Micro and macro indicators of competition: comparison and relation with productivity change

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Statistics Netherlands

2009

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Discussion paper (09024)

Statistics Netherlands

The Hague/Heerlen, 2009

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
2007–2008	= 2007 to 2008 inclusive
2007/2008	= average of 2007 up to and including 2008
2007/'08	= crop year, financial year, school year etc. beginning in 2007 and ending in 2008
2005/'06–2007/'08	= crop year, financial year, etc. 2005/'06 to 2007/'08 inclusive

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

Publisher
Statistics Netherlands
Henri Faasdreef 312
2492 JP The Hague

Prepress
Statistics Netherlands - Grafimedia

Cover
TelDesign, Rotterdam

Information
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Telefax +31 70 337 59 94
Via contact form: www.cbs.nl/information

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ISSN: 1572-0314

6008309024 X-10

Micro and macro indicators of competition: comparison and relation with productivity change

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Abstract

This paper investigates competition in the Dutch manufacturing sector. We look at various indicators that have been used throughout the literature and relate these to productivity growth. Moreover, where possible, the indicators and productivity growth are calculated at both the firm and industry level. This enables us to investigate differences in competition and in its relation with productivity for both aggregation levels. Our results indicate that contemporaneous competition is associated with lower productivity, while lagged competition is positively associated with productivity. This finding is consistent between micro and macro, and robust over the various indicators and industries. The results are consistent with the idea that firms first experience negative effects of changes in competition and need time to adjust, while in the period after adjustment productivity rises again.

Keywords: competition, productivity change, growth accounts, Production Statistics, micro-macro

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Contents

1. Introduction

It is a common belief that competition is good for the performance of firms. This is illustrated for example by various recent policy measures by the Dutch government, concerning among other things the liberalization of markets and the abolishment of barriers to trade (Creusen et al. 2006a). Although there are many arguments to support the hypothesis that competition stimulates productivity, there are also arguments against it. Moreover, empirical evidence on the effect of competition on productivity is limited and ambiguous (OECD, 2008). This study aims to shed new light on this issue by investigating the relation between firm performance and competition using firm and industry level data, and by looking at a broad range of indicators.

1.1 What is competition?

To study the relationship between competition and productivity, it is natural to start with defining what we mean by competition. Unfortunately, a clear-cut definition of competition is not available from the literature. A possible reason for this is the many forms that competition may take. Instead of trying to give a definition, we therefore shortly describe a few manifestations of competition, mainly to create some intuition of the concept and without the illusion of being exhaustive. This paper focuses on competition in the product market. Thus, when speaking of competition, we think of firms competing against each other for the demand for their products. This fight can take place in many ways, but the common denominator is that firms will try to distinguish themselves from their competitors. Perhaps the most obvious example is that firms can compete for demand by lowering their prices. They can achieve this by cutting margins, or decreasing production costs. In addition, it is likely that there is strong competition when the product market is homogeneous. That is, if products are very similar, competition is high. Thus, besides lowering prices, a firm may attract demand by means of product differentiation or, for instance, by offering complementary services. Another way is to improve on sales methods or marketing, for example by offering the possibility to order via internet or through increased advertising. In order to increase its competitiveness, a firm may also look at possibilities to merge with or acquire competing firms.

With these examples of competitive behaviour in mind, we think of the degree of competition in a particular market as the extent to which firms engage in actions to attract demand. The degree of competition may change due to a change in the number of competitors and/or a change of behaviour of incumbent firms. At the micro-level, a firm experiences a change in competition when new rivals enter its market or when existing rivals exit or adjust their efforts to compete.

1.2 Competition: good or bad for performance?

In what way can competition affect firm performance? To start with the arguments in favour of a positive effect of competition on performance, the underlying idea is roughly that in a competitive market firms are forced to work more efficiently in order to make profits and survive. Competition leads to price pressure since it is more difficult to pass on costs to consumers. It therefore exerts a downward pressure on profits, which in turn stimulates firms to produce more efficiently through the reduction of wastages, slack in input utilization or wage cost (Banker et al. 1996). In other words, firms allocate resources in a more efficient way: structural excess capacity will be reduced and resources will be put to their most productive use (Creusen et al. 2006b).[1] On the other hand, Nickell (1996) calls this line of reasoning 'simplistic', arguing that under monopolistic competition managers are just as eager to raise performance as under other types of competition. Rather, under stronger competition, profits are more sensitive to managerial efforts, and managerial efforts can be better monitored. In this way competition is good for performance.

In addition, competition can be an incentive to be innovative: the development of new goods and services and/or improvements in the production process are ways for firms to get an edge over their competitors. Related to this is the point that in a competitive environment the diffusion of new knowledge is stimulated. By adaption and imitation, firms are able to learn from their most successful competitors and therefore become more productive.[2] In Van der Wiel et al. (2008) it is found that this learning process is speeded up when the degree of competition is higher. Similarly, international competition (i.e. international trade) may affect productivity in a similar way, through the diffusion of knowledge (e.g. foreign R&D).

At the industry level, competitive pressure may also result in better performance due to a selection effect: due to competition the least efficient firms are forced out of the market. Entry and exit of firms therefore play an important role in increasing industry productivity. Entry of new firms entails higher competition, and also brings new technology and knowledge to the market. The less productive, inefficient firms will be forced out of the market and the most productive, efficient firms will survive. Due to the selection mechanism inherent to these industrial dynamics, the average productivity of the market increases.

Thus, many arguments support the hypothesis that competition is good for both productivity and productivity growth. However, there are also reasons why competition may not be good. Firstly, due to competition it may be that there is not enough cash flow to finance R&D, which in turn deters a firm to be innovative and improve performance in the long run. This line of reasoning goes back to Schumpeter (1942), who suggested that competition is detrimental to innovation. Investment in R&D is only possible with sufficient financial resources. With respect to internal financing, Schumpeter claimed that monopoly is the optimal market form for innovation.

[1] An interesting example is that competition may influence productivity through its effect on the characteristics of organizational design. Guadalupe and Wulf (2008) found that competition leads firms to become flatter. This reduces the number of positions between the CEO and division managers, and increases the number of positions reporting directly to the CEO, indicating that communication becomes more efficient.

[2] On the other hand, if due to competition firms have less opportunity to enjoy competitive advantages from their innovation, this may actually deter innovation, which in turn leads to lower productivity. See also below.

Moreover, external finance may not always be an option (Mohnen et al. 2008). Aghion et al. (2005) suggest that the truth about the relation between competition and productivity may be somewhere in the middle: they find that moderate competition stimulates innovation, but if competition is too fierce firms have no scope to be innovative.

Secondly, if potential sales of new products are uncertain due to competition, firms may also be hesitant to invest in the development of new products. Under uncertain conditions, firms are known to postpone investments (e.g. Dixit and Pindyck, 1994), which is also likely to hamper productivity growth. Moreover, firms may enjoy less competitive advantage from their innovations due to imitation behavior of their competitors. This provides less incentive to be innovative. Finally, competition may also involve a battle of incumbent firms to keep entrants out of the market. This involves strategic decisions, which are not necessarily optimal in terms of performance for the incumbent firms. Power (1998) finds no effect of investment on productivity and argues that this could be due to the fact that the investment decision may involve strategic considerations.[3] In addition, young and dynamic firms are found to be a major source of productivity growth at the aggregate level (e.g. Foster et al. 2000), which suggests that entry deterrence due to competition is bad in this respect.

1.3 Relation to the literature and aim of the paper

All in all, the direction of the effect of competition on productivity is not clear *a priori*. One of the main complications in testing the relation between competition and performance, is the definition and measurement of competition. This is a difficult and largely unresolved issue. For example, the intensity of competition is sometimes measured by the number of firms in a market or firms' market shares. These measures can be ambiguous, however, as a market with two or three large firms can be as competitive as a market consisting of several hundreds of small firms depending on how aggressive the behaviour of the firms is. In addition, it is usually not clear how the firm's market is defined.

In the available literature, competition has been measured with several different indicators, each measuring a single aspect of competition. The Herfindahl index, for example, measures the concentration of firms within a market, whereas the price cost margin (PCM) measures the profitability of firms. Despite its multidimensional character, only few studies used multiple indicators of competition. In this paper, we use a selection of competition indicators, and discuss their advantages and drawbacks. To our knowledge, no study has investigated a set of indicators as extended as we use in this paper.

As mentioned above, there is only some empirical evidence on the competition-productivity link, which is limited to a few countries (mainly US or UK firms), a

[3] Thus, relating this to the previous point about firm investment, competition may lead to the delay of investment, but also to investment that is not (directly) aimed at fostering the performance of the firm. In both cases, productivity is negatively affected.

few industries, or specific periods of time (OECD 2008). Despite its relevance for policy, the development of competition in the Netherlands since the early 1990s has hardly been investigated at an economy-wide scale (Creusen et al. 2006a). Several studies have empirically investigated the relationship between different indicators of competition, labour productivity and/or multi-factor productivity (e.g. Nickell, 1996). Although each of these studies made a valuable contribution, they have some limitations with respect to the number of industries studied, the number of indicators studied, and the number of observations used to specify the relationships empirically. In particular, none of the studies that we found investigated the relationship between competition and productivity by combining firm-level data and macro-economic data from the National Accounts. Previous research did however find differences between similar indicators that were both measured at the macro level and the micro level (Creusen et al. 2006a).

The aim of this paper is to make a contribution to the empirical literature on the measurement of competition and its relation to firm performance. Our analysis has an explorative nature. We consider various existing measures of competition and their relation with productivity at different levels of aggregation. Both productivity and competition indicators are calculated on the basis of firm- and industry-level data from respectively the Production Statistics (PS) and the National Accounts (NA) covering the period 1995-2005. It is interesting to look at whether the various indicators point into the same direction, and whether they suggest the same relation of competition to productivity. In particular, for the indicators that can be calculated on both micro and macro data, it is interesting to see whether the results are consistent. Finally, the use of micro as well as macro data, offers the possibility to use the official multi-factor productivity statistics in the growth accounts of Statistics Netherlands (CBS, 2008), while also exploiting the richness of the available micro data. It may be that due to aggregation, some indicators do not correlate with productivity at the industry level, while the micro data do allow to identify such a correlation.

Our study contributes to the existing literature in the following ways. Firstly, as mentioned, we use a combination of micro and macro level indicators of competition and productivity. This allows us to compare the relationship at two different aggregation levels. Secondly, we use a broad set of competition indicators. This allows us to analyse the multiple aspects of competition and their relationships with productivity. Thirdly, we use KLEMS multi-factor productivity as a dependent variable instead of the more commonly used labour productivity. This allows us to account for changes in capital and/or intermediate use, to disentangle a 'true' efficiency effect. Finally, we analyse the effect of time lags between the competition measures and productivity.

The following research questions will guide the remainder of this study:

- Which indicators can be used to measure competition at the macro and micro level?
- To what extent do similar indicators of competition at the macro and micro level lead to similar results and how can differences be explained?

– What is the relation between competition and productivity?

– How does the relationship between competition and productivity vary over different measures of competition?

The outline of the paper is as follows. Section 2 introduces the competition measures, and gives a brief overview of the calculation of multi-factor productivity change at both the micro and macro level. It also describes the data sources and discusses particular choices that were made with respect to the calculation of the various variables. Section 3 discusses the results for the various competition measures, and the results for various regressions of productivity change on the levels and changes in the competition measures, employing different timing assumptions. Section 4 concludes, summarizes, and gives suggestions for further research.

2. Measuring competition and productivity

There are a number of competition indicators that are suggested throughout the literature. In section 2.1, we review some indicators that are frequently used and that will also be used in this paper. In addition, we describe how productivity growth is measured in section 2.2. The data are briefly described in section 2.3. Section 2.4 discusses a couple of problems that arise when using the competition indicators. Finally, section 2.5 reviews some empirical research in which these indicators have been used.

