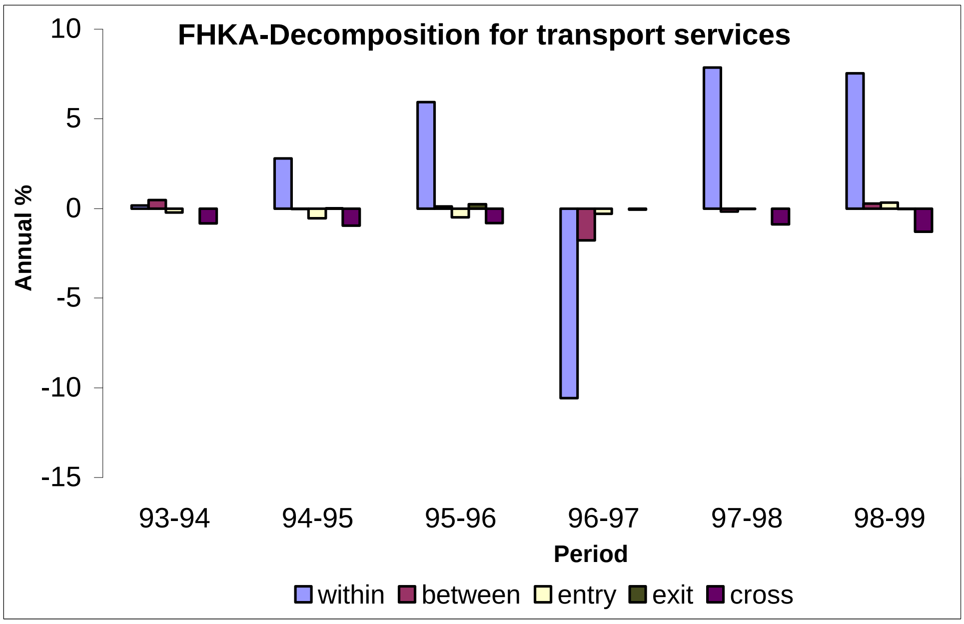


Figure C.1 FHKA-decomposition; small firms


FHKA-Decomposition for trade services
Annual %
5
4
3
2
1
0
-1
-2
-3
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHKA-Decomposition for transport services
Annual %
10
5
0
-5
-10
-15
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross

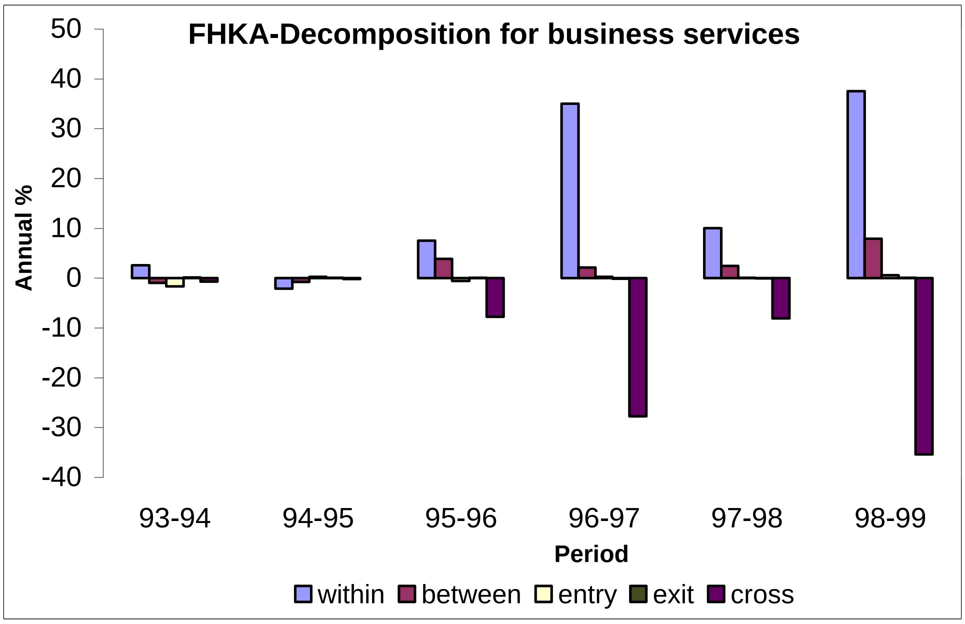


Figure C.2 FHKA-decomposition; large firms

Appendix D.

