

# Productivity Growth over the Business Cycle: The Role of Firm Dynamics

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## PRELIMINARY

**Abstract:** This paper presents an analysis of aggregate productivity in the Norwegian manufacturing industry from 1993 to 2005 using the Capital database from Statistics Norway. Aggregate productivity is calculated as a weighted sum of firm-level productivity, measured by Total Factor Productivity (TFP). The study provides an analysis of improved performance and the reallocation of resources for the existing firms as well as the contribution of firm entry and exit to productivity growth. The main objective is to see whether the relative contribution from these factors differs over the business cycle. I find that exiting firms have lower relative productivity in the contraction period than in the two expansion periods of our observation span. In addition, entrants have higher relative productivity in the contraction period. Furthermore, while booms give grounds for high productivity growth within continuing firms, this productivity growth stagnates in the recession period. All these findings lead to the result that the reallocation process seems to be more important for aggregate productivity growth in contraction than in expansion periods.

**Keywords:** Productivity decomposition, entry, exit

**JEL classification:** D24, E23

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## 1 Introduction

Measuring and describing aggregate productivity is an important piece in the picture of an economy's performance. Growth in aggregate productivity, for an industry or an economy, will depend on improved performance within operating firms as well as reallocation process of new firms replacing exiting firms. The purpose of this paper is to document and describe the sources to productivity growth as well as to look at different conditions providing or preventing growth in the Norwegian manufacturing industry. Studies of the sources of productivity growth have typically focused on within contribution and reallocation contribution as alternative sources. An interesting question is how these effects can be related and to discuss whether the pattern of firm dynamics and within firm growth changes over the business cycle. My hypothesis is that the state of the economy affects the conditions for productivity growth and therefore, the contribution from the factors behind growth will differ depending of the pressure in the economy. So, in this paper, I want to study the performance among existing firms as well as to see if there are changes in the quality of entering and exiting firms over the business cycles. In that regard, some important questions have to be answered; how is the productivity growth within continuing firms affected by the business cycles? Do we observe that the contribution from the reallocation process differs depending on the state of the economy? And especially do the characterization of entrants and exiting firms differ in booms and recessions?

A rapidly growing number of studies provide evidence of heterogeneity in firm behaviour. Over the past two decades, evidence is provided suggesting sizable heterogeneity of firms across different interrelated dimensions, size, growth, market shares and life cycles etc<sup>1</sup>. Furthermore, in all countries studied, there is evidence that the population of firms undergo significant changes over time, both through resource allocation between existing firms and the process of firm exit and entry (see e.g. Foster et al (2000), Bartelsman et al (2004)). Several theories capture the importance of firm heterogeneity for the process of entry and exit of firms in the market. They generally relate to the process of "creative destruction", ascribed to Joseph Schumpeter (1942). The crucial element of Schumpeter's theory is that it recognizes that the continual shift in the composition of the population of firms through entry, exit, expansion and contraction is essential in developing and creating new processes, products and markets.

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<sup>1</sup> see Foster, Haltiwanger and Krizan (2000) for an overview of this literature

One basic theory related to these processes is formulated by Johansen (1972), called the *Vintage capital theory*. In this theory differences in efficiency and survival across firms are explained mainly by differences in the time of entry and the vintage of their capital stock. The main point is that new capital is more productive than old capital, not only because of wear and tear, but also because it consists of the latest technology. The implication of this theory is that, particularly when technology is changing, firms are more likely to exit as their capital ages.

A different point of view concerning the process of entry and exit is formulated by *The passive learning model* (Jovanovic, 1982). This theory considers new entrants as equipped with different performance in production, which are unknown to the firms at the time of entry. As they operate in the market the firms observe their relative efficiency. Those firms that obtain favourable information about their relative efficiency expand, while firms with a poor performance eventually decide to exit. One of the main implications of this model is that smaller and younger firms should have higher and more variable growth rates.

A related model explaining the variability in the fortunes of firms is the *active learning model* presented by Ericson and Pakes (1995). In this model, a firm explores its economic environment actively and invests to enhance its profitability under competitive pressure from both within and outside the industry. Its potential and actual profitability changes over time in response to the stochastic outcomes of the firm's own investments, and of those other producers in the same market. The firm grows if successful, shrinks or exits if unsuccessful. Pakes and Ericson (1998) find that manufacturing firms are more consistent with the active learning model whilst retailing firms are more consistent with the passive learning model<sup>2</sup>. Salvanes and Tveteras (2004) assert both a learning effect and a vintage capital effect in the Norwegian manufacturing industry, and they show that the two effects do indeed work in opposite direction.

Earlier findings from studies on firm heterogeneity show that firm dynamics is not necessarily associated with change in the size of the population of firms, but rather with changes of the characteristics of firms<sup>3</sup>. This paper will be focusing on how these differences affect

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<sup>2</sup> See Bartelsman et al (2004)

<sup>3</sup> See e.g Foster et al (2000) and Bartelsman et al (2004)

aggregate performance or more specific; aggregate productivity growth. Decomposition of productivity has become a common method for analyzing aggregate productivity growth at the plant or firm level. Such decompositions can indicate the relative importance of *within contribution* and *reallocation contribution*. The contribution of continuing firms is due to improved productivity within firms and employment shifts between producing firms, from less to more productive firms. The contribution from entering and exiting firms depends on the size and productivity level of these firms. Different methods for decomposing productivity growth have been proposed in the literature. Foster et al (2000) give a summary of the different methods and compare empirical results from the recent literature.

Bartelsman et al (2004) have provided an international comparison of different factors' contribution to productivity growth. They find that in all countries the process of creative destruction affects productivity directly, by reallocating resources towards more productive uses. In addition new firms contribute indirectly through the effects increased market competition. Although these processes are observed in all countries, their contribution to aggregate productivity growth differs across countries.

Related studies of firm dynamics in the Norwegian economy present different results. Møen (1997) emphasize the role of reallocation of resources from exiting firms to new establishments as the most important source to the productivity growth, while Balsvik and Haller (2005) find that the largest part of the productivity growth is generated within continuing plants. However, the latter study also emphasize that the contribution of external restructuring via entry and exit of plants is not negligible. A recent paper by Raknerud (2007) provides a theory-founded econometric model to identify the extent to which profitability can explain exit behaviour.

How business cycles affect the allocation of resources has been a subject for discussion by economists since this relation was formulated by Schumpeter in 1939. From his argument that recession promotes a more efficient allocation of resources by driving out bad investments and release resources for more efficient use, there has developed models that formalize this allocation of resources as a “cleansing effect of recessions”<sup>4</sup>. Concerning firm dynamics, the “cleansing effects” of recessions work through the mechanism that low productive firms are

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<sup>4</sup> See e.g. Davis and Haltiwanger (1992), Mortensen and Pissarides (1994)

forced to leave the market and release resources to new more productive firms to establish. In this way a recession can assure a more efficient reallocation of the resources between operating firms. Some studies have suggested alternative views about the effect of recessions on firm dynamics. Caballero and Hammour (1994) argue that fewer entrants during recessions give less competition for existing firms and can help low-production firms to survive. Furthermore, Barlevy (2002) show how recessions may reduce aggregate efficiency by discouraging the reallocation of workers.

Baldwin et al (2000) presents some empirical findings on the efficiency of the reallocation processes related to the state of the economy. One result is that firm-specific factors such as age and size exert a strong influence on the failure rate. An important consequence of new firms in the market is that they provide as new ideas and processes. In addition new firms have an indirect effect on productivity providing an important source of competition. Competition continuously separates winners and losers with unsuccessful firms exiting the market relatively rapidly, and successful survivors are growing and adapting. The magnitude of this competition seems to depend on the state of the economy and the effects of the business cycle will vary between different sectors in the economy. Firm specific size characteristics of industries also influence the failure rate as well as changes in industry concentration and turnover. There are also findings where macroeconomic conditions exert a modest influence on the survival rate. The fortunes of new firms vary cyclically with the business cycle, a higher growth rate in real output leads to more survival.

I choose total factor productivity (TFP) as a measure of productivity and calculate firm level TFP by estimating production functions. Productivity at the aggregate level is then calculated as a weighted sum of the productivity for all operating firms in the market. I find that exiting firms have lower relative productivity in the contraction period than in the two expansion periods of our observation span. In addition, entrants have higher relative productivity in the contraction period. Furthermore, while booms give grounds for high productivity growth within continuing firms, this productivity growth stagnates in the recession period. All these findings lead to the result that the reallocation process seems to be more important for aggregate productivity growth in contraction than in expansion periods.

The structure of the paper is as follows. Section 2 presents the data and describes some important choices to be considered in the productivity analysis. Section 3 provides a

description of the calculation of aggregate productivity growth and presents alternative methods for decomposing productivity. Some descriptive statistics on entry and exit rates and information about firm characteristics is presented and discussed in Section 4. Section 5 describes aggregate productivity in the entire manufacturing industry and presents the results from the decomposition analysis. Thereafter the decomposition analysis is performed at the sector level. The findings from this analysis are presented in section 6. (Preliminary: In Section 7 the performance of entrants and exiting firms is analyzed more exhaustively. Section 8 provides a discussion of other factors behind productivity growth.) Finally, Section 9 briefly concludes.