2.1 Measures of competition

2.1.1 Price cost margin

The price cost margin (PCM, sometimes referred to as the Lerner index) is an indicator for profitability. It reflects a firm's ability to set its prices above marginal cost. As competition increases, firms are forced to reduce their markup, the limit being perfect competition where prices equal marginal costs. Strictly speaking, the indicator is defined as the difference between price and marginal costs, but because the latter are not observed, it is often operationalised as the difference between production-based output and average variable costs (labour input, L and intermediate use, which is the sum of energy, material and service costs, $E + M + S$). A higher PCM is indicative of a less competitive market.[4] It is calculated as:

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[4] A problem with the PCM that often goes unnoticed is that a shift to a more capital intensive production method ('capital deepening') leads to a higher PCM. In this case, it suggests a lower level of competition while there has only been a shift in the mix of production factors. This can be accounted for by adjusting the profit measure for (exogenous) capital cost (i.e. 'clear' profits). In this paper, however, we use the PCM as it is applied in the literature. Calculations on the macro data show that the PCM based on clear profits is highly correlated with the original PCM, and that the regression results are similar when using either definition.

$$PCM_{it} = \frac{Y_{it} - (L_{it} + E_{it} + M_{it} + S_{it})}{Y_{it}}$$

where *i* and *t* indicate the firm and year

PCM_{it}	price cost margin
Y_{it}	production value (total revenue)
L_{it}	labour costs
E_{it}	energy costs
M_{it}	materials costs
S_{it}	costs of services

The PCM for an industry *j* can be calculated in two ways. Firstly, we can use the National Accounts variables for industry *j* to calculate:

$$PCM_{jt} = \frac{Y_{jt} - (L_{jt} + E_{jt} + M_{jt} + S_{jt})}{Y_{jt}} .$$

Secondly, using the firm-level PCM, we can do a weighted summation to get:

$$PCM_{jt}^{(PS)} = \sum_{i \in j} \alpha_{it} msh_{it} PCM_{it} ,$$

where

α_{it}	sampling weight of firm *i*
msh_{it}	the share of firm *i* in the total value of (unconsolidated) production[5] of industry *j* (i.e. market share)

Except for the sampling weight, this last measure is also used in Creusen et al. (2006a).[6] Observations in the micro data where the PCM is larger than one are considered outliers and are therefore not taken into account.[7]

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[5] Consolidation refers to the netting-out of supply and use streams in order to aggregate smaller units to a larger single unit.

[6] Small firms are included in the PS according to a stratified sampling. Each firm receives a weight that reflects how many firms it represents in the total population. Thus, strictly speaking, these firms should be weighted when aggregating.

[7] Note that if total variable costs ($L + E + M + S$) and production value (Y_{jt}) are non-negative the PCM cannot exceed one by definition.

2.1.2 Labour income ratio

The labour income ratio (LINC) indicates the share of labour income in net value added. The idea is that a higher labour-income ratio points to more competition, as value added consists to a larger extent of labour costs and profits are lower. This is an admittedly rough measure of competition, and is included here mainly as it is a frequently used economic yardstick in policy (see Creusen et al. 2006a).[8] The labour income ratio for firm *i* is calculated as:

$$LINC_{it} = \frac{L_{it}}{NVA_{it}}$$

where

$LINC_{it}$	labour income ratio
NVA_{it}	net value added (i.e. $NVA_{it} = VA_{it} - D_{it} = Y_{it} - (E_{it} + M_{it} + S_{it}) - D_{it}$, where VA_{it} is value added and D_{it} is depreciation)

Similarly, for industry *j*, $LINC_{jt}$ is calculated as

$$LINC_{jt} = \frac{L_{jt}}{NVA_{jt}}$$

From the micro data we can also calculate

$$LINC_{jt}^{(PS)} = \frac{\sum_{i \in j} \alpha_{it} L_{it}}{\sum_{i \in j} \alpha_{it} NVA_{it}} .$$

Again this last measure is similar to that used in Creusen et al. (2006a). Observations where the labour costs exceed the production value are not taken into account.

2.1.3 Import quote

The import quote indicates the contribution of foreign firms to competition in a domestic market. Due to strong foreign competition on their output market, companies are forced to work more efficiently. This results in a higher productivity. The import quote is measured at the commodity level. It reflects the share of imports of a certain product in the total (domestic) use of that commodity.[9] A higher import quote means

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[8] One drawback of the LINC is that a high value may also reflect the bargaining power of employees in a certain industry. In addition, the inverse of the LINC is related to (the inverse of) labour productivity. If an increase in competition forces firms to work more efficiently, labour productivity is expected to rise. Since the LINC is inversely related to labour productivity it will fall, which – following the line of argument above – wrongly suggests a fall in competition.

[9] Commodities are measured at the lowest available aggregation level of the Supply and Use tables (104 commodity groups of which the main producing industry is part of the manufacturing industry).

that there is more competition from foreign firms on the domestic market. To calculate the import quote per industry, we assign total imports and total domestic use of a product to the main producing industry. Furthermore, adjustments for imported goods that are directly re-exported are made. The import quote is calculated as:

$$IMPQ_{jt} = \frac{\sum_c \omega_{jc} IMP_{ct}}{\sum_c \omega_{jc} DU_{ct}}$$

where,

IMP_{ct}	imports net of transit for commodity *c*
ω_{jc}	1 if *j* is main producing industry of commodity *c*
	0 otherwise
DU_{ct}	domestic use of commodity *c* in year *t*

This indicator has been used before in CBS (2008). There is no similar indicator available at the firm-level from the PS, since the import quote is by definition a macro indicator.

2.1.4 Export quote

The export quote measures for what part of sales companies rely on foreign markets, and is therefore an indicator for the exposure to competition on foreign markets. It is calculated as the share of total domestic production that is produced for foreign markets. A higher export quote means that firms are for a larger part of their sales exposed to competition on foreign markets. This competition indicator is different from all other indicators, since all other indicators measure competition on domestic markets.

Similar to the import quote, the macro export quote is measured at the commodity level. In this case, the total exports and production of a commodity are assigned to the main producing industry. Again exports are net of transit goods. The export quote is then calculated as:

$$EXPQ_{jt} = \frac{\sum_c \omega_{jc} EXP_{ct}}{\sum_c \omega_{jc} Y_{ct}},$$

where

ω_{jc}	= 1 if *j* is the main producing industry of commodity *c*
	= 0 otherwise
EXP_{ct}	export value of commodity *c*
Y_{ct}	total domestic production value of commodity *c*

At the micro level, we observe how much a firm exports. It is not possible to follow exactly the definition of the macro-indicator, however, since we do not have a break-

breakdown by commodity type. As a firm-level indicator of exposure to competition on foreign markets, we use the share of exports in total sales by a firm:[10]

$$EXPQ_{it} = \frac{EXP_{it}}{S_{it}}$$

where EXP_{it} total value of exports

S_{it} total sales value

An industry indicator for *EXPQ* from the micro data follows from a weighted summation of the numerator and denominator

$$EXPQ_{jt}^{PS} = \frac{\sum_{i \in j} \alpha_{it} EXP_{it}}{\sum_{i \in j} \alpha_{it} S_{it}} .$$

Note that the weighted micro data indicator is in this case conceptually different from the indicator based on macro data, since the latter is based on export data per commodity group and assigns a main producing industry to each commodity. In practice, however, the macro export quote hardly changes when it is calculated according to the "micro definition".

2.1.5 Profit elasticity

The profit elasticity (PE), or *relative profits measure*, introduced by Boone (2000), describes the relation between a firm's profit and its marginal costs. It is calculated as the percentage change in profits due to a 1 percent change in marginal costs (i.e. the elasticity of profit with respect to marginal costs). The main idea of the indicator is that fiercer competition enables efficient firms to earn relatively higher profits than less efficient competitors. Thus, in a highly competitive market the elasticity of profit with respect to costs will be higher. Boone (2000) emphasizes that comparison of the indicator over industries is hampered due to the fact that marginal costs are unobserved and that it is difficult to define the relevant market.[11,12] However, it can be argued that the bias in the indicator does not change too much over time within

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[10] We normalize on total sales instead of total production value as exports refer explicitly to sales abroad. Among other things, sales do not include changes in the stock of commodities. This ensures that the export quote is smaller than 1. Note that this is a difference with the macro-definition. At the industry-level, however, changes in inventories are usually small relative to production since positive and negative changes at the micro-level cancel out.

[11] In addition, Boone mentions the problem of an 'unlevel playing field' within a market. That is, market conditions may not be equal for different firms, for example due to tax exemptions. Failing to account for this, distorts the interpretation of the profit elasticity as a competition measure.

[12] Since the estimation of the profit elasticity in principle does not require observations on all firms in the market, the problem of the definition of a market can be mitigated if there is a sample of firms available for which it is clear that they belong to the same market.

an industry, so that comparing the elasticities over time provides an indication of the development of competition.

The PE can only be calculated on micro data. It can be calculated for different industries and years separately. Following Boone et al. (2007), the profit elasticity is calculated as the β_t in the regression

$$\ln(Y_{it} - VC_{it}) = -\beta_t \ln(MC_{it}) + \alpha_i + \lambda_t + u_{it} \qquad \text{for } i \in j$$

where

$VC_{it} = L_{it} + E_{it} + M_{it} + S_{it}$	variable costs
MC_{it}	marginal costs
α_i	firm fixed effect
λ_t	year dummy
u_{it}	(idiosyncratic) disturbance

This regression is carried out for each industry j and year t separately. Thus, the PE is industry and year specific. Because marginal costs are unobserved, average costs are used as a proxy, following e.g. Boone et al. (2007). Thus, $MC_{it} \approx (VC_{it}/Y_{it})$. To control for firm-specific effects, the equation is estimated by Fixed Effects (FE).[13]

2.1.6 Herfindahl concentration index

The Herfindahl concentration index, or Herfindahl index for short, indicates the number and size of firms in a sector. It is defined as the sum of squared market shares. A market with one single firm has a Herfindahl index of 1, while a Herfindahl index close to 0 means that there is a large number of firms with a low market share. A decreasing Herfindahl index means that the concentration in a market is reduced and, since it is inversely related to competition, this is interpreted as a rise in competition. The Herfindahl can only be calculated on the basis of micro data and is given by:

$$HERF_{jt} = \sum_{i \in j} \alpha_{it} msh_{it}^2 \,.$$

[13] Basic outlier detection is followed in this estimation: we only use records based on actual response to the PS survey (i.e. imputations are excluded), and drop the lowest and highest percentile in a Cobb-Douglas production function estimation as well as those records for which this estimation cannot be done due to missing values or non-positive in- or output. Time-effects are controlled for by year dummies.

2.1.7 C4

The C4 indicator is a measure similar to the Herfindahl index, and reflects the aggregate market share of the four firms with the largest market shares. Similar measures, such as *C5* and *C10*, are also commonly used. It is given by

$$C4_{jt} = \sum_{i \in C_j} msh_{it}$$

where C_j is the group of four firms with the largest market share in industry j. If the market shares of the largest firms increase, this is evidence for further concentration of the market, and hence a fall in the level of competition.

2.2 Productivity measurement

For productivity measurement, the KLEMS–Y model is used. For any entity i (either a firm or an industry) this can be written as

$$w_{it}^K x_{it}^K + w_{it}^L x_{it}^L + w_{it}^E x_{it}^E + w_{it}^M x_{it}^M + w_{ti}^S x_{it}^S + \Pi_t = p_{it} y_{it}$$

where

w_{it}^k	the unit cost of input k, $k \in \{K, L, E, M, S\}$
x_{it}^k	the quantity of input k
$w_{it}^K x_{it}^K = K_{it}$	the user cost of capital
$w_{it}^L x_{it}^L = L_{it}$, $w_{it}^E x_{it}^E = E_{it}$, $w_{it}^M x_{it}^M = M_{it}$, $w_{it}^S x_{it}^S = S_{it}$	total costs of factor k
p_{it}	the output price
y_{it}	the output quantity
$p_{it} y_{it} = Y_{it}$	value of total output
Π_t	clear profits (i.e. profits net of user cost of capital)

In the calculations of the user cost of capital at the macro level, an exogenous interest rate is used. Therefore total costs do not equal total revenue. This gives rise to clear profits on all aggregation levels. An exogenous interest rate is chosen so that we do not have to use neoclassical assumptions in our productivity measurements. More detailed information on measuring productivity without neoclassical assumptions is given by Balk (2008). At the micro level there is no information available on the costs of capital, which are therefore proxied by the sum of depreciation and rental payments.