Table D.1: Labour factor shares for base periods (a^{0}) and comparison periods (a^{1}), energy factor shares for base periods (ß^{0}) and comparison periods (ß^{1}) and materials factor shares for base periods (?^{0}) and comparison periods (?^{1}).

Data set	**Period**	**a^{0}**	**a^{1}**	**ß^{0}**	**ß^{1}**	**?^{0}**	**?^{1}**
Trade	88-90	0.09	0.09	0.00	0.00	0.85	0.85
	90-92	0.09	0.10	0.00	0.00	0.85	0.85
	92-93	0.10	0.10	0.00	0.00	0.85	0.84
	93-94	0.10	0.10	0.00	0.00	0.84	0.85
	94-95	0.11	0.10	0.00	0.00	0.85	0.85
	95-96	0.10	0.10	0.00	0.00	0.85	0.85
	96-97	0.10	0.09	0.00	0.00	0.85	0.86
	97-98	0.09	0.10	0.00	0.00	0.86	0.86
	98-99	0.09	0.10	0.00	0.00	0.86	0.86
Transport	95-96	0.35	0.35	0.00	0.01	0.52	0.53
	96-97	0.36	0.33	0.01	0.01	0.53	0.54
	97-98	0.32	0.32	0.01	0.01	0.54	0.55
	98-99	0.32	0.32	0.01	0.00	0.55	0.57

Appendix E.

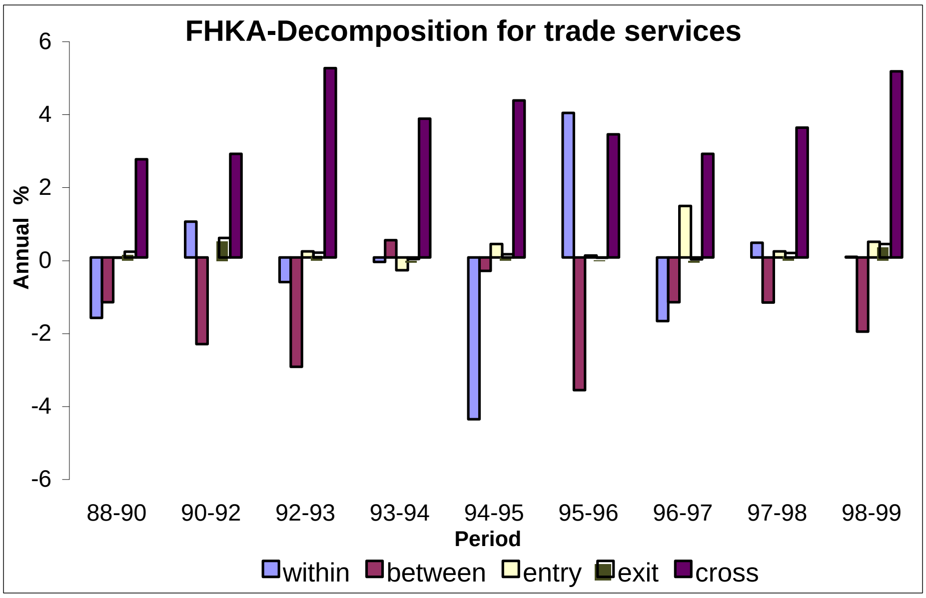
Table E.1: Cost-based labour factor shares for base periods (a^0) and comparison periods (a^1).

Data set	Period	a^0	a^1	Period	a^0	a^1
Trade	88-90	0,87	0,87	95-96	0,86	0,86
	90-92	0,86	0,87	96-97	0,86	0,86
	92-93	0,87	0,86	97-98	0,86	0,87
	93-94	0,87	0,87	98-99	0,87	0,86
	94-95	0,87	0,86			
Transport	93-94	0,79	0,79	97-98	0,79	0,79
	94-95	0,79	0,79	98-99	0,79	0,80
	95-96	0,79	0,79			
	96-97	0,79	0,79			
Business	93-94	0,90	0,90	97-98	0,85	0,85
	94-95	0,90	0,83	98-99	0,85	0,85
	95-96	0,83	0,84			
	96-97	0,83	0,84			