## 2 Data

### 2.1 General description

My analyses are based on the Capital database which is a recently established database from Statistics Norway (see Raknerud et al (2004) for documentation). This database comprises information on key economic figures (e.g., number of employees, value added and capital) for manufacturing joint-stock firms. A firm is defined as “the smallest legal unit comprising all economic activities engaged in by one and the same owner” and may consist of one or more plants. The unique feature of this data set is that one is not limited to book values, since the key variables are measured in current prices (taking account of depreciation). I will explain the advantage of this feature further when describing the measurement of capital below. This data set contains more than 90 000 observations during the period 1993 – 2005 on more than 10 000 firms. In 2001 these firms correspond to 80 per cent of all firms in the Norwegian manufacturing industry<sup>5</sup>.

### 2.2 Identifying entries and exits

I define a firm as an *Exit-firm* in year  $t$  if the firm is present in the data set in year  $t$  but is absent in year  $t+k$ . Similarly, a firm is defined as an *Entrant* if the firm is observed in year  $t+k$  but is absent in the year  $t$ . The firms with observations both in year  $t$  and year  $t+k$ , are defined as *Stayers*. Using these common definitions of exit and entry may be problematic

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<sup>5</sup> This analysis only includes firms from the Norwegian manufacturing industry. The excluded firms correspond to 3 per cent of total firms in 1993.

because firms could disappear from the data set from other reasons than a real shutdown<sup>6</sup>. One problem is that identification numbers might change due to data error. I have chosen to exclude firms with gaps of one and two years from the sample. These observations represent about 8-11 per cent of the sample of firms in each year. This choice is made to ensure that missing observations for only one or two years are not counted as exits and entries. Secondly, if there is a merger or a takeover, this method will register the firms changing their identification number as exits. I make no further attempts to limit the number of so called spurious firm entries and exits, but as the analysis is based on firms rather than establishments such measurement errors are likely to be smaller. At the firm level the incidence of mergers and takeovers will be smaller compared to the establishment level<sup>7</sup>.

I have chosen to include all firms with two or more employees in the analysis and it is important to remember that my results can be sensible to the choice of firms included in the sample. Table A1 in the appendix presents the shares of exits and entries for four different groups of firms grouped by their firm size. The main part of the firms belongs to the group with number of employees larger or equal to five and less than 20, corresponding to a total annual share of 46.5 per cent. Firms with lower than 5 employees represent about 25 per cent of the total number of firms, while the percentage for the last two groups is about 22 and 6 per cent respectively. The exit and entry rates are higher for the two groups consisting of small firms. High entry and exit rates amongst small firms suggest that the process of entry and exit of firms involves a proportionally low number of workers. Although the differences are small, the entry rate is higher than the exit rates for the two groups with low employment, while we observe the opposite pattern for the two groups of firms with a higher number of employees. This result supports earlier findings that exiting firms in general are larger than entering firms, see e.g. Haltiwanger (1996). A sample where firms with five or fewer employees are excluded could miss out on important information about firm dynamics, but there may be less measurement errors in identifying exiting and entering firms.

I have calculated the average size of entering and exiting firms relative to the average size of continuing firms in my dataset. The relative size of entering firms varies from 50 to 80 per cent and the relative size of exiting firms varies from 60 to 80 per cent. Bartelsman et al (2004) provides an overview of the relative size of entering and exiting firms for several

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<sup>6</sup> See (Salvanes og Tveteras, 2004)

<sup>7</sup> This is in line with the argumentation in Vestad (2007)

countries. My findings for the Norwegian manufacturing industry are comparable to findings in countries like Denmark, Finland and East Germany (60 to 80 per cent the average size of continuing firms) while these numbers is much lower for countries like USA, Canada and several transition economies.

### *2.3 Measuring Physical Capital*

The uniqueness of the Capital database rises from the fact that it contains estimates of firm specific variables at current prices. The method of calculating capital values at current prices is described in Raknerud et al (2007)<sup>8</sup>. With information about firms' investments through a year it is possible to deduce the reduction in the firm's capital stock from one year to the next by the book values. Raknerud et al. calculate a reduction rate as the reduction in capital as a share of the capital stock at the beginning of the year plus investments during the year. This reduction rate consists both of a depreciation rate and a potential sale of capital. Tangible fixed assets in current prices is then calculated by taking the book values of capital at the beginning of the year, add investments and subtracting the reduction, and adjust for prices corresponding to new capital. This measure of capital in current prices is then the capital stock for the firm the subsequent year<sup>9</sup>.

I interpret the term capital in line with Raknerud et al. as a durable tangible production factor, corresponding to the term *tangible fixed assets* in the business accounts. Their approach separates between two classes of assets: 1) Buildings and land and 2) Other tangible assets. The latter group consists of machinery, equipment, vehicles, movables, furniture, tools, ships, rigs and aircrafts, and is therefore quite heterogeneous. The expected lifetimes of the assets in the first group are considerable larger than in the second. Valuated at current prices these two types of assets are defined as  $C^1$  and  $C^2$  respectively in equation (2.1). Raknerud et al calculate a reduction rate for each of these two classes of assets as described above. This gives us two reduction rates for each firm each year, defined as  $\gamma_{it}^1$  and  $\gamma_{it}^2$  in equation (2.1). When estimating the firms' production functions we are interested in the capital service from the capital stock through a year, the capital's contribution to production. In this sense it is

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<sup>8</sup> For a detailed description of the method used and a discussion of alternative methods see Raknerud, Rønningen and Skjerpen, 2007.

<sup>9</sup> A strong assumption is essential for this method, namely that book values in the first year, 1993, equal current prices. This assumption implies an underestimation of the current prices for this first year.

more reasonable to consider the cost of capital rather than the value of the capital stock. The cost of capital will contain annual cost of all equipment used in production and is by Raknerud et al calculated as the sum of reduction, predicted interest costs and leasing costs.

The cost of capital in production in current prices, year  $t$ :

$$(2.1) \quad C_{it} = (\gamma_{it}^1 + \frac{r_t}{100})C_{it}^1 + (\gamma_{it}^2 + \frac{r_t}{100})C_{it}^2 + R_{it}^1 + R_{it}^2$$

$R_{it}^1$  and  $R_{it}^2$  represent the leasing costs for each of the classes of tangible assets, while  $r$  is the real interest rate for year  $t^{10}$ . A volume index for the capital variable can be constructed by deflating  $C_{it}$  by the price index of capital. I have used the price index for new investments in all tangible fixed assets as a total, given in the Capital database. The reference year is 2001 and the price index variables are at the industry level.

#### 2.4 Measuring productivity

A fundamental basis in order to discuss the driving forces to productivity growth is to get a reliable measure of productivity. I prefer TFP as a measure of productivity although there are some potential measurement and econometric problem related to this concept. TFP takes into account the effect of changes in the capital stock and provides more information about changes in technology than does labour productivity. There are several methods of calculating TFP<sup>11</sup>. I have chosen to measure TFP by estimating production functions.

The basis for the analysis is the Cobb Douglas production function:

$$(2.2) \quad Y_{it} = A_{it} C_{it}^{\beta_1} L_{it}^{\beta_2}$$

$Y_{it}$  is a measure of output, while  $C_{it}$  and  $L_{it}$  represent the usage of capital and labor, respectively.  $A_{it}$  is interpreted a firm's total factor productivity (TFP) which measures change in output with given amounts of capital and labor.

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<sup>10</sup> Using the 10 year Norwegian Government bonds

<sup>11</sup> For a brief overview of methods for estimating plant productivity see Arnold, 2005

Transforming the Cobb-Douglas production function into logarithms allows linear estimation. One advantage of choosing this functional form is that the estimated coefficients,  $\beta_1$  and  $\beta_2$ , correspond to the input factor elasticities and will then be easy to interpret. A simple standard estimation equation can be written as:

$$\ln y_{it} = \ln A_{it} + \beta_1 \ln C_{it} + \beta_2 \ln L_{it} \quad (2.3)$$

$$\ln y_{it} = \beta_1 \ln C_{it} + \beta_2 \ln L_{it} + e_{it}$$

The firm specific TFP,  $\ln A_{it}$ , may be expressed as an error term  $e_{it}$ . Given this equation, one can calculate an estimate for the error term, provided the coefficients are consistently estimated.

The problem usually referred to as the *endogeneity problem*, arises from the possibility that some of the inputs in production are unobserved for the researcher and these variables are therefore not specified in the estimation equation. If this is the case, and if the decision for the observed inputs, capital and labour, is related to these unobserved inputs, the OLS estimates of the coefficients for the observed inputs will be biased. Technically we say that the regressors and the error term in equation (2.3) are correlated, which means that the regressors are endogenous.

If we believe that the part of TFP that influences firm behaviour is a plant specific attribute which is invariant over time, the Fixed Effect (FE) model will give consistent estimators if the model is correctly specified. This FE approach consists of subtracting a firm's mean from each observation and by this make all firms' observed and unobserved time-invariant fixed effects drop out<sup>12</sup>.

To take account of the time specific variables I include time dummies in the regression equation. Adding these elements lead to the following expression:

$$(3.3) \ln Y_{it} = \alpha + \beta_1 \ln C_{it} + \beta_2 \ln L_{it} + \bar{D}\delta + u_i + \varepsilon_{it}$$

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<sup>12</sup> For a discussion of drawbacks of the FE method see e.g. Griliches and Mairesse (1995).

where  $Y_{it}$  is the firm  $i$ 's value added<sup>13</sup> in year  $t$  and  $C_{it}$  and  $L_{it}$  are the amount of capital and labor used in production.  $u_i$  is the firm-specific variable,  $\bar{D}$  is a dummy-vector for the years 1994-2003,  $\alpha$  is a constant and  $\varepsilon_{it}$  is an error term with standard properties,  $\varepsilon_{it} \sim N(0, \sigma^2)$ . The production functions are estimated industry by industry so that returns to the input factors are allowed to differ between different sectors. The estimates from these estimations are presented in Table A3 in the appendix.