Dropping the subscript i for notational convenience, productivity change is calculated as (unless stated otherwise, changes always refer to from year t–1 on year t)

$$IMFP_{t,t-1} = \frac{Q^{Y}_{t,t-1}}{Q^{X}_{t,t-1}}$$

where

$IMFP_{t,t-1}$	the index of multi-factor productivity (*mfp*)
$Q^{Y}_{t,t-1}$	the volume index of the output
$Q^{X}_{t,t-1}$	the volume index of the inputs

Volume changes are calculated with a Laspeyres index, that is both the quantities in year t and t–1 are weighted by prices of t–1. The volume index of the inputs is therefore calculated as

$$Q^{X}_{t,t-1} = \frac{\sum_{k} w^{k}_{t-1} x^{k}_{t}}{\sum_{k} w^{k}_{t-1} x^{k}_{t-1}},$$

and similarly for output Y.

2.2.1 Productivity measurement at the macro level

At the macro level, productivity measurement is based completely on the Dutch national accounts. For this purpose, the manufacturing industry is divided into 13 separate industries. Annex 1 provides a list of these industries.

A thorough overview of the methods used to calculate productivity change at the macro level is given by Van den Bergen et al. (2007). A few characteristics are:

– Sectoral output is used for the calculations. Consolidation is based on square industry by industry input-output tables constructed for each commodity distinguished in the Dutch supply-use system.

– It is assumed that self-employed have the same yearly labour income as employees.

– The nominal interest rate used in the calculation of the user cost of capital is based on the average interest rate that companies must pay on outstanding bonds. It is estimated as the internal reference rate (IRR) between Dutch banks plus a surcharge of 1.5 percent.

2.2.2 Productivity measurement at the micro level

The calculation at the micro level follows that at the macro level as closely as possible, see Annex 6 for details on the calculation of each of the variables. Due to the lack of data, however, we use depreciation and rental payments data to proxy for the user cost of capital. Price indices are drawn from the supply and use tables.

2.3 Data

Data at the macro level were obtained from the National Accounts (NA). The availability of time-series on productivity statistics and the restriction to use only final year data limits our dataset to the years 1995 to 2005. Micro data come from the Production Statistics (PS). Data for the industry 'manufacture of petroleum products' were not considered, since there are very few firms in this industry (less than 30) and the micro data proved to be too volatile with respect to the macro data in this industry. This means that we distinguish in total 12 industries, in accordance to the publication level of the Dutch growth accounts.

The analysis was limited to manufacturing industries for several reasons. Firstly, it is not possible to calculate the competitition indicators and/or *mfp* growth for various industries in the service sector, due to the lack of micro data. In addition, despite promising developments at the macro-level for a selection of industries, price and volume measures are in general not as well established in the service sector as in manufacturing. Finally, and only with respect to the degree of international competition, it can be expected that the impact of exports and imports is far less an issue in services than in manufacturing.

2.4 Issues with measuring competition

The existing literature suggests some problems with conventional measures of competition. We review some of them in this paragraph and add some reservations of our own.

2.4.1 What is the firm's market?

Competition is usually regarded as a market phenomenon, and therefore competition measures often refer to a 'market', which is usually equated to an industry. However, it is generally hard to say what exactly the firm's market is. An industry can be quite heterogeneous with respect to its products, even at low levels of aggregation. Also, when firms are very diversified they may be active in various markets and experience different degrees of competition in different markets, while they are classified in a single industry. In addition, there is usually no information on the spatial dimension of competition. For example, retailers may be classified in the same industry but can be monopolists on their local markets, while similar firms need to deal with a competitor across the street. In addition, because of globalisation, firms are more and more internationally active. This means that firms experience competition from foreign firms, in the domestic as well as foreign markets. Due to the rise of internet sales, it is not even necessary for a firm to be physically present abroad to be internationally active (or, *vice versa*, a competitor does not need to be physically present in a firm's country). The international dimension of competition is typically hard to measure, however, because survey based data is usually confined to the *national* activities of *domestic* firms.

The upshot of the preceding is that there can be a difference between the degree of competition in a market or industry with the degree of competition experienced by the firm. In this paper, we will use industry-level as well as firm-level indicators, the latter (based for example on a firm's profit) being independent from the definition of a firm's market.

2.4.2 *Selection, reallocation, mergers and acquisitions*

Most indicators focus on a particular aspect of competition. For example, the Herfindahl index and other measures are based on market shares. These measures pick up the change of entry barriers over time relatively well, but if competition intensifies due to more aggressive conduct of firms, they point into the wrong direction. To see this, note that the increase in competition forces the least efficient firms out of the market. This increases market shares, so that concentration indices actually point to less competition. Thus, they fail to pick up a selection effect.

Related to this point, an increase in competition can lead to a reallocation effect, in the sense that market shares of efficient firms (in terms of marginal costs of production) are raised relative to those of inefficient firms. Concentration increases in this case, so that concentration indices point to less competition in these instances. Boone et al. (2007) argue that such reallocation effects also distort the (industry level) PCM indicator. That is, an increase in competition raises the market share of efficient firms with a high PCM. If the more efficient firms are also more profitable, this means that the *industry* PCM may in fact increase, suggesting a fall in competition. Boone et al. identify the reallocation effect in the PS data for 1993 to 2002. They find that the PCM tends to misrepresent the development of competition over time in markets with few firms and high concentration. Note that the reallocation effect does not play a role for the firm level definition of the PCM, since it does not depend on the firm's market. The PE is also claimed not to have these disadvantages, as increasing competition always leads to increased profits of efficient firms to the adverse of less efficient firms (Boone, 2000).

Finally, competition may manifest itself in the threat of being taken over or the need to merge with other companies to become a more competitive market player. Industries that are characterized by this type of competition include for example the airline industry and financial industries, as well as the energy sector. Clearly, concentration indices are less suitable to describe competition in a market that is characterized by mergers and acquisitions.

2.4.3 *Endogeneity*

The indicators discussed above are all based on variables which are thought to be (inversely) related to competition: profitability, market share, export and import. The problem that arises when relating these indicators to firm performance, is that the underlying variables are not determined completely independently from the performance measure. Firms may be more profitable if they are more productive, higher productivity may lead to a higher market share, better performing firms may have a higher chance to be active on the international market. In addition, both the PCM and LINC implicitly refer to the value component of profitability, whereas productivity is the volume component of profitability. The fact that the underlying variables are not independent from (changes in) productivity, makes the competition indicators endogenous to productivity. In fact, the examples suggest that in this case there is a negative relationship between productivity and competition.

To account for this, we also use lagged values next to contemporaneous values for the competition indicators (cf. Van der Wiel et al. 2008). Because the level of competition in year t–1 is not jointly determined with productivity in year t, and productivity changes in year t do not cause changes in competition in year t–1, it can be argued that the lagged values are exogenous. Besides accounting for endogeneity, this specification reflects that there may be a lagged effect of competition on productivity. As companies become less profitable due to competition in one year, they will change business processes and become more productive. It may take time, however, for firms to adjust to changes in competition, especially if production structures are inflexible. Therefore, changes in competition need time to effectuate and increase productivity.[14]

2.4.4 Micro-macro inconsistencies

Another problem is that data sources on which competition measures can be calculated may lead to differing results. In their study on measuring competion in the Netherlands, Creusen et al. (2006a) compared the PE, PCM, LINC, and the Herfindahl, using data from the PS (PE, PCM, Herfindahl) and NA (LINC, PCM). Most indicators point to a decline of competition in the Netherlands in the period 1993-2001. In particular, all indicators derived from firm-level data and the LINC indicate such a decline. The NA version of the PCM, however, points to a rise in competition and therefore disagrees with the firm-level PCM. According to the authors, this finding could reflect that NA data come from various aggregated micro sources which are integrated to get a consistent picture of the Dutch economy. In Annex 2b it can be seen, however, that for most industries the PCM based on the NA data follows that based on the PS quite closely. The reason for the differing results with Creusen et al. could lie in the fact that a slightly different time frame is used here. Indeed, the similarity seems to have improved after 2001, which is the last year of the CPB study. In addition, the correspondence between micro and macro results may also benefit from the use of sampling weights and exclusion of outliers as we have done here.

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[14] Alternatively, if productivity in year t is believed to be affected by competition in year t, a possibility to account for the endogeneity issue is to use the lagged competition variables as *instruments* for the current values (for example by using an Instrument Variables estimation method like Two Stage Least Squares (2SLS) or the Generalized Method of Moments (GMM)). We will not pursue this in this report; unreported results for 2SLS, however, show that the results do not differ much from those with the lagged variables. This is not surprising, because in that case the competition indicator is replaced by a prediction based on its lag.

2.4.5 Caveat to the profit elasticity

The PE is a relatively new measure of competition and has not been used frequently in empirical research. Although the indicator has a sound theoretical founding, a few question marks are in place regarding its empirical application. In particular, the PE is defined as the sensitivity of profits to marginal costs. Because marginal costs are not observed, these are replaced by average costs. Thus, the estimating equation is

$$\ln(Y_{it} - VC_{it}) = -\beta_t \ln(VC_{it}/Y_{it}) + \alpha_i + \lambda_t + u_{it} \qquad \text{for } i \in j$$

In fact, this estimation relates profits to (the inverse of) profitability. But if profitability goes up, profits go up *by definition*. It is therefore doubtful whether this approach is suitable to estimate the sensitivity of profits to *efficiency*.

This point is left for further investigation. We shall estimate the profit elasticity as it is used in the current literature.

2.5 Some results of previous research

Several studies have investigated the relationships between different indicators of competition and productivity. Most of them pointed to a positive effect of product market competition on productivity growth. In this section we discuss the results of a few studies in this area to be able to relate our own results to those in the literature.

Nickell (1996) investigated the relation between productivity and competition, using the following competition measures: market share, the Herfindahl index, import penetration, average rents, and a survey based measure on the number of competitors (“Have you more than five competitors in the market for your products?”). The average rents measure was calculated as an average over the sample period of profits less capital costs (i.e. ‘clear’ profits), as a percentage of value added. Endogeneity was controlled for by using Generalized Method of Moments (GMM) estimation. Data from a panel of UK firms over the period 1972-1986 showed a weak effect of competition on multi-factor productivity levels, but a stronger effect on productivity growth. The strongest effect was observed for the rents indicator.

Two studies performed an analysis in the spirit of Nickell (1996) for the Netherlands. Felsö et al. (2001) used data for the manufacturing, construction, and trade sectors for the period 1985-1996. Productivity growth showed a significant correlation with the competition measures used: the profit elasticity, the Herfindahl index, market share, and average firm size. Lever and Nieuwenhuijsen (1998) focussed on the Dutch manufacturing sector. They found that the increase of concentration in markets (in terms of higher market shares) leads to lower levels of productivity. Industries with relatively lower levels of market concentration, higher export shares and higher import shares show more than average growth of productivity. The authors further conclude that profitability has a positive and significant effect on productivity. According to the authors, this finding supports the so-called Schumpeter’s

Mark II hypothesis that monopoly profits are necessary for investments in research and development and innovation.[15]

With respect to the development of competition, Lever and Nieuwenhuijsen found that competition in Dutch manufacturing increased in the period 1978-1993. For the retail sector, Creusen et al. (2006b) used the PE to evaluate changes in competition. It was shown that on average, the competition in this sector decreased in the time period 1993-2002. However, for some parts of this sector, an increase in competition was observed. Linking the data with the innovation surveys, it was shown that there was a positive and linear relationship between innovation and competition. The report concluded that stimulating competition is conducive for innovation. Both competition and innovation were shown to have a positive correlation with multi-factor productivity. Creusen et al. (2006a) found that competition at the level of the market sector in the Netherlands declined in the period 1993-2001. Competition was measured with the PCM and PE. It was found that competition did not increase for most industries. In fact, a considerable number of industries experienced a sharp rise or strong fall in competition. As discussed in Boone et al. (2007), Creusen et al. (2006a) found that the PCM and PE can lead to contradicting results if reallocation effects within an industry are substantial. After estimating a model relating competition to a number of explanatory variables at the industry level the authors found that regulatory reforms have probably intensified competition, but also that considerable growth of demand has weakened competition in the period 1993-2001.

3. Results

3.1 Summary statistics

Annex 2 and 3 provide an overview of the development of competition indicators and *mfp* change in 12 Dutch manufacturing industries in the period 1995-2005 (excluding the manufacture of petroleum products). The similarity between macro indicators and their micro equivalents is reasonably good. Divergence between macro and micro indicators can be attributed to such things as aberrant or incorrect observations of individual firms in the micro data and the use of various sources in the macro data.