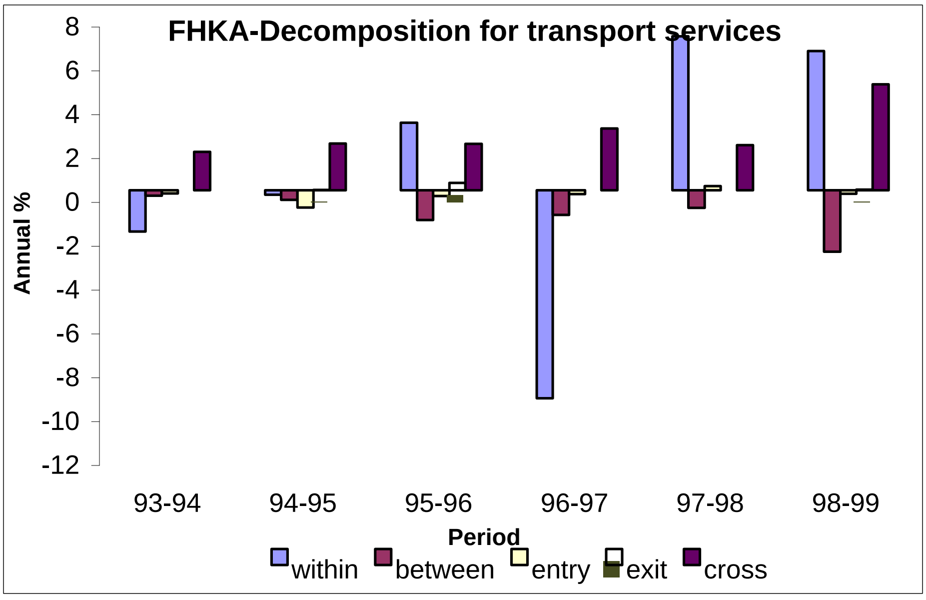
Table E.2 Averages of firm-specific labour factor shares for base periods (a^0) and comparison periods (a^1).

Data set	Period	a^0	a^1	Period	a^0	a^1
Trade	88-90	0,84	0,84	95-96	0,82	0,82
	90-92	0,83	0,83	96-97	0,82	0,83
	92-93	0,86	0,86	97-98	0,82	0,83
	93-94	0,82	0,82	98-99	0,83	0,84
	94-95	0,82	0,81			
Transport	93-94	0,80	0,80	97-98	0,79	0,79
	94-95	0,80	0,80	98-99	0,79	0,79
	95-96	0,80	0,80			
	96-97	0,79	0,80			
Business	93-94	0,84	0,82	97-98	0,78	0,78
	94-95	0,82	0,77	98-99	0,80	0,79
	95-96	0,76	0,76			
	96-97	0,76	0,77			

Appendix F.



FHKA-Decomposition for trade services
6
4
2
0
-2
-4
-6
Annual %
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross



FHKA-Decomposition for transport services
8
6
4
2
0
-2
-4
-6
-8
-10
-12
Annual %
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross

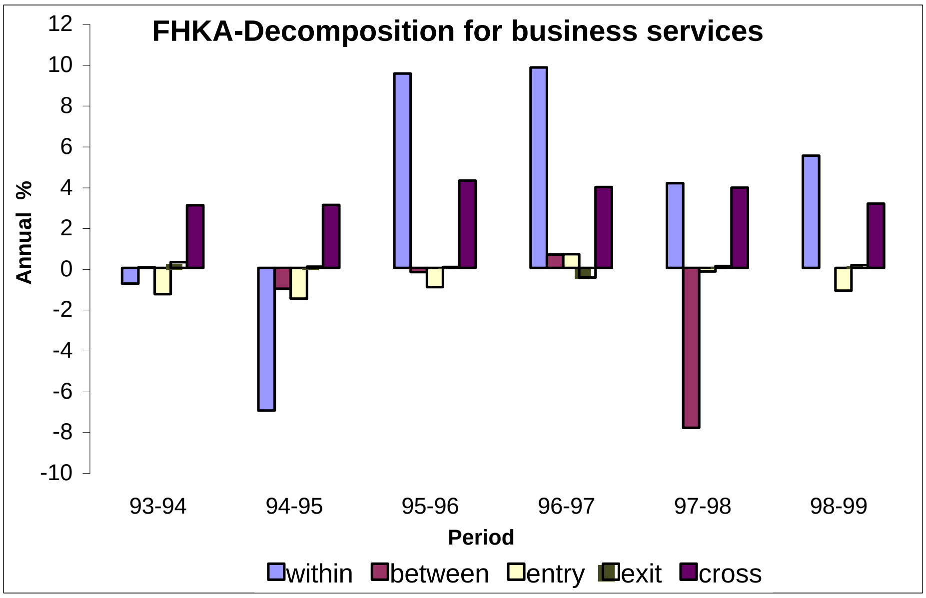
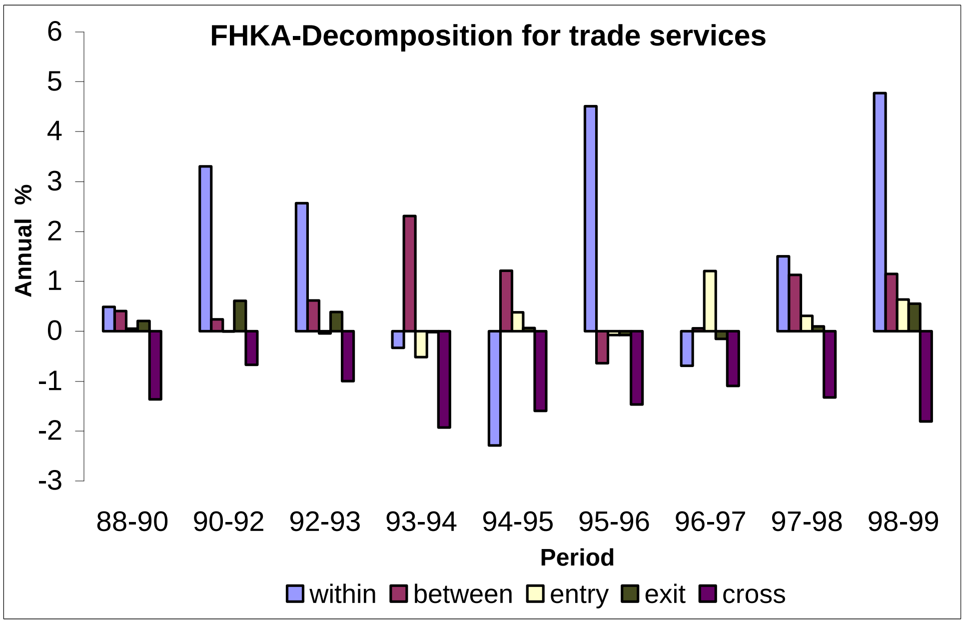
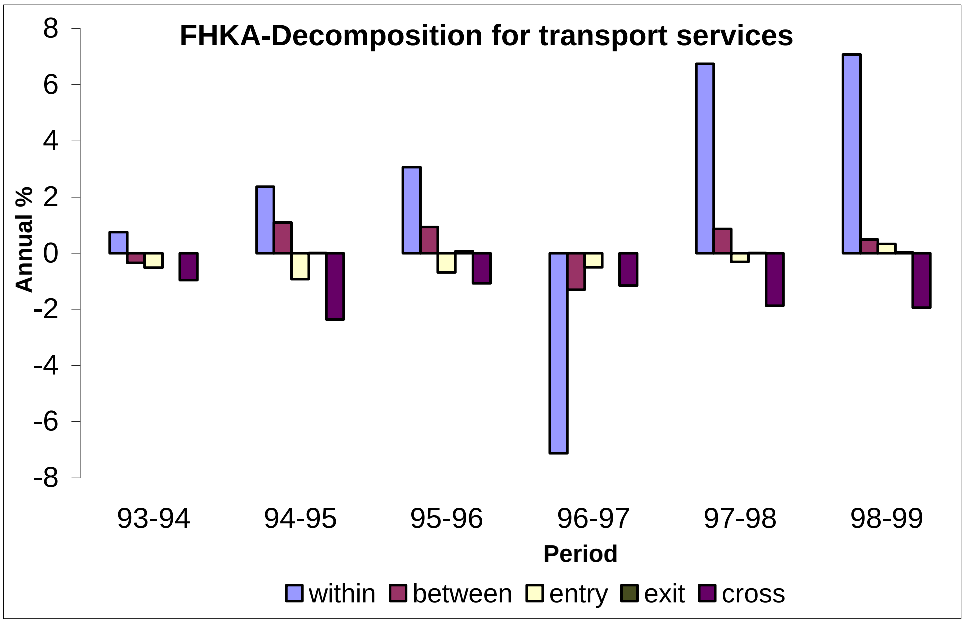