We assume that the  $u_i$ 's are firm specific fixed effect, being the same for each firm within all years. With the additional assumption that the sum of all the  $u_i$ 's equal to zero,  $\sum_{i=1}^N u_i = 0$ , we can interpret the constant in the regression equation as the average productivity. This means that the year dummies can be interpreted as average productivity growth for the respective year to the base year 1993.

Another important choice in estimating production functions is how to measure the output term. In this analysis I have used the firms' value added, and this choice is due to the available data at hand<sup>14</sup>. The alternative would be to use sales where I do not subtract intermediate inputs. Then, from theory, sales should be regressed on the three inputs: capital, labour and intermediate inputs. Unfortunately, I do not have any information about the different components of the firms' intermediate inputs and it is then difficult to find a suitable price index for deflating this term. Sales will not capture effects of variation in intermediate inputs, but I believe that using a deflated term for the intermediate inputs at hand could give a misleading picture of the actual variation. So, I have used single deflation of value added where value added at current prices is deflated with the commodity price index for industrial sectors (9 subsections).

In general there will be some difficulties to consider when we deflate the output term. Firstly, any quality improvement in output that is not reflected in the deflator will result in a

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<sup>13</sup> The volume index for value added results from deflating the firms' value added by the producer price index for the manufacturing industry

<sup>14</sup> According to Bartelsman (2000) value added seem to be more useful for making welfare statements at an aggregate level but is less useful for understanding sources to productivity growth. The more disaggregated the data, the greater the advantage of using gross production for productivity measures.

downward bias in productivity. Secondly, I do not have access to micro level prices. Assuming the prices to be the same implies that firms with higher than average prices will mistakenly be assigned higher productivity while higher than average prices for intermediate inputs will give the opposite effect. Using a deflator at the sector level we solve some of these problems, but differentiating between productivity differences and differences in markups will still be difficult, if not impossible. Although one of the basic findings related to productivity using micro data is the high dispersion in productivity between firms and industries, there is still a question how much of the dispersion at the micro level is noise and how much is real.

### 3 Decomposing productivity

Previous empirical studies have used different methods to measure the contribution of reallocation and firm turnover to productivity growth (see Foster, Haltiwanger and Krizan, 2000 for a review). I have considered three different methods for the decomposition of aggregate productivity growth. I will in the main part of the paper follow the decomposition method proposed by Foster, Haltiwanger and Krizan (FHK henceforth, 2000), but I present the results from two alternative methods for comparison. The advantage of the FHK approach is that it gives a clear interpretation of the different terms by tracking changes in productivity relative to a reference point, industry average in the base year<sup>15</sup>.

Aggregate productivity growth is calculated from a weighted sum of individual productivity for all operating firms in the industry.

$$(3.1) \quad \ln TFP_t = \sum_i \theta_{it} \ln TFP_{it}$$

where  $TFP_{it}$  is  $TFP$  for firm  $i$  in year  $t$  and  $\theta_{it}$  is the firm's share in the industry measured by share of total employment<sup>16</sup>. In this analysis the firm specific term  $TFP$  will consist of the following parts:

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<sup>15</sup> A full discussion of how this method compares to alternative decompositions as those suggested by Bailet al (1992) and Griliches and Regev (1992) is provided in Foster et al (1998) and Disney et al (2004).

<sup>16</sup> The calculation of value added in the dataset seems to give some negative values for some firms. I have not taken care of this yet, so I have chosen share of employment instead of share of output in the industry as weights. This choice is in contrast to the statement held in Bartelsman et al (2004): "The shares are usually based on employment in decomposition of labor productivity and on output in decomposition of total factor productivity."

$$(3.2) \ln TFP_{it} = \ln Y_{it} - \beta_1 \ln K_{it} - \beta_2 \ln L_{it}$$

$$(3.3) \ln TFP_{it} = \delta_t + u_i + \varepsilon_{it}$$

where  $\delta_t$  is the average productivity growth in year  $t$  compared to 1993,  $u_i$  is the firm's fixed effect (interpreted as the time invariant firm specific productivity) and  $\varepsilon_{it}$  is the residual for firm  $i$  in year  $t$ . I have removed firms with residuals three times the standard errors for the residuals to avoid outliers caused by measurement errors. I then choose to interpret the residuals for the remaining firms as the time variant productivity measures for the firms.

Changes in productivity will occur as some firms improve productivity and as employment share changes. Changes in employment shares reflect firm turnover as well as growth and decline of existing firms.

To examine these different sources to productivity growth the FHK method decomposes the change in industry productivity between year  $t$  and year  $t-k$  in the following way:

$$(3.4) \Delta \ln TFP_t = \ln TFP_t - \ln TFP_{t-k}$$

$$(3.5) \Delta \ln TFP_t = \underbrace{\sum_{Stayers} \theta_{i,t-k} \Delta \ln TFP_{it}}_{WITHIN} + \underbrace{\sum_{Stayers} \Delta \theta_{it} (\ln TFP_{it-k} - \overline{\ln TFP_{t-k}})}_{BETWEEN} + \underbrace{\sum_{Stayers} \Delta \theta_{it} \Delta \ln TFP_{it}}_{COVARIANCE}$$

$$+ \underbrace{\sum_{entrants} \theta_{it} (\ln TFP_{it} - \overline{\ln TFP_{t-k}})}_{ENTRY} - \underbrace{\sum_{exits} \theta_{i,t-k} (\ln TFP_{i,t-k} - \overline{\ln TFP_{t-k}})}_{EXIT}$$

The first term in equation (6.3) shows the contribution to productivity growth from TFP productivity growth within surviving firms, the “within-effect”. The second term is the “between firms effect”, which is positive if those plants that initially had above average TFP are the ones that gain market shares. The third term is a “covariance” term that will be positive when market shares increase (fall) for plants with positive (negative) productivity growth. The last two terms present the contributions to productivity growth accounted for by entry and exit. The sum of entry and exit effect is the net entry effect. These terms are positive when there is entry (exit) of firms with above (below) initial average productivity. One

potential problem with this method is that, in the presence of measurement errors in assessing market shares and relative productivity levels in the base year, the correlation between productivity and changes in market share could be spurious, affecting the within- and between effect. The next method I present for decomposing productivity growth attempts to tackle this potential problem.

The formula used by Griliches and Regev (1995) (GR) is supposed to be less sensitive to measurement error in output and inputs relative to the FHK-method.

$$\begin{aligned} \Delta \ln TFP_t = & \underbrace{\sum_{i \in Stayers} \bar{\theta}_i (\ln TFP_{it} - \ln TFP_{it-k})}_{WITHIN} + \underbrace{\sum_{i \in Stayers} (\theta_{it} - \theta_{it-k}) (\overline{\ln TFP}_i - \overline{\ln TFP})}_{BETWEEN} \\ & + \underbrace{\sum_{i \in New} \theta_{it} (\ln TFP_{it} - \overline{\ln TFP})}_{ENTRY} - \underbrace{\sum_{i \in Exit} \theta_{it-k} (\ln TFP_{it-k} - \overline{\ln TFP})}_{EXIT} \end{aligned}$$

This method replaces the industry productivity in the base year  $\overline{\ln TFP}_{t-k}$  in the FHK decomposition with the industry average productivity for all firms taken over the two periods  $\overline{\ln TFP}$ . The disadvantage of this method is that the measured within effect will now be reflected in the covariance effect and the measured between effect components. (\*må utbroderes mer. Mer intuitiv forklaring) The FHK and the GR method compare the entering and exiting firms with an average firm in the industry in measuring the contribution of firm turnover to productivity growth. Baldwin and Gu (2003) argues that entering firms essentially replace exiting firms so its more appropriate to compare productivity between entering and exiting firms.

The BG formula is to be presented as follows:

$$\begin{aligned} \Delta \ln \ln TFP_t = & \underbrace{\sum_{i \in Stayers} \theta_{it-k} \Delta \ln TFP_{it}}_{WITHIN} + \underbrace{\sum_{i \in Stayers} (\ln TFP_{i,t-k} - \ln TFP_{Exit,t-k}) \Delta S_{it}}_{BETWEEN} + \underbrace{\sum_{i \in Stayers} \Delta \theta_{it} \Delta \ln TFP_{it}}_{COVARIANCE} \\ & + \underbrace{\sum_{i \in New} \theta_{it} (\ln TFP_{it} - \ln TFP_{Exit,t-k})}_{NET ENTRY} \end{aligned}$$

Here  $P_{Exit,t-k}$  is the weighted average labor productivity of exiting firms in the base year.

Although it may be more appropriate to compare productivity between entering and exiting firms, this alternative also implies that the between component uses the exiters as the base for that component and this is more difficult to motivate.