The figures in annex 2 and 3 clearly show that it is nearly impossible to draw a single conclusion on the development of competition for all manufacturing industries in the period 1995-2005. There are large differences in the development of competition indicators between industries. For example, some industries, such as the manufacture of basic metals or the manufacture of electrical and optical equipment, show more erratic developments than others. Moreover, different indicators sometimes point into different directions. According to some indicators, competition increases,

[15] However, this finding may also be caused by reversed causality. Profitability may itself be influenced by productivity, see also section 2.4.3.

whereas other indicators point to a decline in competition. For example, the C4 and Herfindahl index show a peak in 1999 for almost all manufacturing industries, indicating a decreased level of competition afterwards. At the same time, the PCM and the LINC indicate increased levels of competition in the manufacture of basic metals and the manufacture of machinery and equipment.

Table 1 shows the correlations between macro *mfp* change and different indicators of competition based on industry data in Dutch manufacturing. The first six indicators are based on micro data and the last four indicators are based on macro data. The significance of correlations between indicators of competition may be inflated as all individual years are used in the analysis and the levels of competition indicators within industries do not vary much between years.

The correlation coefficients (r) between similar indicators based on micro data and macro data (LINC, PCM and export quote) are relatively high (r = .73, r = .64, and r = .91, respectively). This demonstrates that the correspondence between variables that have been aggregated from the micro data and variables that have been calculated based on macro data is indeed reasonably good. The correlation between the LINC and PCM is negative in all cases. This makes sense since the LINC is inversely related to the PCM. Naturally, since both indicators are based on market shares, the Herfindahl and C4 indices are highly correlated. It is striking that the import and export quotes show high correlations with most of the other indicators. They are for example positively associated with more concentrated markets (positive correlation with Herfindahl and C4) and negatively associated with less profitable markets (negative correlation with PCM). Finally, it should be noted that the PE only has a moderate (but significant) positive correlation with the LINC, but not with the other indicators.

The upper panel of table 2 shows the correlations among the firm-level indicators. Only the Herfindahl and C4 show a very strong correlation again. The PCM and LINC show a significant and negative correlation again, but it is more moderate than in the macro case. The low correlations are an indication that the indicators measure different dimensions of competition. Alternatively, there are situations where some indicators may point into the wrong direction (Boone et al. 2007).[16] It is somewhat striking that the correlations of the PE with the micro-level indicators are significant, whereas there is no correlation with the macro counterparts in table 1. These correlations are very moderate however.

[16] Differences between table 1 and table 2 for the micro indicators that only vary by industry (PE, C4 and Herfindahl) arise for two reasons. Firstly, table 2 calculates the correlations at the firm level without industry weights. Thus, industries with more firms get more weight in table 2. Secondly, as mentioned in the table note, outliers and imputations are excluded from the micro data while we did use these to calculate the aggregates from the micro data.

Table 1. Correlation matrix macro and aggregated micro competition measures.

		based on microdata (aggregated)						based on macrodata			
		Profit elasticity	C4	Herfindahl	Labour income	Price cost margin	Export quote	Labour income	Price cost margin	Export quote	Import quote
based on microdata (aggregated)	Profit elasticity	1									
	C4	–.08	1								
	Herfindahl	–.08	**.94**	1							
	Labour income	**.21**	.09	**.22**	1						
	Price cost margin	–.14	**–.22**	**–.19**	**–.60**	1					
	Export quote	–.04	**.64**	**.59**	–.01	**–.32**	1				
based on macrodata	Labour income	–.01	**.22**	**.39**	**.73**	**–.38**	.09	1			
	Price cost margin	–.05	**–.33**	**–.41**	**–.57**	**.64**	**–.40**	**–.80**	1		
	Export quote	.02	**.61**	**.50**	–.06	**–.36**	**.91**	–.02	**–.34**	1	
	Import quote	–.04	**.57**	**.52**	**.26**	**–.44**	**.76**	**.27**	**–.49**	**.86**	1

Correlations that are significant at the 5% level are bold faced.

Table 2. Correlation matrix micro and macro competition measures.

		based on microdata					
		Profit elasticity	C4	Herfindahl	Labour income	Price cost margin	Export quote
based on microdata	Profit elasticity	1					
	C4	**–.086**	1				
	Herfindahl	–.117	**.937**	1			
	Labour income	**.005**	.002	.001	1		
	Price cost margin	**–.108**	.006	**.022**	**–.241**	1	
	Export quote	**.089**	.137	.078	–.003	**–.057**	1
based on macrodata	Labour income				–.004		
	Price cost margin					**.035**	
	Export quote						**.330**

Correlations that are significant at the 5% level are bold faced. Potential outliers were excluded from the micro data; see also section 3.2.2. Nb. table 2 differs from table 1 in that competition measures based on microdata are not aggregated (i.e. correlations are at the firm-level).

The bottom panel of the table gives the correlations for the micro indicators with their National Accounts counterparts. In this case, only the export based indicators show a substantial correlation. This is an indication that there is great heterogeneity at the micro level for the PCM and LINC, so that the value for the industry is not representative for the individual firms. For example, the competition indicators are likely to be determined by the larger firms, which may not be representative for the degree of competition experienced by a smaller firm.

3.2 Relation between productivity and competition indicators

Since we use both micro and macro data, we can relate productivity growth and competition indicators at different levels of aggregation. In section 3.2.1, industry-level productivity growth is related to industry-level competition indicators calculated from the macro as well as from the micro data. In section 3.2.2, firm level productivity growth is related to firm-level competition indicators, as well as to industry-level competition indicators calculated from the macro data.

3.2.1 Macro productivity

Table 3 shows the results of our regression analyses of *mfp* change at the macro level on indicators of competition at the macro level, the latter calculated from macro as well as from micro data. A simple linear regression model is estimated for each relationship. We use industry and year dummy variables to control for industry- and year specific effects. The analyses are conducted for both the levels and the changes of the competition indicators, employing different timing assumptions. The contemporaneous models refer to the relationships between *mfp* change in year *t* and competition indicators in year *t*. In the 1-year lagged models we analyze the relationships between *mfp* change in year *t* and indicators of competition in year *t*–1. Table 3 shows the expected signs of the relationships, the estimated regression coefficients, and standard errors.

Several interesting results of the macro level *mfp* analyses are described below. Firstly, we find that the regression analyses for similar micro and macro indicators of competition (i.e., LINC, PCM and export quote) lead to similar results. For example, in the contemporaneous model the LINC is negatively and significantly related to *mfp* change, both when the LINC is calculated on macro data and when it is calculated on micro data. This finding shows that despite some moderate differences between similar indicators based on both data sources, the overall relationship between these micro and macro level indicators and productivity change is the same.

Secondly, all signs of the significant results in the contemporaneous models are opposite to the expected sign when one assumes that competition fosters productivity growth. Both the level and the changes of several aspects of competition in year *t* are negatively related to *mfp* change in year *t*. A possible conclusion could be that competition is in fact bad for productivity growth. However, as discussed in section 2.4.3, a possible problem with the contemporaneous indicators is that they are endogenous. We therefore also relate productivity to the lagged competition indicators. Modelling a time-lag between the indicators of competition and *mfp* change acknowledges that it takes time before the effects of competition are realized and reduces the problem of endogeneity. The results of the lagged models in table 3 show that the signs of the relationships between *mfp* change, the LINC and the PCM have the expected directions both at the micro and the macro level. Compared to the contemporaneous models the signs of these relationships are reversed. In a similar way, the signs of the relationships in the lagged models for the profit elasticity, macro export and macro import quote have switched into the hypothesized directions, but they remain insignificant. These results are consistent with the idea that firms need time to adjust to changes in competition. First they need time to make adjustments in the production process which initially has a disruptive effect. In later periods, this results into productivity gains.

Finally, and contrary to prior expectations, the C4 and Herfindahl index are positively related to *mfp* change in both the contemporaneous and lagged models. A potential explanation for this result is that the C4 and Herfindahl index can, as discussed in section 2.4.2, easily be influenced by selection and reallocation effects. This means that if competition changes due to the aggressive conduct of firms, concentration indicators such as C4 and the Herfindahl index may point into the wrong direction. Consequently, the signs of the relationship between these indicators and *mfp* change will then be in the wrong direction too.

Table 3. Relationships between macro *mfp* change and indicators of competition.

Indicator	expected sign[a]	contemporaneous coeff.	contemporaneous s.e.	1-year lagged coeff.	1-year lagged s.e.
Based on micro data					
Profit elasticity	+	–0.22	0.26	0.06	0.32
Profit elasticity (change)	+	–0.17	0.19	0.20	0.21
C4	–	16.45**	7.25	11.36	8.68
C4 (change)	–	0.10	0.08	0.02	0.09
Herfindahl	–	23.63**	9.66	15.05	11.86
Herfindahl (change)	–	21.98*	13.09	46.52***	13.22
Labour income	+	–8.22**	3.52	10.41**	4.48
Labour income (change)	+	–0.12***	0.03	–0.02	0.03
Price cost margin	–	24.82**	11.67	–35.70**	13.86
Price cost margin (change)	–	0.42***	0.10	0.05	0.12
Export quote	+	3.33	3.72	2.87	4.24
Export quote (change)	+	0.00	0.03	0.02	0.03
Based on macro data					
Labour income	+	–4.90***	1.83	6.71***	1.99
Labour income (change)	+	–0.14***	0.02	0.02	0.02
Price cost margin	–	19.95**	9.17	–41.71***	9.59
Price cost margin (change)	–	0.46***	0.07	–0.14	0.09
Export quote	+	–3.69	5.84	0.92	6.62
Export quote (change)	+	–0.09	0.07	–0.03	0.08
Import quote	+	–3.59	7.08	8.58	7.92
Import quote (change)	+	–0.17**	0.09	0.03	0.10

[a] This is the expected sign according to the hypothesis that more competition leads to a higher productivity. Thus, if a higher value of an indicator indicates stronger competition (e.g. in case of the PCM), the expected sign is positive. Likewise, if a lower value of an indicator indicates stronger competition (e.g. in the case of the Herfindahl index) the expected sign is negative.
Significance levels: * = .10, ** = .05, *** = .01.

3.2.2 Micro productivity

To avoid a distortion of the regression results due to influential data points, we exclude some potential outliers in advance. First of all, we exclude firms with *mfp* levels smaller or equal to zero, and those with an absolute *mfp* growth of more than 400%. In addition, we estimate a simple loglinear version of the Cobb-Douglas function of gross output on the KLEMS production factors and exclude the observations associated with the lowest and highest percentile of the residuals of this regression. This procedure for the exclusion of outliers avoids the inclusion of firms with an atypical production structure. Also, the observations for which the production function could not be estimated are ruled out. The latter selection drops records with either missing observations for input or output variables or (because of the log transformation) for which they are non-positive. Finally, we only use observations that are based on actual response by firms (i.e. quality flag 'A', thus excluding imputations and corrections made for statistical purposes).[17]

Table 4 gives the results for the OLS regression of firm-level productivity on the various competition measures. The results are again reported separately for the indicators based on firm-data and those that are calculated on the macro data. In annex 4, results are reported for the regressions by industry (naturally only for those indicators that vary by firm). The main conclusion from the regressions by industry is that, although there is some variation in the magnitudes of the coefficients, there is not much heterogeneity among industries. Signs and significance are almost always the same.

– Results for micro data indicators

In line with the macro results, what is striking about the contemporaneous effects of the indicators calculated on micro data is that most signs are opposite to what is expected, the only exception being the Herfindahl index. Looking at the results for the lagged variables in the right panel of table 4, we see that – again in accordance to the macro-regressions – almost all signs of the competition indicators are reversed with respect to the contemporaneous effects. Thus, all signs are in line with the expected sign according to the hypothesis that competition improves productivity (the exception being the C4 indicator, which is the only one for which the level as well as the difference has an insignificant effect). The Herfindahl index remains to have the correct sign. This is somewhat surprising since the Herfindahl index had an unexpected positive contemporaneous effect in the macro regressions, and was the only indicator not to change sign when using the lags. Thus, this result is one of the few instances where we find contradicting micro and macro results.

The fact that we find a positive effect of lagged competition on productivity, as well as a reversal of signs when using lags, for such various indicators, shows that the effect is quite robust. In addition, most findings are consistent between both the micro and macro regressions. In some cases, like for the PE, we find significant effects in the micro regressions but not for macro. This may be due to the fact that industry data hides a lot of heterogeneity at the firm level, which possibly deters the identification of an effect at the macro level. This shows the value of using micro data to explain macro phenomena.