Figure F.1 FHKA-decomposition; output weights


FHKA-Decomposition for trade services
Annual %
6
5
4
3
2
1
0
-1
-2
-3
88-90
90-92
92-93
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross


FHKA-Decomposition for transport services
Annual %
8
6
4
2
0
-2
-4
-6
-8
93-94
94-95
95-96
96-97
97-98
98-99
Period
within
between
entry
exit
cross

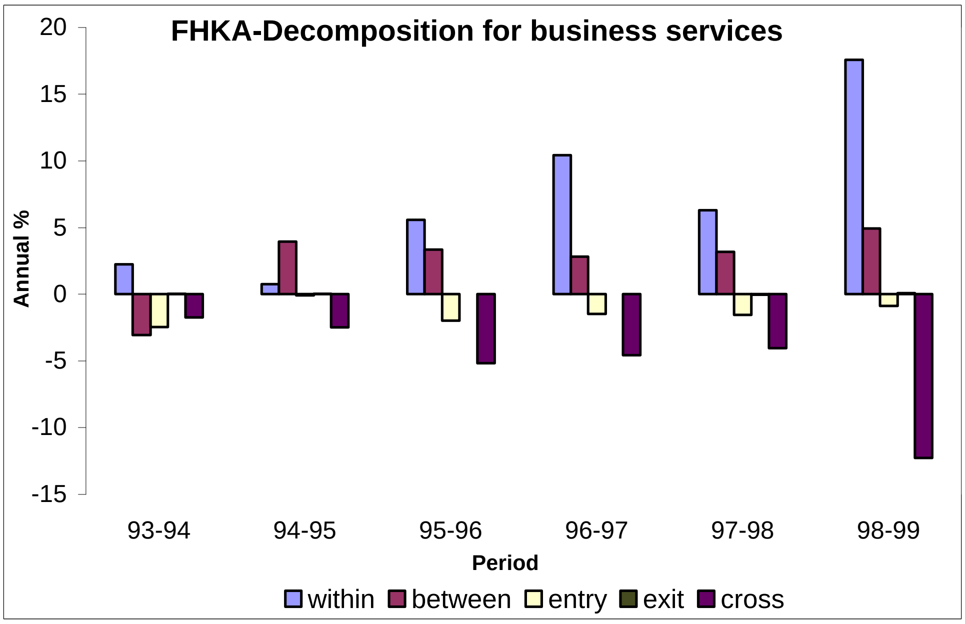


Figure F.2 FHKA-decompositions; geometric weights

Appendix G.

Table G.1 Number (Numb.) and contribution (Cont.) to the annual percentage of aggregate productivity change of entering (N), continuing (C) and exiting (X) firms.

Data set	**Period**	**N**		**C**		**X**	
		Numb.	**Cont.**	**Numb.**	**Cont.**	**Numb.**	**Cont.**
Trade	93-94	232	-0.20	9,822	3.24	121	-0.02
	94-95	242	0.11	9,830	0.56	190	0.09
	95-96	20	-0.01	7,792	-1.00	146	0.02
	96-97	88	0.11	6,290	1.63	85	0.12
	97-98	18	0.02	6,645	-0.93	98	0.17
	98-99	23	0.09	7,374	4.61	99	0.21
Transport	93-94	28	0.01	1,455	-0.66	4	0.00
	94-95	97	-0.61	1,405	-5.64	3	0.00
	95-96	71	-0.19	2,043	5.23	7	-0.01
	96-97	71	-0.47	1,824	-0.38	8	-0.01
	97-98	72	-0.25	1,884	7.75	4	0.01
	98-99	66	0.10	2,006	5.11	9	0.03
Business	93-94	122	-0.88	2,593	-4.25	83	0.34
	94-95	311	-1.45	2,348	1.10	48	0.48
	95-96	453	-2.07	3,039	-1.86	30	0.22
	96-97	452	-1.49	3,351	5.98	48	0.22
	97-98	520	-1.47	3,644	2.58	40	0.05
	98-99	701	-1.41	4,409	6.81	53	0.17
Total	**93-99**	**3587**		**77754**		**1076**	
Average (%)	**93/99**	**4.4**		**93.3**		**1.3**	

Table G.2 Shares of entering firms (N), continuing firms (C), exiting firms (X) and firms to which a change of structure took place (S) for the population of all firms in the ABR.