*(Preliminary: There are several arguments concerning the sensitivity of the relative contribution of entry, exit and stayers to various assumption choices. 1: output versus employment shares. 2: period chosen.)*

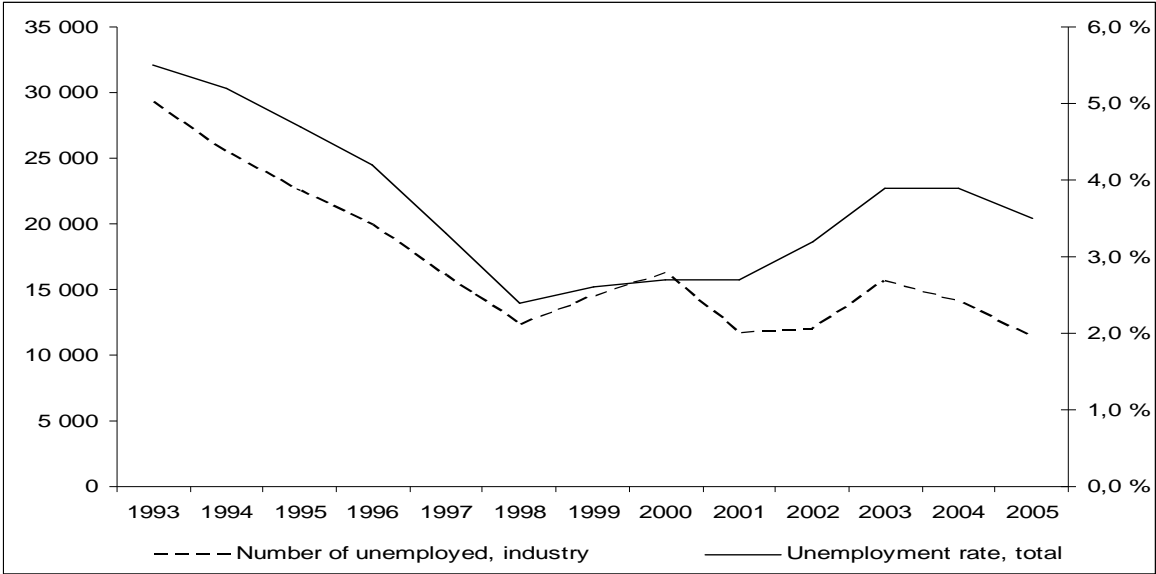
#### **4 Pattern of entries and exits in the Norwegian manufacturing industry**

A large number of plants enter and exit the Norwegian manufacturing industry each year. About 58,5 per cent of the total number of firms in 1993 left the market and were no longer operating in 2005 and about 63,6 of the manufacturing plants in 2005 were plants that entered between 1993 and 2005.

Previous studies on the exit and entry of producers have documented considerable fluctuations in entry and exit rates, but there is less documentation on how the characteristics of entering and exiting of plants vary through the business cycle. Recently some researchers have turned to these questions, see Lee and Mukayama (2008). This section follows the work from Lee and Mukoyama in terms of providing a description of entrants and exiting firms as well as of continuing firms and of how the characteristics changes with the business cycles.

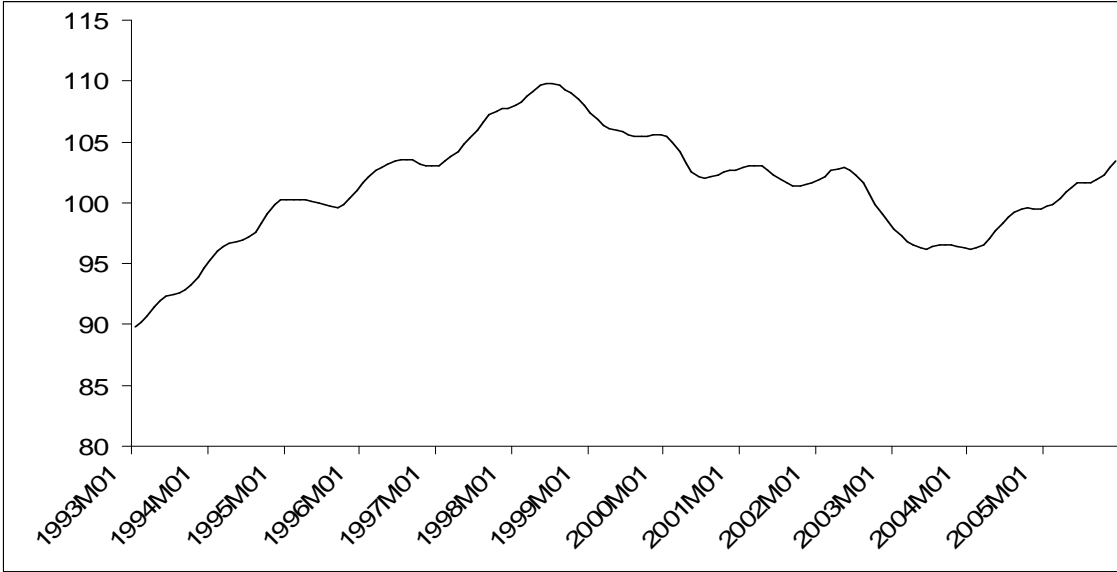
I have documented patterns of entry and exit over the business cycle documented in terms of entry and exit rates, employment and productivity through the years 1993 to 2005. Figure 1 and Figure 2 provide an illustration of the Norwegian business cycles over this time period, represented by the rate of unemployment in the economy and the number of unemployed in the Norwegian manufacturing industry in Figure 1, while Figure 2 provides monthly production indexes for the industry.

**Figure 1: Total number of unemployed in the industry and the unemployment rate in Norway, 1993-2005**



Note: Numbers from the Norwegian Labour and Welfare Organisation (NAV).<sup>17</sup>

**Figure 2: Index of production for manufacturing, trend cycles series**



Note: StatBank Norway, Statistics Norway. Indexed to reference year 1995.

In the beginning of 1993 the economy started on a long period of strong economic expansion after the deepest recession since World War 2 in the late 1980`s. Significant reduction of the interest rate, growth in public spending and generally better times internationally where some

<sup>17</sup> Different statistics describing the Norwegian labour force are available at <http://www.nav.no>

explanatory factors for this long expansion period. The unemployment rate in 1998 decreased to about half as compared to 1993. In Figure 2 we see a steady growth in industrial production from 1993 to 1998. The turbulence in financial markets internationally from the Asian Crisis, reduction in the oil price and higher interest rate to defend the value of the Norwegian krone (NOK) resulted in a slowdown in the economy after 1998. The US economy went to a recession in 2001 and the rest of the OECD-countries followed subsequently. In autumn 2002 the Norwegian economy followed as well, but this recession turned out to be moderate and short-lived. For the Norwegian manufacturing industry the high wage growth compared to the wage growth internationally led to a difficult situation. In addition to a significant appreciation of the NOK from 2000 to 2002, the recession internationally hit the Norwegian manufacturing industry hard. This situation involved several closures and reductions and a lot of jobs were lost in the period 2001-2003. We can see the result captured by a slight decline in industrial production until 2001. Then, for several reasons the interest rate was reduced remarkably from 2002 to 2004 which led to a depreciation of the NOK during 2003. This decreased interest rate played a significant role of making the recession moderate and short-lived. The Norwegian economy came into a boom at the end of 2004 and in the summer 2005 it had been in an expansion for two years. The improved situation for the Norwegian economy and better times internationally, ended the negative state of the Norwegian manufacturing industry during 2004<sup>18</sup>. From 2001 to the mid 2002 there are small changes in the industrial production before we observe further decline in production from the middle of 2002 to the middle of 2003 in Figure 2. After 2004 the production in the manufacturing industry expands.

I define the expansion and contraction periods of my analysis based on the annual growth rate of total manufacturing output compared to the average growth for the period. From the index of production numbers given by Statistics Norway I calculate total production each year and find the growth from one year to the next. Annual average growth rate for the entire period equals 0.7 %. The years 1999-2003 all have a negative growth rates. These years represent harder times for the Norwegian economy in my analysis and the period is then characterized as a contraction period. The years from 1993-1998 and 2003-2005 are all years with higher than average production growth and represent the good years in the analysis. This gives us two periods characterized as expansion periods in the economy (1993-1998 and 2003-2005).

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<sup>18</sup> Source: Samfunnsspeilet nr.4, 2005. Statistics Norway

Table 1 provides both employment shares and shares of number of firms for the three periods. The annualized exit rates for the three periods are 5.4, 7.3 and 7.2 per cent respectively. The exit rates follow the counter cyclical trend documented in the literature, although the third period characterized as an contraction period have a relatively high annual exit rate. The annual entry rates are 8.4, 7.3 and 3.9 respectively. The last period consists of only two years, so it is not directly comparable with the other two. The employment shares for exiters and entrants are relatively smaller compared the employment shares for stayers, indicating that the exiting and entering firms are on average smaller than continuing firms. Nevertheless, these shares are still considerable. In 1998 about 27.9 per cent of total employment was in firms entering after 1993 and 23.2 per cent of employment in 1993 was in firms closed by 1998. These numbers are even higher for the second period, indicating that the reallocation process involves a larger share of employees in the recession period<sup>19</sup>.

The last two columns give measures for average productivity for each group weighted by employment for each firm. The former column present the weighted average TFP measured as absolute values, so we can easily compare average productivities between all groups of firms. In the latter column the numbers are indexed relative to weighted average TFP for stayers measured in the first year of each period (the periods' "Base year").

From the last column we see that exiting firms have a significant lower average productivity compared to stayers measured in the same year for all three periods. When we relate these results to the economical situation, we can say that the exiting firms in the expansion periods have a lower average productivity compared to the stayers than in the contraction period. The difference between the indexed TFP for exiting firms in the two first periods is significantly different from zero at a 99 % confidence level, while the difference is not significantly different from zero between the second and the third period<sup>20</sup>.

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<sup>19</sup> Since the three sub-period consists of different number of years, for these measures only the two first periods are comparable. In chapter 6 we will see these numbers at a year to year basis.