[17] Some additional restrictions are made for the regressions with respect the PCM and the LINC. For the PCM, we also exclude observations where the PCM is larger than 1. For the LINC we exclude observations with labour costs higher than the production value, or when the LINC is larger than 4 in absolute value. (These observations are also excluded from the aggregated competition indicators based on micro data.)

Table 4. Relationships between micro *mfp*-change and indicators of competition.

Indicator	expected sign[a]	contemporaneous coeff.	s.e.	1-year lagged coeff.	s.e.
Based on microdata					
Profit elasticity	+	–0.37***	(0.11)	0.54***	(0.11)
Profit elasticity (change)	+	–0.46***	(0.08)	0.25***	(0.09)
C4	–	0.34	(2.44)	–2.85	(2.47)
C4 (change)	–	4.09	(2.66)	–2.21	(2.83)
Herfindahl	–	–11.15***	(3.75)	–8.57*	(4.37)
Herfindahl (change)	–	–8.28	(5.10)	–16.57***	(5.36)
Labour income	+	–6.60***	(0.14)	0.09***	(0.01)
Labour income (change)	+	–0.14***	(0.01)	0.01	(0.01)
Price cost margin	–	30.02***	(0.52)	–24.52***	(0.48)
Price cost margin (change)	–	115.61***	(0.35)	–31.27***	(0.82)
Export quote	+	–0.23	(0.18)	0.03	(0.18)
Export quote (change)	+	–0.47	(0.35)	1.23***	(0.38)
Based on macrodata					
Labour income	+	3.27***	(0.76)	0.86	(0.73)
Labour income (change)	+	1.65***	(0.64)	–0.82	(0.67)
Price cost margin	–	–21.41***	(3.77)	–0.75	(3.70)
Price cost margin (change)	–	–22.00***	(3.89)	8.97**	(4.09)
Export quote	+	1.32	(2.28)	4.74**	(2.00)
Export quote (change)	+	–6.45**	(2.58)	–0.43	(2.67)
Import quote	+	1.20	(2.52)	4.90**	(2.24)
Import quote (change)	+	–6.04**	(2.73)	–1.51	(2.88)

[a] This is the expected sign according to the hypothesis that more competition leads to a higher productivity. Thus, if a higher value of an indicator indicates stronger competition (e.g. in case of the PCM), the expected sign is positive. Likewise, if a lower value of an indicator indicates stronger competition (e.g. in the case of the Herfindahl) the expected sign is negative.
Significance levels: * = .10, ** = .05, *** = .01.

– Results for the macro data indicators

The results for the regression of micro *mfp*-growth on the macro-indicators of competition are reported in the bottom panel of table 4. The most remarkable result from these regressions is that, contrary to the macro-macro and micro-micro results, the contemporaneous effects for the LINC as well as the PCM have the expected sign. This finding holds also true when the aggregated micro data indicators are used (see table A5.1). The fact that these results are different from those from the regressions on the micro-counterparts of these indicators, is in line with the low correlation between the indicators at both aggregation levels given in table 2. This is an indication that due to heterogeneity at the firm-level, the industry-level indicators are not representative for the degree of competition a firm experiences. Indeed, the export quotes based on both the micro and macro data have a stronger correlation, and we see that this indicator does have the same sign as in the micro-micro regression. But why do we find these low correlations between the micro and macro LINC and PCM? And why are the signs of the relation with productivity reversed?

We suspect that the explanation of this result lies in the role of small versus large firms. On the left-hand side of the equation, we have firm-level *mfp*-growth. Each firm has equal weight in the regressions. On the right-hand side, however, firm-level values are aggregated for the macro-indicator, so that large firms play a bigger role than small firms. It can be hypothesized that the degree of competition a small firm experiences is not the same as that experienced by larger firms. For example, larger firms may be primarily competing against each other, while smaller firms operate locally or in market niches that are less affected by competition. When linking micro to macro in this case there is thus the risk that the productivity growth of small firms is being related to a competition indicator that is largely determined by large firms. In addition, since we are looking at *mfp*-growth, we only have continuing firms at the left-hand side. On the right-hand side, however, all firms are included in the indicator. This may also lead to a distortion, since the productivity growth of continuing firms is related to the competition as experienced by both continuing firms as well as those who have entered or exited. The productivity of continuing firm is likely to be higher, while competition is likely to be felt more intensely by exiters. So the positive effect of competition may be inflated due to this issue. In annex 5 we present some evidence that the influence of large firms and the effect of entry and exit play a distorting role when relating micro-level productivity growth to competition. All in all, our results indicate that one should be cautious with interpreting correlations between micro-level productivity and aggregate measures of competition.

4. Conclusions and future research

4.1 Summary of conclusions

In this paper we have looked at various indicators for competition, and related these to multi-factor productivity change. This was done both at the industry- and firm-level. The analysis was restricted to the manufacturing industry and the period 1995-2005. The most important conclusions are:

- Regressions of productivity growth on contemporaneous values for the competition indicators reveal a negative effect of competition on productivity growth. This effect is reversed when a time-lag in the relation between competition and productivity is introduced. We find this for both the micro and macro regressions, and this result is robust across most of the indicators. This finding indicates that firms first experience a negative effect of competition, while in subsequent periods productivity is increased. A possible explanation is that firms need time to adjust, e.g. through investment in R&D or by making necessary adjustments in the production process, which may first have a disruptive effect but lead to productivity gains in later periods;

- High correlations between similar aggregated micro (based on PS data) and macro-indicators (based on the NA) point at consistency of micro and macro data. In general, micro indicators follow the pattern of the equivalent macro indicator quite closely. Moreover, as mentioned above, the regression results relating productivity growth at both aggregation levels to similar competition indicators calculated from micro and macro data are largely consistent;
- Firm-level regressions by industry do not show many differences in the outcomes per industry. There is some heterogeneity in the magnitude of the effect of competition on productivity growth, but there is almost no heterogeneity in the direction or significance of the relationships;
- Low correlations between micro-level indicators and similar macro indicators point at heterogeneity at the firm level, possibly due to differences in small and large firms;
- Relating firm-level productivity growth to industry-level competition indicators gives a distorted picture, possibly due to the effect of large firms on the aggregated indicators;
- We find only weak effects for the effect of international competition on productivity growth.

4.2 Limitations and future research

This study has an explorative nature. We have looked at simple correlations and linear regressions. The relation between firm performance and competition is likely to be far more complicated than what has been investigated here. In particular, various other variables have an impact on productivity growth, thus it would be an interesting exercise to investigate the impact of competition when also controlling for these other factors. In addition, other variables may interact with competition, and the impact of competition on productivity growth may also run via these interactions For instance, Van der Wiel et al. 2008 show that there is a larger catch-up effect of firms that are not on the technological frontier when competition is stronger. Moreover, an important part of the effect of competition may run via its effect on R&D.

The analysis was limited to manufacturing industries to facilitate the comparison of micro and macro data and because in general the level of international competition is higher for the manufacturing industry than for services. Since the share of the services industry in gross domestic product is much larger than the share of the manufacturing industry it would also be interesting to investigate the effects of competition on productivity for services. As services industries are more domestically oriented than manufacturing industries, the set of competition indicators should then be limited to a smaller set of indicators excluding export and import measures of competition. Analysing the effects of different indicators of competition on productivity for manufacturing and services industries would give a more complete view on these relationships for the total economy. However, measures for the volume change of production in the services sector tend to be less well established than for manufacturing.

In terms of econometrics, we controlled for the endogeneity of competition by replacing contemporaneous values with lags. Estimation methods like Instrumental Variables and the Generalized Method of Moments are alternatives to take account of this. The use of these methods could shed light on the issue whether there is truly a timing effect or whether the results are driven by an endogeneity problem.

Although we analyzed a substantial set of indicators related to (relative) profitability, market concentration and international competition, we did not include institutional measures of competition. Future research may include institutional measures such as (changes in) the liberalization of markets, international trade quota, employment protection or merger restrictions and patent protection mechanisms. Including these measures may show to what extent government policies have affected market structures and firm performance. An advantage of this type of measures is that, since they are imposed from outside the market, they can be treated as exogenous.

Finally, this study was limited to the use of a single dependent variable, productivity change, which is the volume component of the change in profitability. It would also be interesting to investigate the effects of competition on the price component of profitability, as it is more difficult for companies to raise prices and margins in the face of strong competition. Despite the positive effects of competition on productivity, firms' profitability may therefore decrease due to lower margins. This would also provide evidence for the appropriateness of profit based competition indicators. Moreover, the effect of competition on other performance variables as firm size and employment are worth investigating.

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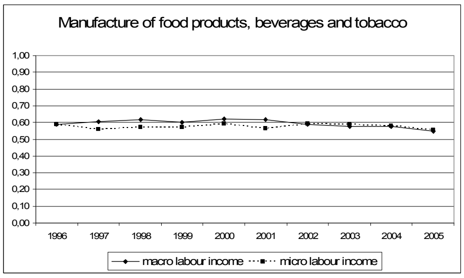
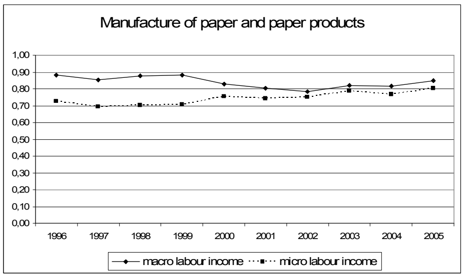
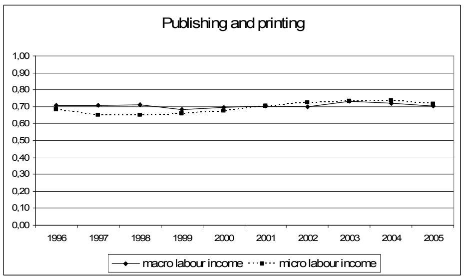
Annex 1. NACE codes and names of manufacturing industries

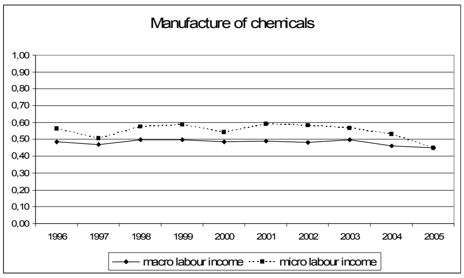
NACE code	Industry name
15+16	Manufacture of food products, beverages and tobacco
17+18+19	Manufacture of textile and leather products
21	Manufacture of paper and paper products
22	Publishing and printing
23	Manufacture of petroleum products
24	Manufacture of chemicals
25	Manufacture of rubber and plastic products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products
29	Manufacture of machinery and equipment n.e.c.
30+31+32+33	Manufacture of electrical and optical equipment
34+35	Manufacture of transport equipment
20+26+36+37	Other manufacturing

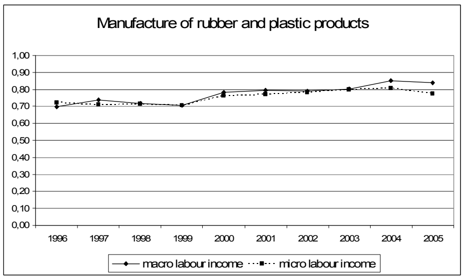
Annex 2a. Comparison of micro and macro labour income ratios