Data set	**Period**	**N**	**C**	**X**	**S**
Trade	93-94	0.06	0.87	0.06	0.01
	94-95	0.14	0.74	0.10	0.01
	95-96	0.13	0.76	0.10	0.02
	96-97	0.11	0.67	0.10	0.12
	97-98	0.09	0.68	0.09	0.15
	98-99	0.10	0.78	0.08	0.05
Transport	93-94	0.04	0.87	0.07	0.01
	94-95	0.13	0.76	0.08	0.04
	95-96	0.12	0.79	0.06	0.02
	96-97	0.11	0.74	0.06	0.10
	97-98	0.10	0.73	0.08	0.10
	98-99	0.11	0.79	0.06	0.05
Business	93-94	0.05	0.88	0.06	0.01
	94-95	0.14	0.75	0.08	0.02
	95-96	0.13	0.73	0.07	0.07
	96-97	0.11	0.66	0.07	0.16
	97-98	0.11	0.68	0.08	0.13
	98-99	0.12	0.77	0.06	0.05
Average	**93/99**	**0.11**	**0.76**	**0.08**	**0.06**

Table G.3 Contributions of entering (N), continuing (C) and exiting (X) firms to the annual percentages of productivity change; adapted raising factors

Data set	Period	N	C	X
Trade	93-94	-0.03	2.57	-0.74
	94-95	-1.37	-0.21	0.57
	95-96	-8.88	9.20	0.43
	96-97	-3.62	2.19	2.09
	97-98	0.27	0.09	0.74
	98-99	7.77	1.29	0.20
Transport	93-94	-0.02	-0.56	0.03
	94-95	-0.28	-4.35	0.17
	95-96	-0.71	5.67	0.04
	96-97	-0.74	-0.15	0.17
	97-98	-1.11	8.50	0.53
	98-99	0.65	4.87	0.02
Business	93-94	-0.07	-3.34	0.38
	94-95	-1.25	2.38	1.25
	95-96	-1.82	0.11	1.00
	96-97	-2.18	7.90	0.95
	97-98	-1.19	10.49	-4.66
	98-99	-0.46	9.95	0.93

Table G.4 Number (Numb.) and contributions (Cont.) to the annual percentages of aggregate productivity change of entering (N), continuing (C) and exiting (X) firms.

Data set	**Period**	**N**		**C**		**X**	
		Numb.	**Cont.**	**Numb.**	**Cont.**	**Numb.**	**Cont.**
Trade	93-94	311	-0.08	9.606	3.73	235	0.17
	94-95	209	-0.05	9.702	0.35	183	0.14
	95-96	210	-0.50	7.795	-1.52	94	0.13
	96-97	17	0.00	6.377	1.15	127	0.27
	97-98	225	-0.28	6.764	-1.00	259	0.47
	98-99	267	-0.85	7.571	4.04	190	0.32
Transport	93-94	69	-0.25	1.441	-0.45	18	-0.11
	94-95	43	-0.19	1.405	-4.98	26	-0.01
	95-96	102	-0.27	2.026	5.29	6	0.02
	96-97	10	-0.02	1.859	-0.51	40	0.19
	97-98	115	-0.63	1.912	7.08	41	0.19
	98-99	95	-0.50	2.043	4.79	48	0.13
Business	93-94	242	-1.34	2.466	-3.67	167	0.75
	94-95	169	-1.10	2.311	1.88	121	0.47
	95-96	453	-2.07	3.039	-0.01	30	0.22
	96-97	75	-0.29	3.381	8.52	160	0.44
	97-98	487	-0.72	3.478	3.66	163	0.60
	98-99	618	-0.93	4.225	9.52	170	0.67
Total	**93-99**	**3717**		**77.401**		**2.078**	
Average (%)	**93-99**	**4.5**		**93.0**		**2.5**	