<sup>20</sup> See appendix for significance results

**Table 1: Firm turnover, size and productivity differences**

	Share of the number of plants	Employment share	Average size	Weighted average TFP	Weighted average TFP, index
<b>1993-1998</b>					
Exiters	27,0	23,2	30,1	0,54	0,86***
Entrants	42,2	27,9	22,9	0,62	0,97
Stayers, Base year	73,0	76,8	36,9	0,63	1,00
Stayers, End year	57,8	72,1	43,1	0,76	1,19***
<b>1998-2003</b>					
Exiters	36,7	28,9	27,3	0,54	0,69***
Entrants	36,6	31,3	27,8	0,83	1,05***
Stayers, Base year	63,3	71,1	38,9	0,79	1,00
Stayers, End year	63,4	68,7	35,1	0,79	1,01
<b>2003-2005</b>					
Exiters	14,3	9,6	21,7	0,59	0,72***
Entrants	7,7	4,9	20,1	0,91	1,10***
Stayers, Base year	85,7	90,4	34,3	0,83	1,00
Stayers, End year	92,3	95,1	32,7	0,88	1,06***

Note: The shares for the exiting firms reflect the shares in the base year, while the shares of entrants are the shares in the end year of the periods. Average TFP is weighted by employment at each firm and is expressed both in absolute values and relative to the weighted average for continuing firms in the base year for each period. The results in table 1 that are significantly different from the average TFP of stayers in the base year at the 99 % and 95 % confidence level are marked with \*\*\* and \*\* respectively.

In the last column the entering firms' productivity are also indexed relative to stayers' productivity measured in the first year of each period while the entrants' productivity is measured in the end year of each period. Intuitively there will be differences between these averages because of average productivity growth within these years. By looking at the absolute productivity measures we see that the average productivity for entrants is higher for

entrants than for exiting firms in all periods (these averages are measured in the end year and the base year respectively). Furthermore, the entrants' average productivity is lower than for the stayers measured in the end year of the first period, but it is higher than the average productivity for stayers measured in the end year of the two other periods. The indexed TFP for entrants differs significantly between the periods. Looking at the first period, we see that entrants measured in 1998 have a lower average TFP than the stayers in the period measured in 1993. In the second period the average productivity for entrants is higher compared to the stayers measured both in the base year and in the end year of this period. This is also the case in the third period. The difference between the indexed TFP is significantly different from zero at 99 % confidence level for two first periods and at a 90 % confidence level for the second and the third period. The average TFP for entrants in the third period is not consistent with the argument that new firms are less productive in expansion periods than in contraction periods because of stricter selection mechanisms in harder times. Since the third period only consists of two years, the measured TFP, especially for entrants, is not directly comparable to the other periods since this group will have fewer years in improving performance before the group is measured in 2005. But this argument does not explain that the indexed TFP is higher for this period even though this is an expansion period.

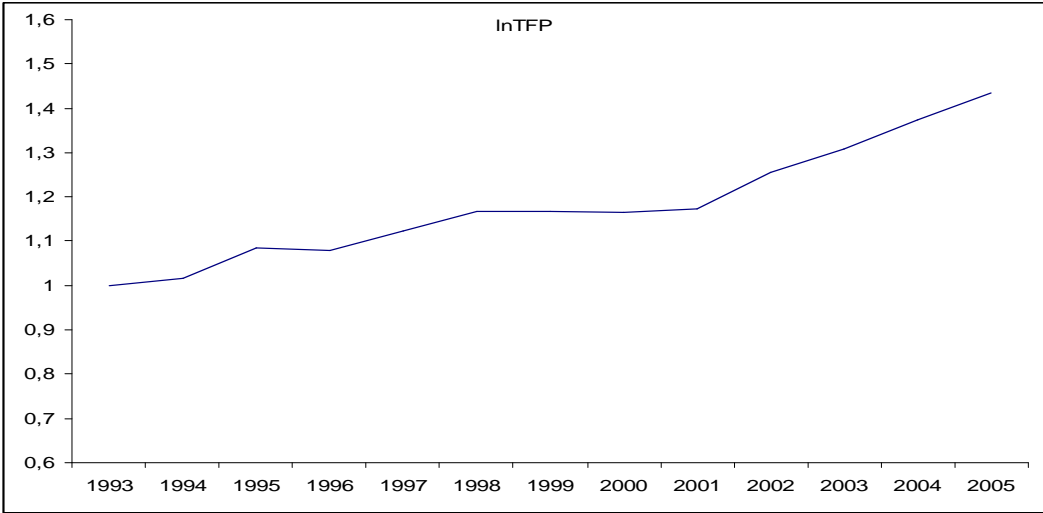
The average productivity growth within continuing firms differs significantly between the periods. The difference between the indexed TFP is significantly different from zero both for the first and second and for the second and third period at a 99 confidence level. These results indicate the contraction period is characterized by low productivity growth within continuing firms, and therefore, the aggregate productivity growth by far will be driven by the reallocation process of new more productive firms replacing less productive firms that exit. In the first period the firms who exit have much higher productivity than the firms' who exit in the subsequent contraction period. Also the entrants in the first periods are less productive than entrants in the second period. This result supports the argument of recessions implying an important cleansing mechanism for firm dynamics. But another finding from these results, may seem just as important, namely the low within productivity growth in the contraction period.

We see that entrants during recessions are larger and are more productive than firms entering during booms, at least for the first periods<sup>21</sup>. This result may indicate that new firms are both replacements for exiting firms and as well as they imply important competition for continuing firms. Related to the discussion of decomposition methods in the previous section, this is an argument against the BG method. The argument that the productivity of new firms should be compared only with existing firms does not seem to fit to my data. In the next section we will see that the decomposition method chosen will not be crucial for the results of the analysis.

**5 Aggregate productivity and the results from the decomposition analysis**

Figure 3 present the aggregate productivity in the Norwegian manufacturing industry calculated from the weighted sum of the individual productivity measures for each firm. The aggregate productivity growth from 1993-2005 is found to be 27 per cent in this period. This gives an annual growth of 2.2 per cent. For our three sub-periods presented above, the respective productivity growth rates are found to be 10.3, 8.6 and 7.6, with corresponding annual growth as 2.1, 1.7 and 3.8 per cent<sup>22</sup>.

**Figure 3: Aggregate productivity in the Norwegian manufacturing industry, 1993-2005**



Note: The aggregate productivity is indexed relative to lnTFP in 1993.

<sup>21</sup> The first result is in line with results from Baldwin and Gu (2003) and we find similar results to the latter result in Lee and Mukoyama (2008)

<sup>22</sup> The TFP growth is concurrent with the results from Balsvik and Haller (2005) for the years 1993-1998 (10.32 % and 10.36% respectively). Raknerud and Rønningen (2004) calculate annual growth in labour productivity using the Capital database for the period 1993-2002. This is measured as 2.9 % for the years 1993-1999 and 2.0 % for the years 2000-2002.

Table 4 presents the results for the three different decomposition methods described in Section 3. Here, the effects are presented as the components' annual shares of annual productivity growth. The absolute values for each component are given in Table 5, where only the results from the FHK method are considered. The contribution from the net entry effect can be compared between the different methods. We recognize the same pattern for all three methods, meaning that the net measured impact of entry and exit does not appear to be very sensitive to the method used. At the same time we can see that the FHK and the RG methods provide very different estimates of the relative importance of entry versus exit. The FHK method compares the productivity of entrants with the productivity for stayers and exiters in the base year, while the RG method compares their productivity with an average productivity for stayers and exiters over the entire period. Using the RG method decreases the effect of entry. Comparing the FHK and BG methods we see identical measures of the within effect and the covariance term. In the BG method the between term and the net entry term are calculated comparing stayers' and entrants' productivity relative to the productivity of exiting firms. This gives some differences in the estimated measures of these effects between the methods, but nevertheless, we do observe the same pattern, so it seems like the results of the analysis will not be so sensitive to the method chosen. I will from here only discuss the results from the FHK method.

<b>Table 4: Decomposition shares of aggregate productivity growth, three periods</b>							
	$\Delta \ln TFP$	<b>Stayers within</b>	<b>Stayers between</b>	<b>Stayers covariance</b>	<b>Net entry</b>	<b>Entry</b>	<b>Exit</b>
<b>FHK</b>							
1993-1998	2,1	105,6	-7,1	-15,0	16,4	0,9	15,5
1998-2003	1,7	0,9	-16,6	17,2	98,5	40,8	57,7
2003-2005	3,8	77,8	-4,9	-6,6	33,6	6,9	26,7
<b>RG</b>							
1993-1998	2,1	98,1	-12,2	-	14,1	-13,0	27,1
1998-2003	1,7	9,5	-6,8	-	97,3	25,1	72,1
2003-2005	3,8	74,5	-10,5	-	36,0	4,5	31,5
<b>BG</b>							
1993-1998	2,1	105,6	-10,2	-15,0	19,6	-	-
1998-2003	1,7	0,9	-21,4	17,2	103,3	-	-
2003-2005	3,8	77,8	8,2	-6,6	20,6	-	-

Note: The values represent the shares of annual aggregate productivity growth for each period.  $\Delta \ln TFP$  is the annual percentage point growth.

	$\Delta \ln TFP$	Stayers within	Stayers between	Stayers covariance	Net entry	Entry	Exit
<b>1993-1998</b>	0,021	0,022	-0,001	-0,003	0,003	0,000	0,003
<b>1998-2003</b>	0,017	0,000	-0,003	0,003	0,017	0,007	0,010
<b>2003-2005</b>	0,038	0,030	-0,002	-0,003	0,013	0,003	0,010

Note: The values represent the each component's productivity growth as absolute values

We can see that the components' partial importance differs significantly for the three periods<sup>23</sup>. The productivity growth from continuing firms explains most of the aggregate growth in the years 1993-1998 and 2003-2005, while for the period 1998-2003 the within productivity growth seems insignificant to the aggregate growth. The reallocation of resources between continuing firms, given by the Between and the Covariance term, seems to be inefficient (negative) for all periods except for the Covariance term in the period 1998-2003. In this period, where within productivity growth is very low, there seems to be a more efficient reallocation of resources through shift in employment towards those firms that do have productivity growth.