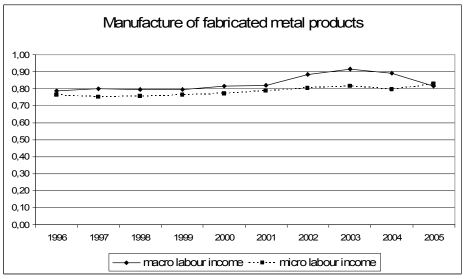


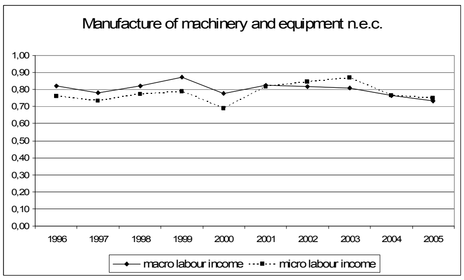


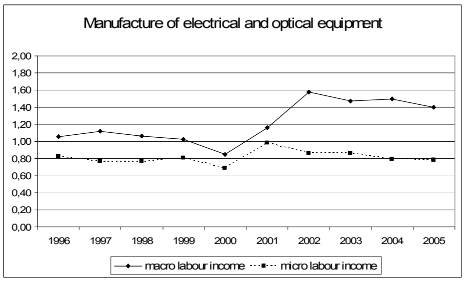


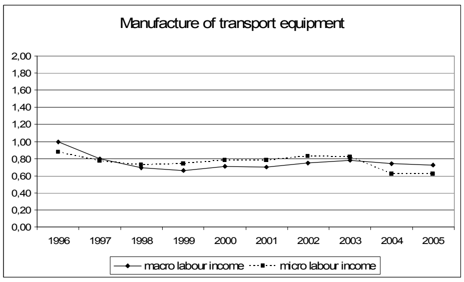


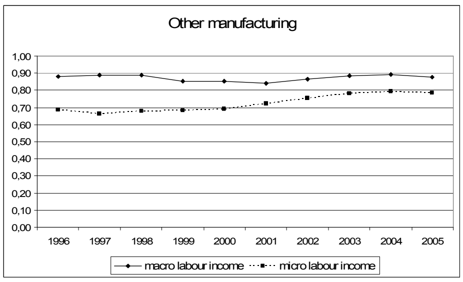




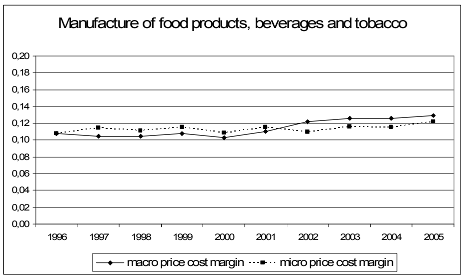


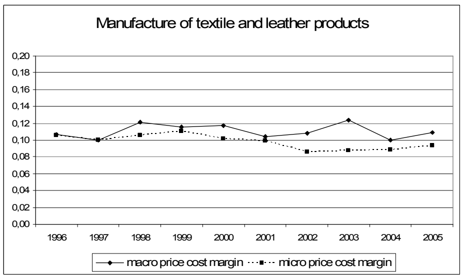


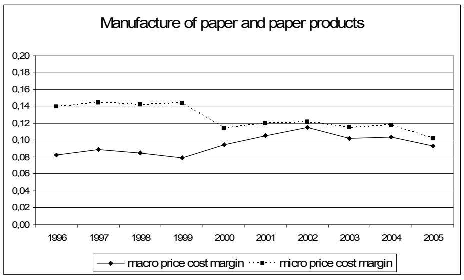


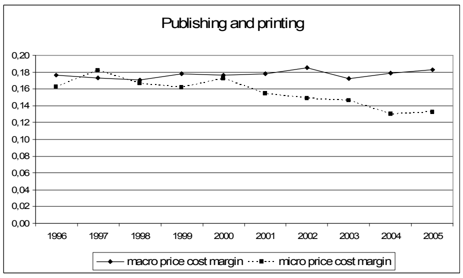


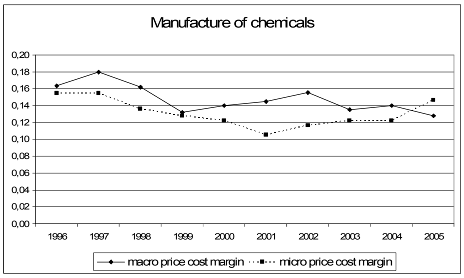
Annex 2b. Comparison of micro and macro price cost margins

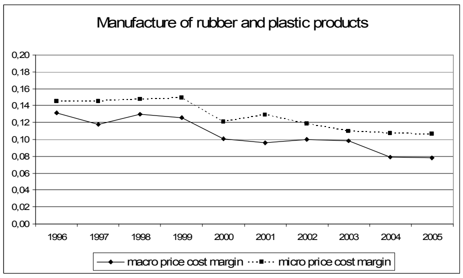


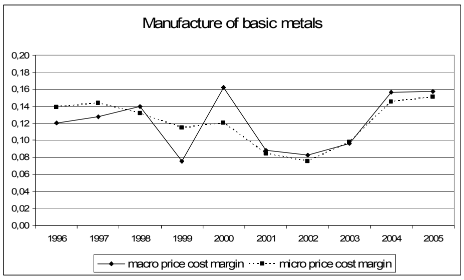


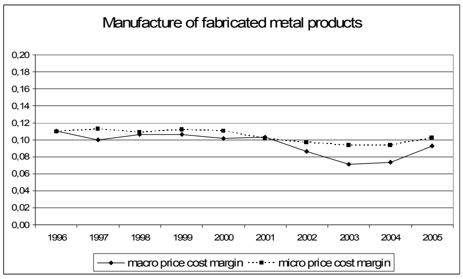


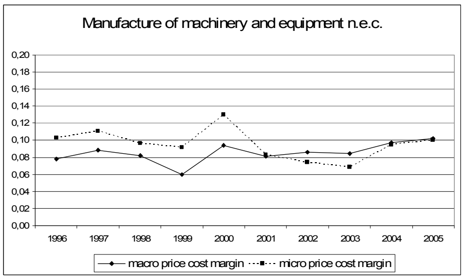


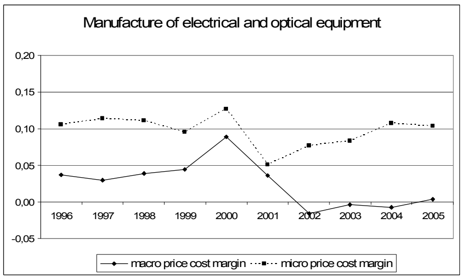


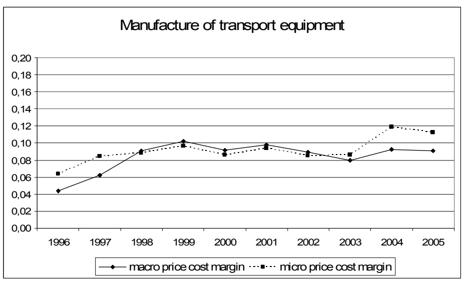


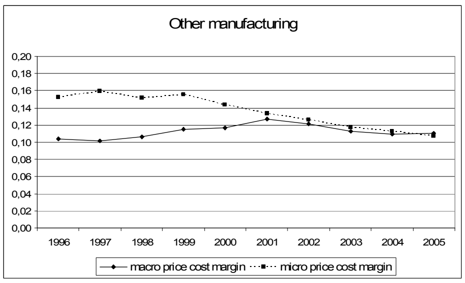




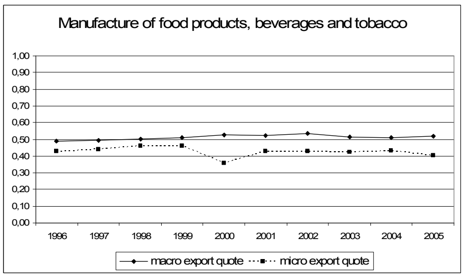


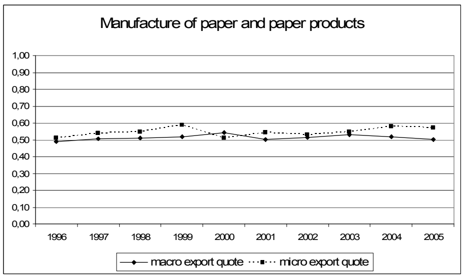


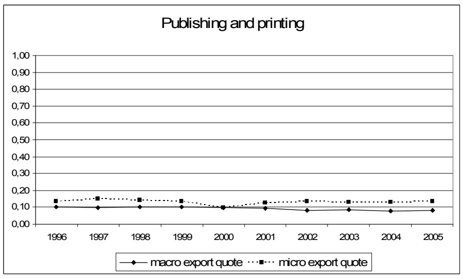


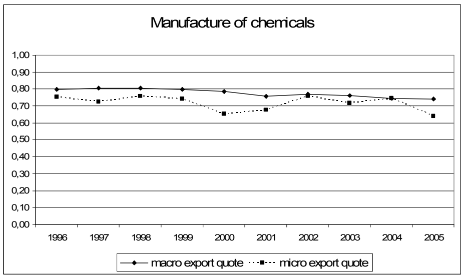


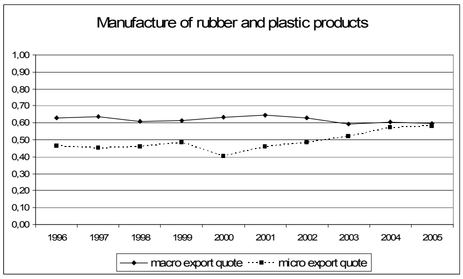
Annex 2c. Comparison of micro and macro export quotes

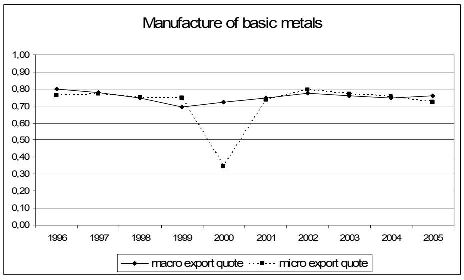


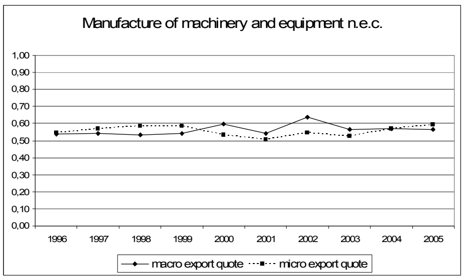


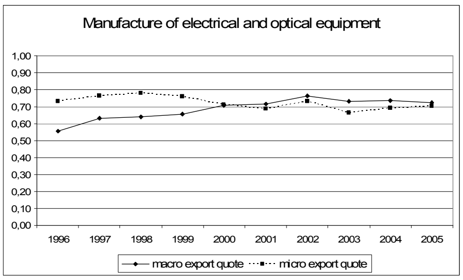


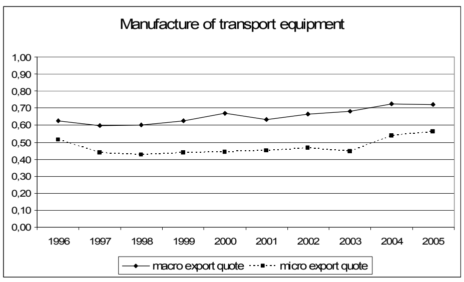




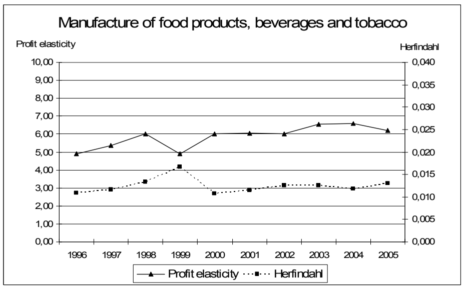


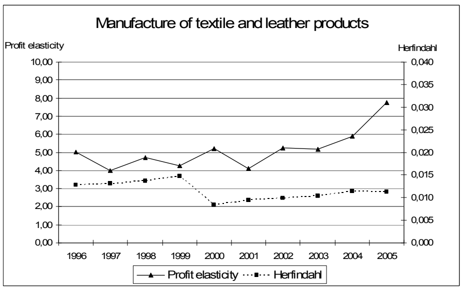


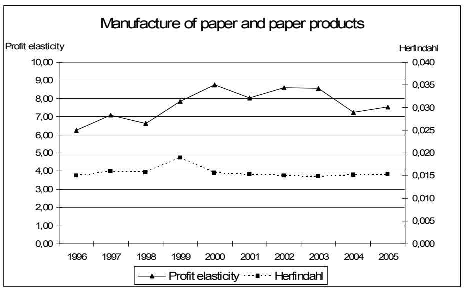


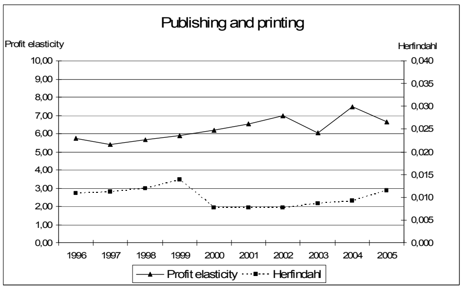


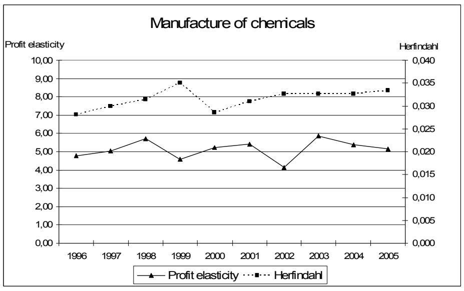
Annex 3a. Development of profit elasticity and Herfindahl index