We see that the Net entry effect is significantly low for the first period compared to the others, and that this is caused by low contribution from both exiting and entering firms. Turning to the period 1998-2003, the productivity growth from the Net entry component is the driving force to aggregate productivity growth, explaining about 97 per cent of aggregate growth. The net entry effect gets smaller in the years 2003 to 2005, but is still a considerable source to productivity growth in this period, where it explains about 33 per cent of aggregate growth.

So the results from the decomposition analysis both support and supplement the discussion related to in Table 1 above. The contribution of the different components seems to vary over time and apparently through the cycle. We have seen that entrants' average productivity relative to stayers is higher in the contraction period compared to the first period with expansion. An interpretation may be that a boom for the years before and up to 1998 have revealed new creations which do not improve average performance in the industry, while this

<sup>23</sup> The results from the first period are comparable with the work by Balsvik and Haller (2005) and the results indicate the same conclusions except from the negative covariance term in my analysis.

kind of establishment seems to be prevented in the years with contraction. In addition the exiting firms have a lower average productivity relative to stayers in the recession period compared to both periods with expansion. This result supports the theory of a “cleansing effects” of recessions where low productive firms are forced to leave the market and release resources to new more productive firms to establish. Furthermore, we observe that while booms give grounds for high productivity growth within continuing firms, this productivity growth stagnates in the recession period. From Table 5 we can see that the growth from continuing firms equals zero in the years 1998-2003. An explanation for this low productivity growth can be low innovation investments for the continuing firms as well as inefficient adjustments of inputs or outputs due to reduced demand.

All these findings indicate a higher contribution from the Net entry component in the contraction period and this is exactly what we observe in Table 4 and Table 5. We see that while the productivity growth from the Net entry component in absolute values is much higher from the first to the second period, the difference is not that large between the second and the third period. Still the share of Net entry of aggregate productivity growth given in Table 4 differs significantly both between the first and second and between the second and the third period. This leads to the result that the reallocation process of entrants replacing exiting firms seems to be more important for aggregate productivity growth in contraction than in expansion periods.

## **6 Decomposition for different sectors**

When analyzing productivity growth at the aggregate manufacturing level we are faced with a risk of missing important information about differences at the industry level. These differences may be significant sources to productivity growth. Although the production functions are estimated for each sector, allowing for sector specific coefficients and average productivity growth, the partial contribution from stayers, entrants and exiting firms can still differ significantly between the sectors. The average productivity for exiting and entering firms will depend on which sectors expand and which sectors decline substantially in number of firms in each period. Sectors are characterized with different productivity and if there is a large decline in sectors with low productivity and a large increase of firms in high productive sectors these events can explain a considerable part of the difference in average productivity between entering and exiting firms. The data at hand contains firms in 21 manufacturing

industries at the 2-digit NACE level<sup>24</sup>. From the information of total employment growth in each sector each year I will divide the sectors into two groups. Firms in expanding sectors are sampled in one group and firms in declining sectors will be in the other. Afterwards, I decompose the aggregate productivity growth in each sector group in the same manner as in last section. With this approach the productivity growth is to be analyzed for different economic conditions at the sector level.

By comparing exit and entry rates across sectors we can test whether entry and exit rates are mostly driven by sector specific structural differences or changing macroeconomic environment associated with business cycles or changes in technology relevant for all sectors. Figure 4 and Figure 5 present annualized exit and entry rates for all sectors in the three sub-periods. Here I use annual identification of entrants and exiting firms meaning that firms observed in year  $t$ , but not in year  $t+1$  is defined as an exiting firm in year  $t$  while firms observed in year  $t$ , but not in year  $t-1$  is named an entrant<sup>25</sup>.

We see from Figure 4 that all sectors, except Nace 21, 26, 32 and 37, have higher exit rates in the years 1998-2003 than in the other two periods. This result supports the findings of counter-cyclical exit rates in the literature. The sectors Recycling, Manufacturing of radio, television and communication equipment, Manufacturing of non-metallic mineral products and Manufacturing of pulp, paper and paper products have higher exit rates in the years from 1993 to 1998.

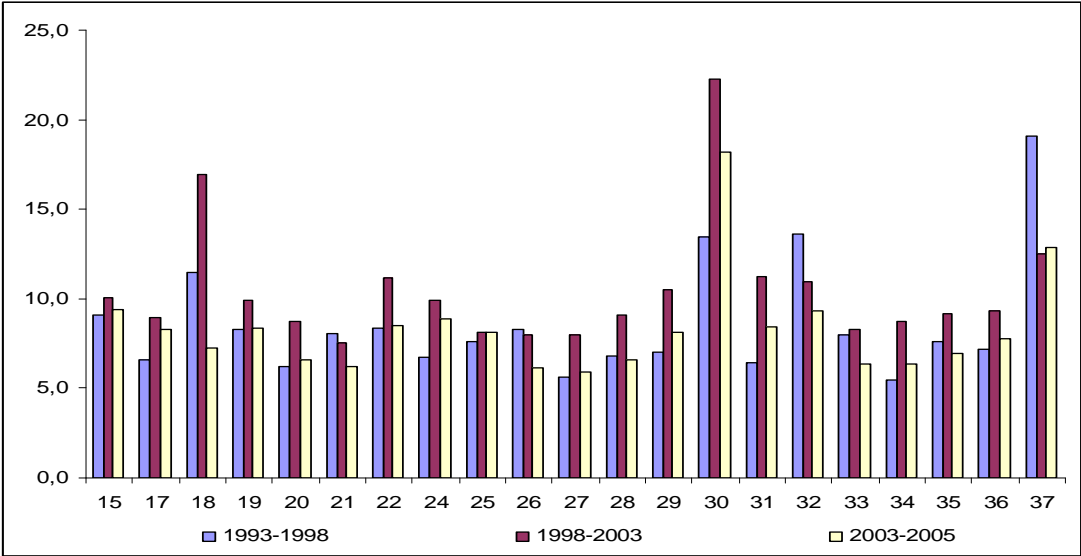
We see that most of the firms have higher entry rate for the first period of the observation span, and all sectors except Manufacture of wear apparel and Manufacture of office machinery and computers have the lowest annual entry rate in the years between 2003 and 2005. Although the magnitude of the exit and entry rates differs across sectors, the pattern for the three periods is similar, indicating that macroeconomic factors are the main driving sources for changes in these rates.

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<sup>24</sup> See List A1 for NACE-codes in appendix. Firms from NACE 16 and NACE 23 are removed from the sample due to few observations.

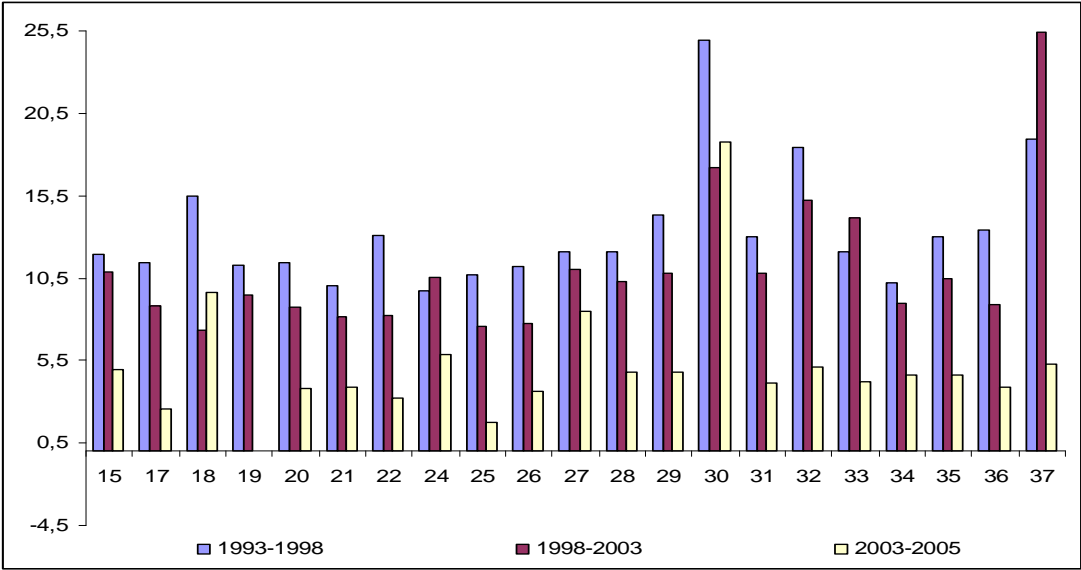
<sup>25</sup> In section 5  $k=5$  for the two first periods and  $k=2$  for the last period in the analysis. Here  $k=1$ .

**Figure 4: Exit rates by sectors for the three periods**



Note: Annual exit rates averaged over the three periods

**Figure 5: Entry rates by sectors for the three periods**



Note: Annual entry rates averaged over the three periods.

The purpose of this section is to see whether the conditions for productivity growth differ between expanding and declining sectors. To get a sufficient number of observations for each group I have to do the analysis first year by and year, and then combine these results for each period, using the average over all years in each period. Table 5 present the characteristics for the firms in both sector groups for the three periods. I have done the analysis for all firms as well (presented by the column named Total) to be able to compare the results and to see how the total number of firms is divided into the two groups.

**Table 5: Plant turnover and productivity differences**

	Share of the number of plants			Weighted average TFP			Weighted average TFP, index		
	Exp. sectors	Decl. sectors	Total	Exp. sectors	Decl. sectors	Total	Exp. sectors	Decl. sectors	Total
<b>1993-1998</b>									
<b>Exiters</b>	7,7	7,9	7,7	0,39	0,58	0,43	0,61***	0,77***	0,65***
<b>Entrants</b>	12,0	11,6	12,0	0,49	0,44	0,47	0,77***	0,58***	0,71***
<b>Stayers Base year</b>	92,3	92,1	92,3	0,64	0,75	0,66	1,00	1,00	1,00
<b>Stayers End year</b>	88,0	88,4	88,0	0,66	0,77	0,68	1,04*	1,02	1,03*
<b>1998-2003</b>									
<b>Exiters</b>	9,4	10,1	9,8	0,43	0,55	0,51	0,57***	0,75***	0,69***
<b>Entrants</b>	10,8	9,3	9,8	0,99	0,57	0,83	1,32***	0,78***	1,12***
<b>Stayers Base year</b>	90,6	89,9	90,2	0,75	0,73	0,74	1,00	1,00	1,00
<b>Stayers End year</b>	89,2	90,7	90,2	0,76	0,72	0,72	1,02	0,98	0,97*
<b>2003-2005</b>									
<b>Exiters</b>	7,2	8,0	7,8	1,02	0,51	0,57	0,97	0,63***	0,68***
<b>Entrants</b>	5,7	4,2	4,3	1,25	0,76	0,86	1,18***	0,92	1,03
<b>Stayers Base year</b>	92,8	92,0	92,2	1,06	0,82	0,84	1,00	1,00	1,00
<b>Stayers End year</b>	94,3	95,8	95,7	1,11	0,83	0,86	1,05*	1,01	1,03***

Note: Entrants, exiters and stayers are identified by observations from a year to year basis. Weighted TFP for stayers are then measured for both of the surviving years, the Base year and the End year (weighted by employment at each firm). The TFP values for the Base (End) year for each period is the average of all Base (End) year averages in this period. In the last column the values are indexed relative to the weighted average for continuing firms measured in the Base year for each group.

The indexed TFP for each group in table 5 that are significantly different from the average TFP of stayers in the base year at the 99 %, 95 % and 90 % confidence level are marked with \*\*\*, \*\* and \* respectively.

We observe in Table 5 that there are only small differences between entry and exit rates for the two groups of industries. However the pattern of how they differ is consistent for the three periods. In all periods exit rates are higher in declining than expanding sectors and entry rates higher in expanding than in declining sectors. These are intuitive and expected results.

We observe the same pattern concerning average productivity for the total number of exiters, entrants and stayers as we saw in Table 1. There is an important difference between the results presented in this table and in Table 1, namely that the identification of exiting firms, entrants and stayers here is based on observations from one year to the next ( $k=1$  in the description from section 2.2). The values from each year are then averaged over the years in each period.

We see that exiting firms have lower productivity than stayers in all periods. For entrants the productivity is higher than the average productivity for stayers in the two last periods while it is lower for the first period. The productivity growth for continuing firms is largest for the first and the third period. All these results are in line with the results in Table 1.

The difference between exiting firms' relative productivity in expanding and declining sectors is not consistent for all three periods. Average productivity for exiting firms is higher for firms in declining than expanding sectors for the two first periods. However, the weighted average for entering firms is higher for firms in expanding than in declining sectors in all periods. Also for stayers the average productivity is higher in expanding than in declining sectors. We should notice that in the second period the average productivity for stayers in declining sectors is lower measured in 2003 than in 1998, indicating a decrease in average productivity for these firms. This can be a result of inefficient adjustments of input factors and production level for firms in the declining industries.

To get enough observations for both groups of firms I need to do the decomposition analysis year by year end then averaging the results to our three periods. Using the FHK method presented in section 3 I now separate each component into two groups namely the firms in expanding and the firms in declining sectors in this period.

**Table 6: Decomposing productivity 1993-2005, declining versus expanding industries (shares)**

	1993-1998			1998-2003			2003-2005		
	Exp.	Decl.	Total	Exp.	Decl.	Total	Exp.	Decl.	total
<b>Stayers within</b>	97,3	23,4	120,7	33,3	-46,6	-13,3	29,5	45,4	75,0
<b>Stayers between</b>	22,4	-9,4	13,0	17,1	-12,0	5,1	-0,2	4,9	4,6
<b>Stayers covariance</b>	-36,2	-5,1	-41,4	4,0	-15,3	-11,3	0,5	-12,0	-11,5
<b>Net entry</b>	17,3	-9,7	7,6	112,4	7,0	119,5	6,0	31,9	37,9
<b>Entry</b>	-28,2	-13,1	-41,3	75,3	-26,3	49,0	9,7	-2,9	6,8
<b>Exit</b>	45,5	3,4	48,9	37,1	33,3	70,4	-3,8	34,9	31,1

Note: Each component is now divided into two groups: firms in expanding and declining sectors. The values are shares of total annual productivity growth in each period.

**Table 7: Decomposing productivity 1993-2005, declining versus expanding industries (absolute values)**

	1993-1998			1998-2003			2003-2003		
	Exp. sectors	Decl. sectors	Total	Exp. sectors	Decl. sectors	Total	Exp. sectors	Decl. sectors	Total
<b>Stayers within</b>	2,01	0,48	2,49	0,58	-0,80	-0,23	1,13	1,73	2,86
<b>Stayers between</b>	0,46	-0,19	0,27	0,30	-0,21	0,09	0,18	-0,23	-0,05
<b>Stayers covariance</b>	-0,75	-0,11	-0,85	0,07	-0,26	-0,20	0,02	-0,46	-0,44
<b>Net entry</b>	0,36	-0,20	0,16	1,94	0,12	2,06	0,23	1,22	1,45
<b>Entry</b>	-0,58	-0,27	-0,85	1,30	-0,45	0,85	0,37	-0,11	0,26
<b>Exit</b>	-0,94	-0,07	-1,01	-0,64	-0,58	-1,22	0,14	-1,33	-1,19
<b>ΔTFP</b>	2,1	0,0	2,1	2,9	-1,2	1,7	1,6	2,3	3,8

Note: Each component is now divided into two groups: firms in expanding and declining sectors. The values represent the each component's productivity growth as absolute values

Table 6 presents the results from the decomposition analysis, where each component now consists of two groups of firms. In this table the effects are presented as shares of annual productivity growth. The absolute values for each component are given in Table 7. We can see that the results differ slightly from the analysis presented in Section 4. Changes from year to year are not directly compared to changes with a five years observation span even though the effects are annualized. Especially in the periods consisting of five years in Section 4, productivity for entrants can be measured one, two, three or even four years after their establishment, giving them some time to improve their performance. However we do see the same pattern regarding the different contribution from stayers and reallocation for the three periods as in the first decomposition analysis.

For the difference between firms in expanding and declining industries we see that there is not a consistent pattern for all three periods. In the two first periods the productivity growth is mainly described by firms in expanding sectors. Although the firms in declining sectors contribute positively from within growth in the years 1993-1998 and from a positive Net entry effect from 1998 to 2003. However, in the years 2003-2005 firms in declining sectors contributes most to aggregate growth with a higher share of within growth and Net entry effects than firms in expanding industries.

So, the contribution from growth within firms is larger in expanding than in declining sectors for the two first periods. The negative total within effect in the second period is by far caused by a large negative within term for firms in declining sectors. The contribution from the Net entry effects is largest for the firms in expanding sectors as well in the two first periods. We see that the contribution from closures and entrants differs between these periods in both sector groups. In the first period the effect for new firms is negative for both groups of industries, and it remains negative in the second period for firms in declining industries. A large positive effect from exiting firms in both expanding and declining sectors combined with the positive effect from entrants in expanding sectors result in a large positive Net entry effect in this period from 1998 to 2003. It seems like the contraction period affects entrants in expanding and declining sectors differently. While entrants in expanding sectors contribute significantly more to productivity growth in this period, the entrants in declining sectors reduces productivity growth even more compared to the other periods. Nevertheless, it seems like the effect is the same on the exiting firms, namely that the least efficient firms are forced to exit. The Net entry effect for the third period is mainly driven by the large positive effect

from exiting firms in declining sectors. Entrants in expanding sectors also contribute positively to the Net entry effect in this period from 2003 to 2005.

How effective the reallocation process is within continuing firms is measured by the Between effect and the Covariance term. These terms are all negative for firms in declining sectors in all three periods except for the between effect in the last period.

It is difficult to find convincing results related to whether different economic conditions at the sector level have different implications for productivity growth. A consistent trend in the results is that entrants in expanding industries have a higher average productivity than entrants in declining industries. Furthermore, this difference in productivity seems to be higher in the contraction period. In addition, we have seen that the low productivity growth within continuing firms seems to be due to negative productivity growth within firms in the declining sectors.

## **7 Entrants' and Exiters' performance (Preliminary!)**

To examine the roles of selection and learning I want to look closer at the entrants' performance after their establishment and at the performance of exiting firms in their years before closure. The learning process assumed for producing firms can have two effects on the entrants' performance. On the one hand, it helps them improve their absolute productivity relative to their initial level. On the other hand, it may allow them to catch up with incumbent. Many entrants do not even survive for a year in the market. Those entrants that do survive and operate in the year after establishment correspond to about 80 per cent of the cohort of entrants<sup>26</sup>. The lowest surviving rates are found for entrants establishing in 1998, 2001 and 1997. The share of entrants that are operating two years after their establishment is even lower, around 65 per cent on average. An interesting question concerning the exiting firms is whether these firms are permanently low productive firms struggling for existence all their lives or whether they are firms suddenly facing declining productivity which result in closure.