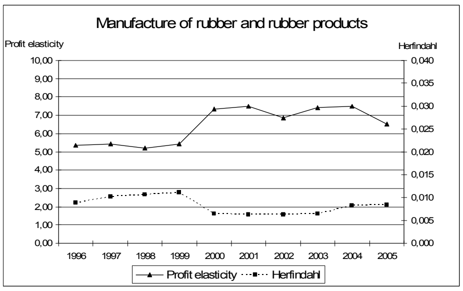


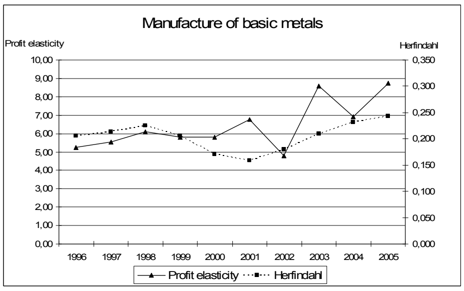


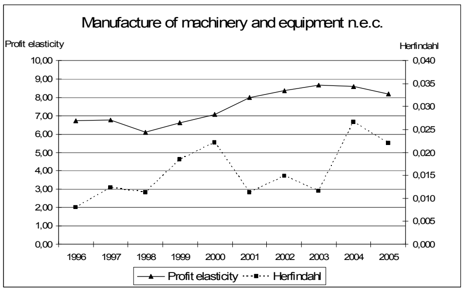


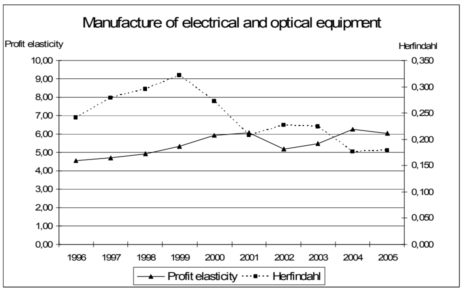


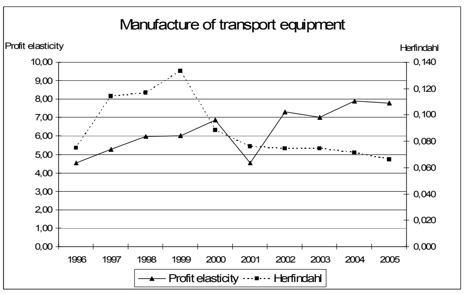


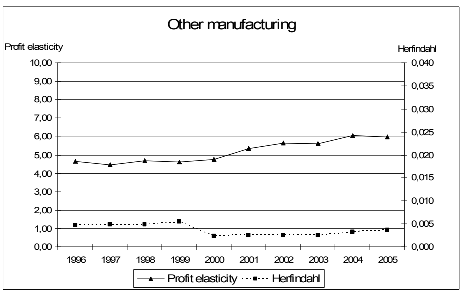




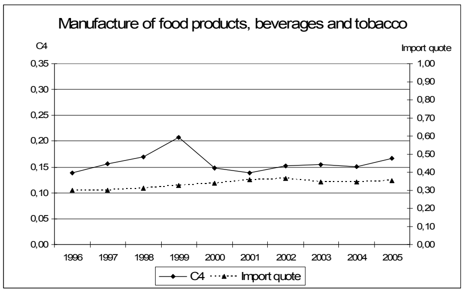


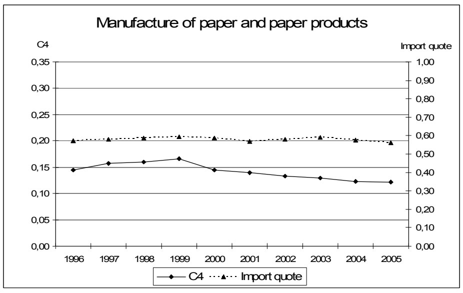


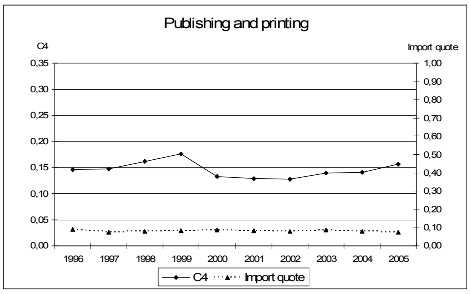


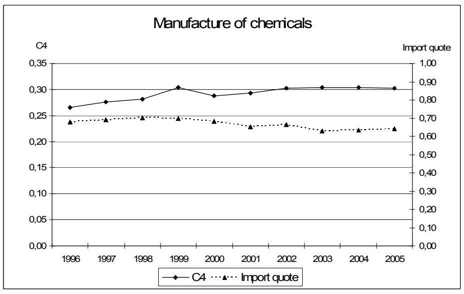


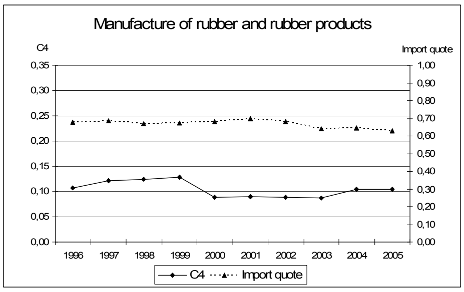
Annex 3b. Development of C4 indicator and import quote

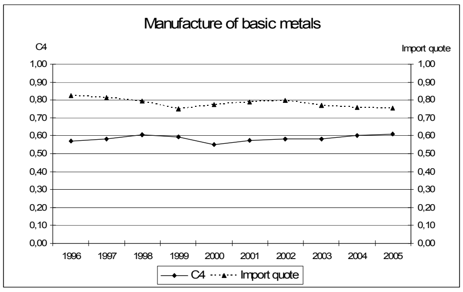


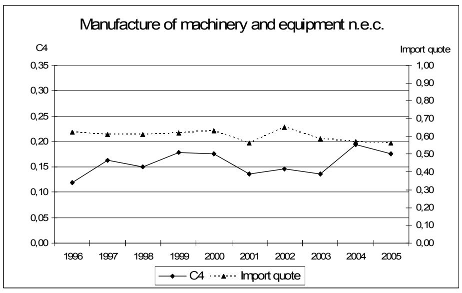


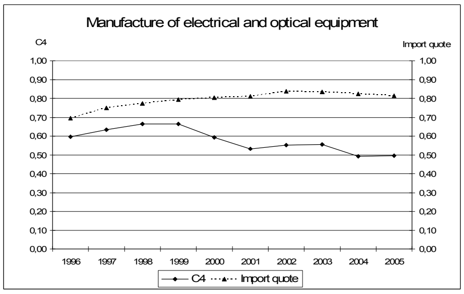


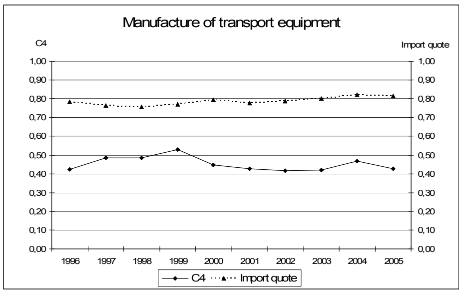


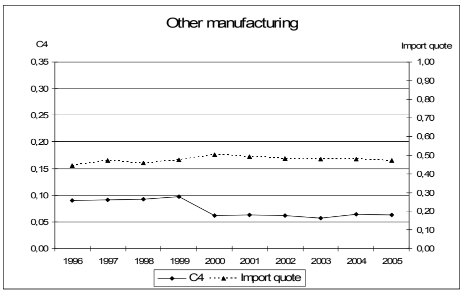




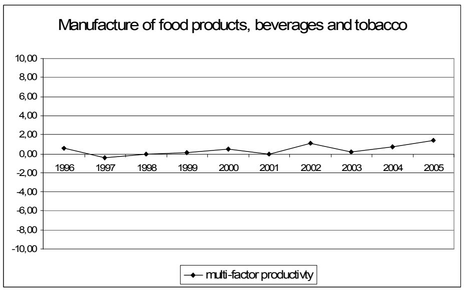


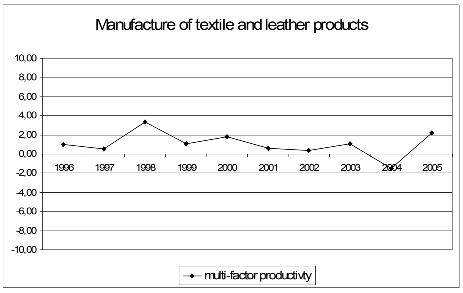


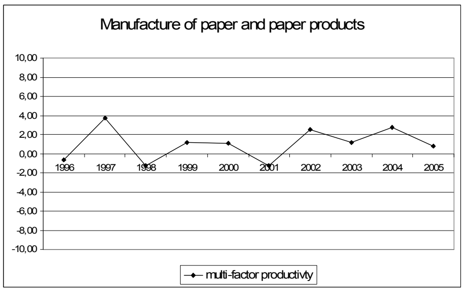


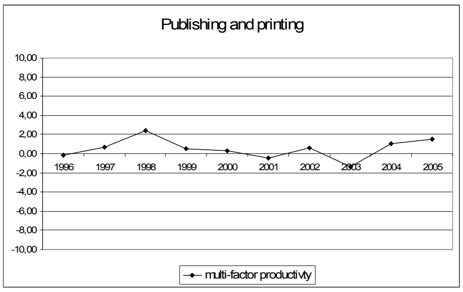


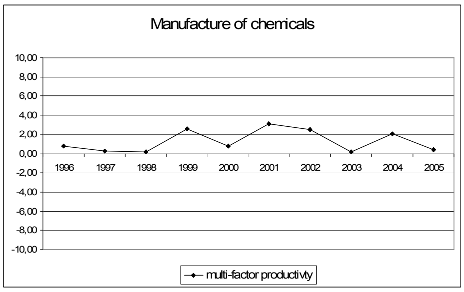
Annex 3c. Development of multi-factor productivity

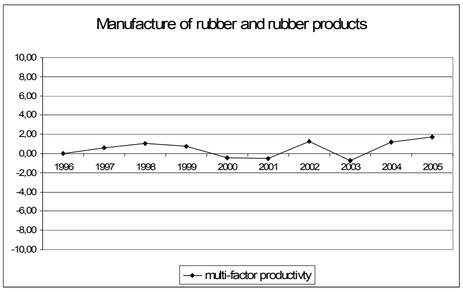


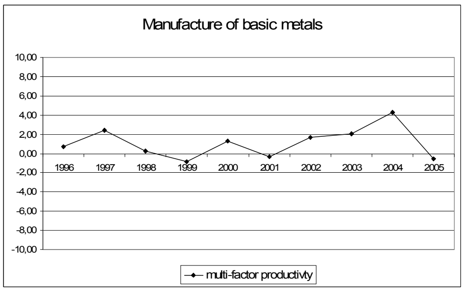


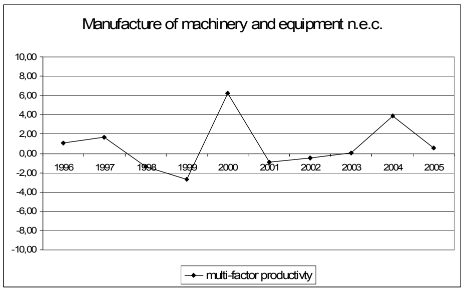


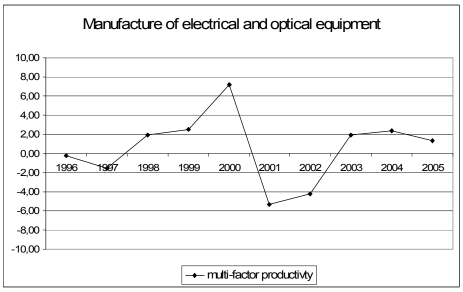


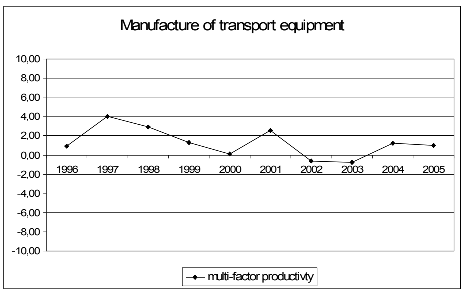


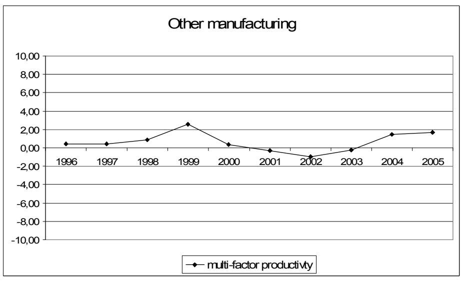












Annex 4. Regression results by industry

	PCM (expected sign: –)			
	level	difference	lag	lag diff
Food products, etc.	30.40***	111.4***	-22.58***	-30.56***
Textile and leather products	29.98***	125.6***	-24.13***	-28.03***
Paper and paper products	22.32***	110.0***	-19.13***	-19.22***
Publishing and printing	27.52***	112.9***	-17.64***	-21.18***
Chemicals	37.57***	116.8***	-28.65***	-29.17***
Rubber and plastic products	33.01***	112.9***	-27.36***	-26.43***
Basic metals	11.14***	102.6***	-20.27***	-27.36***
Fabricated metal products	26.01***	111.4***	-25.33***	-32.20***
Machinery and equipment	35.78***	114.6***	-31.76***	-33.60***
Electrical and optical equipment	39.67***	127.6***	-25.65***	-36.62***
Transport equipment	41.11***	118.3***	-26.31***	-44.53***
Other manufacturing	25.00***	116.4***	-23.18***	-32.15***

	LINC (expected sign: +)			
	level	difference	lag	lag diff
Food products, etc.	-4.12***	-0.62***	0.10	0.00
Textile and leather products	-7.41***	-5.48***	2.85***	1.39***
Paper and paper products	-4.83***	-0.01	0.01	-0.01
Publishing and printing	-7.73***	-11.93***	6.67***	0.43**
Chemicals	-2.71***	-0.01	-0.08	-0.06
Rubber and plastic products	-5.14***	-0.25***	0.22***	0.10***
Basic metals	-4.20***	-0.50	-0.58	-0.58
Fabricated metal products	-9.63***	-2.75***	1.62***	0.42***
Machinery and equipment	-9.01***	-0.31***	0.19***	0.02
Electrical and optical equipment	-9.33***	-2.16***	1.52***	0.36**
Transport equipment	-8.85***	-3.57***	2.18***	0.28
Other manufacturing	-6.12***	-0.06**	0.03	-0.01

	EXPQ (expected sign: +)			
	level	difference	lag	lag diff
Food products, etc.	-0.03	-0.02	-0.05	1.55
Textile and leather products	-0.37	-1.17	-0.06	2.10
Paper and paper products	-0.31	-0.98	0.15	0.48
Publishing and printing	-0.97	-0.78	-0.65	-0.68
Chemicals	-0.83	-0.49	-0.32	3.47***
Rubber and plastic products	-0.30	0.02	0.06	-1.80
Basic metals	-0.90	-3.24	-0.06	-2.24
Fabricated metal products	0.23	-0.25	0.58	0.24
Machinery and equipment	-0.37	-0.76	-0.14	0.35
Electrical and optical equipment	-0.18	-1.02	-0.06	3.34*
Transport equipment	0.03	-0.89	0.79	3.94***
Other manufacturing	-0.45	-0.02	-0.26	1.05

Annex 5. Effect of large firms and entry/exit on competition indicators

To investigate the possibly distorting effect of large firms and entry/exit on the results for the relation between micro-level productivity and macro competition indicators, we have looked at alternative calculations for the indicators. Since we are investigating the effect of particular firms, we will look at industry level indicators calculated from the micro data. For the PCM, we look at a version which is not weighted by market share, as well as one only based on continuing (i.e. 'panel') firms (and both).[18] For the LINC, we cancel the influence of larger firms by taking an unweighted average of the LINC by firm, again also with/without non-panel firms.[19] Table A5.1 reports the results for the various regressions based on the alternative calculations.

We see that the calculation based on the unweighted definitions still lead to the opposite sign as the micro-micro regressions. The panel based definition, however, leads to a reversal of the sign of the PCM. Moreover, basing the calculation on both panel firms and using no weights leads to a change of sign for both the PCM and LINC. Although insignificant, this can be seen as an indication that the aggregate indicators are indeed contaminated by a minority of large firms and by entrants/exiters, whose exposure or sensitiveness to competition is not representative for other firms within the same industry. In fact, as argued in the main text, the degree of competition they experience may be inversely related to that experienced by other firms. If we neutralize the influence of these firms, the effects are more in line with what we find above.

Table A5.1. Estimation results for productivity-competition relation with alternative calculations for PCM and LINC.

	PCM (expected sign: –)		LINC (expected sign: +)	
definition	coefficient	*p*-value	coefficient	*p*-value
micro (aggregated)	-5.828	0.103	2.660	0.023
unweighted	-11.925	0.008	0.478	0.854
panel	1.138	0.782	2.959	0.009
panel and unweighted	1.843	0.818	-1.740	0.517

Nb. Dependent variable is *mfp* growth at the firm level.

A further possible investigation of this interpretation is the breakdown of the results by size class. We do this by considering regression by size class, and by calculating the PCM and the LINC separately for each size class. Table A5.2 gives the results. In the left-hand panel, the results of the regression by size class are reported. The

[18] We reserve the classification 'panel firms' for firms that are present in the data in year t and t–1.

[19] Note that this is different from the original calculation of the indicator, where first sums are taken separately for the numerator and denominator of the LINC.

original definitions of the PCM and LINC are used. We see that it are primarily the lower size classes (6 or lower) that show a sign opposite to the micro-micro regression. This is true for both the PCM and the LINC. These coefficients are also relatively large in magnitude and have generally lower *p*-values. Thus, the aggregated indicators give the opposite sign as the micro-indicators primarily for the smaller firms, whereas the sign for the larger firms is in line with the micro regressions. Although mostly not or only marginally significant, these results again indicate that the opposite signs for the micro and micro-macro regressions are caused by the fact that the aggregated indicators are largely determined by the larger firms. This leads to the opposite sign for the smaller firms as their productivity is being related to the degree of competition experienced by larger firms, which may in fact be inversely related to the competition experienced by smaller firms.

In the right-hand panel, we try to account for the influence of large firms by calculating the PCM and LINC separately for size classes (in addition to by industry and year). We see that in this case most size classes have the same sign as in the micro regression (although again sometimes not or only marginally significant). Thus, when we attempt to correct the indicators for the effect of the larger firms, the same signs as in the micro regressions are found. Again this is consistent with the idea that opposite signs to the micro-micro regressions arise because of the influence of large firms on the aggregated indicators.

Although we cannot completely single out the effect of large firms, we interpret the whole of these sensitivity checks as evidence that the macro-indicators mainly reflect competition for the large firms. Because the micro data consists mainly of smaller firms, using the aggregated indicators in a micro-regression gives distorted results. In addition, the indicators are further influenced by entering and exiting firms, which may experience other degrees of competition as continuing firms. This conclusion is non-trivial, because competition is often seen as an industry-level phenomenon and one might therefore be tempted to link industry-level competition measures to micro data. Our findings suggest caution with the use of these measures. Note that although the PE is an industry-level indicator, it does not suffer this drawback, since in principle each firm has the same weight in the underlying regression carried out to determine the PE.

Table A5.2. Estimation results productivity-competition relationship by size class.

		industry × year				industry × year × size class			
		PCM (−)		LINC (+)		PCM (−)		LINC (+)	
size class	# empl.	coefficient	*p*-value	coefficient	*p*-value	coefficient	*p*-value	coefficient	*p*-value
1	1	-108.401	0.143	17.531	0.320	-9.688	0.704	1.981	0.872
2	2-4	24.598	0.544	-1.004	0.919	-8.107	0.688	-9.109	0.214
3	5-9	-63.424	0.021	8.810	0.164	31.613	0.112	-8.118	0.103
4	10-19	-5.206	0.739	7.012	0.065	-1.664	0.908	-2.630	0.305
5	20-49	5.779	0.499	1.574	0.441	46.392	0.001	-2.955	0.259
6	50-99	-13.289	0.154	2.858	0.195	8.936	0.477	-4.709	0.196
7	100-199	9.313	0.376	-2.468	0.317	48.999	0.000	-4.097	0.115
8	200-499	9.303	0.406	-1.027	0.704	42.921	0.000	-3.084	0.225
9	> 499	-1.812	0.915	2.023	0.656	34.350	0.007	-1.462	0.484

Dependent variable is *mfp* growth at the firm level.

Annex 6. Derivation of KLEMS-Y variables from the PS-data

At the micro-level, data are sourced from the Production Statistics (PS). This annex describes how the KLEMS-Y are derived, following Van Leeuwen et al. (2008).

Y		production value
K	$= C_K + B_1 + \phi_K B_2 - \phi_K Y_2$	costs of capital
L	$= C_L - Y_1 + \phi_L B_2 - \phi_L Y_2$	costs of labour
E	$= C_E + \phi_E B_2 - \phi_E Y_2$	costs of energy use
M	$= C_M + \phi_M B_2 - \phi_M Y_2$	costs of material
S	$= C_S + \phi_s B_2 - \phi_s Y_2$	costs of services

where

C	$= C_K + C_L + C_E + C_M + C_S$	total factor costs (without taxes and subsidies)
ϕ_k	$= C_k / C$	weight of factor $k \in \{KLEMS\}$

Tables A6.1 and A6.2 show how the variables are derived from the PS data.

Table A6.1 Derivation of taxes and subsidies.

variable			IMPECT variable	description
other taxes on production	Y_1	=	SUBSIDI140000	wage subsidies
other subsidies	Y_2	=	SUBSIDI100000	total of restitution and subsidies received
		–	SUBSIDI140000	wage subsidies
taxes on capital	B_1	=	BEDRLST342400	road tax
		+	BEDRLST343420	property tax
other taxes	B_2	=	BEDRLST343410	polution tax
			BEDRLST349600	taxes on products

Table A6.2 Derivation of output and factor costs.

variabele	KLEMS-Y		IMPECT code	description
output	large firms			
	Y =		VERKOOP211000	revenue main economic activity
		+	VOORRAD100900	changes in inventory
		+	VERKOPH212000	revenue from trade and other activities
		–	INKWRDE110000	purchase value of goods intended for resale
		+	OPBRENG112000	revenue from second personnel
		+	ONTVANG100000	received insurance payments from
		+	INVESTN130000	own-account development of investments
		+	OPBRENG110000	other revenue
	small firms			
	Y =		VERKOOP211000	revenue main economic activity
		+	VERKOPH212000	revenue from trade and other activities
		–	INKWRDE110000	purchase value of goods intended for resale
		+	OPBRENG100000	other revenue
capital	C_K =		AFSCHRG110000	depreciation
		+	FINREST120000	rental payments
labour	C_L =		LOONSOM100000	total labour costs
energy	C_E =		BEDRLST341000	total costs of energy use
material	large firms			
	C_M =		INKWRDE120000	purchase value of materials and supplies
		+	INKWRDE131000	purchase value other material
		+	INKWRDE132000	contract work
		+	INKWRDE133000	other purchase value
	small firms			
	C_M =		INKWRDE100000	total purchase value of revenue
		–	INKWRDE110000	total purchase value of goods intended for resale
services	large firms			
	C_S =		BEDRLST342000	total costs of vehicles
		–	BEDRLST342400	road tax
		+	BEDRLST343000	total accommodation costs
		–	BEDRLST343410	pollution taxes
		–	BEDRLST343420	property taxes
		+	BEDRLST345000	total other labour costs
		+	BEDRLST346000	total sales costs
		+	BEDRLST347000	communication costs
		+	BEDRLST348000	total costs of services by third parties
		+	BEDRLST349000	total other costs
		–	BEDRLST349600	other cost price raising taxes
	small firms			
	C_S =		BEDRLST342000	total costs of vehicles
		+	BEDRLST343000	total accommodation costs
		+	BEDRLST345000	total other labour costs
		+	BEDRLST346000	total sales costs
		+	BEDRLST347000	communication costs
		+	BEDRLST348000	total costs of services by third parties
		+	BEDRLST349000	total other costs