I have considered two approaches to analyze the productivity improvement for entrants and the potentially decline in productivity for exiters. First, the regression analysis is extended taken account of entering and exiting firms. I include Dummy variables for whether a firm is

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<sup>26</sup> See Table A6 in Appendix

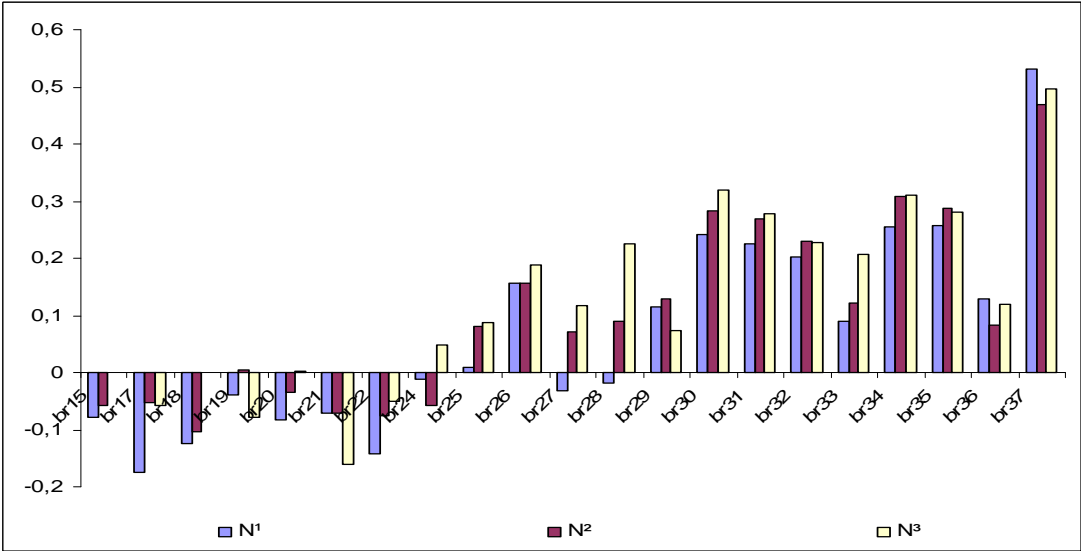
en entrant or an exiting firm and Dummies for whether the firm has one and two years left and for the two years after the entry. This gives the following regression equation:

(7.1)

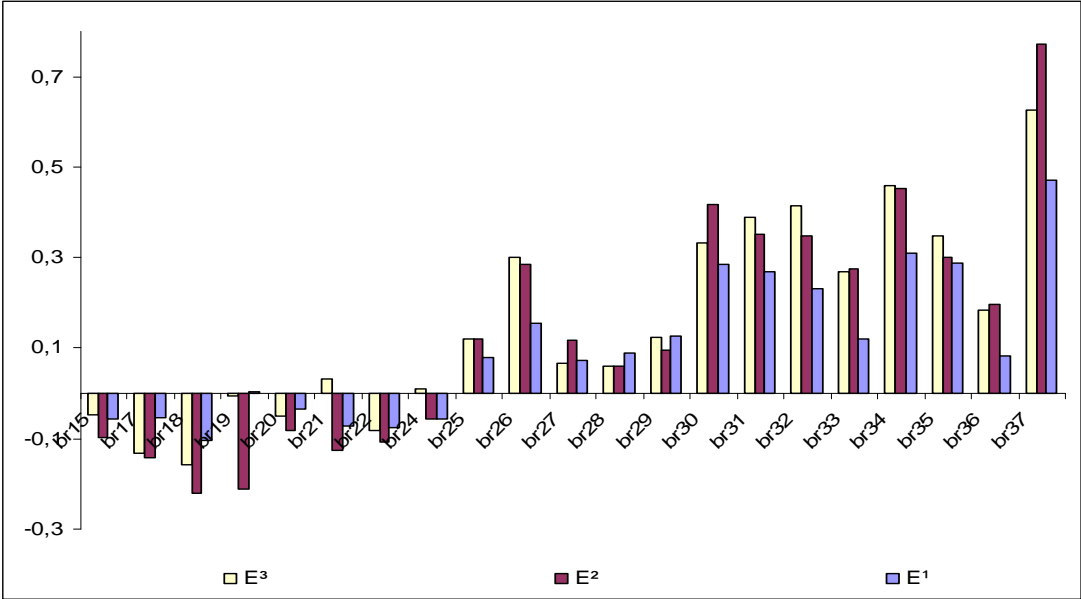
$$\ln Y_{it} = \alpha + \beta_1 \ln C_{it} + \beta_2 \ln L_{it} + \gamma_1 N^1 + \gamma_2 N^2 + \gamma_3 N^3 + \eta_1 E^1 + \eta_2 E^2 + \eta_3 E^3 + \bar{D}\delta + u_i + \varepsilon_{it}$$

The results from both OLS and FE regression are presented in the Appendix. The fixed effect model estimates a negative effect for a new firm, but it gets smaller after one and further after two years in the market. For the exiting firms we find as expected a high negative effect in their years of closure. This effect can be explained by the special situation for a firm in its last year of production, concerning both use of capital and the record of their financial accounts. However, we do observe negative effect for exiting firms one and two years before closure and the effect is higher for one year before exit than two years. All estimates are significant at a 0.95 confidence level. Furthermore, the estimation allowing different slope coefficients for the sectors show similar results. The following figures provide the estimated coefficients for the newly added dummy variables. Table A presents the estimation results marked with stars indicating their significance levels.

**Figure 6: Estimated coefficients for three dummy variables relating to a new firm**



**Figure 7: Estimated coefficients for three dummy variables related to an exiting firm**



Further we can compare these results with measures of average productivity for the different groups of firms. I define entrants entering in one year and surviving for two more years as a cohort for each year, next I sample firms surviving four years naming them Stayer Cohorts for each year. If we follow the cohorts for entrants and stayers for these three years we can observe their productivity improvements, and detect whether the entrants firstly improve their absolute productivity and secondly whether they improve their productivity relative to the stayers in these years.

The non-weighted average productivity for entrants operating at least to years after establishment are shown in Figure 8. As we have seen earlier (Table 1) the productivity for entrants are low in the first sub-period 1993-1998. The non-weighted means are negative for the entrants in 1993-1998, but their performance improves after one or two years. We also observe improving trends for the other cohorts of entrants indicating a learning process where entrants improve their performance relative to their initial level.

An other finding is that the average productivity for those entrants exiting the market after one or two years are found to be much smaller, where the productivity for those exiting after one year is lower than for those exiting after two years. The average productivity for cohorts of stayers is increasing for most of the years, with the exceptions in 1998-2000 and 1999-

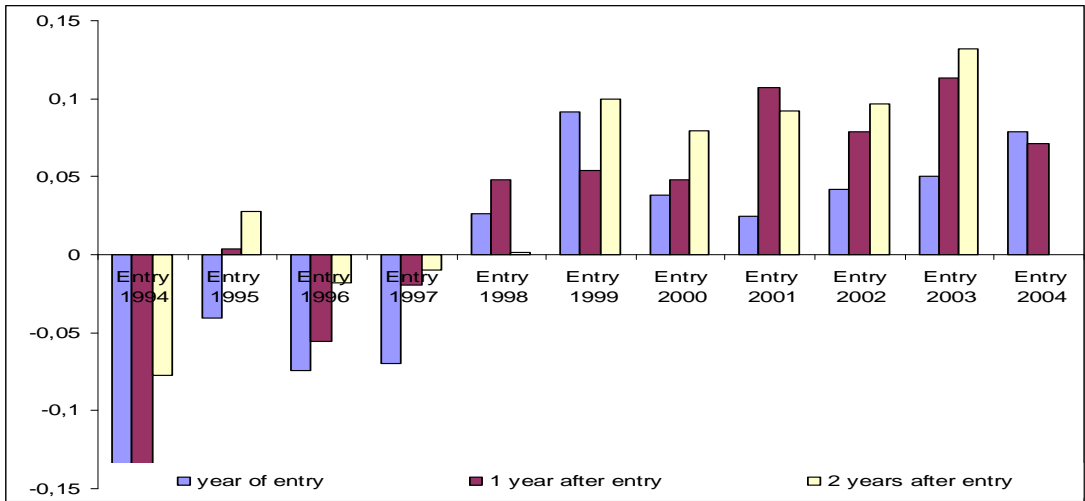
2001<sup>27</sup>. These years correspond to the beginning of the recession period in our observation span.

When comparing the average productivity of entrants and of continuing firms, we can see that the difference between their average productivity is largest in the first years of the observation span (see Figure 9). We observe a decreasing pattern for the productivity differences between the cohorts of entrants and stayers from the year of entry to the first or second year after. Furthermore the difference between entrants and stayers is smallest for the cohorts of 1998, 1999, 2000 and 2001 which support our earlier result of the cleansing effect of recession or what we can call the selection process. Only the most productive firms are allowed to entry in the years of recession.

The implications from these figures are that the learning effect is important for entrants. First they improve their performance and second, the difference compared to continuing firms gets smaller after one and two years of producing in the market.

Furthermore, Figure 10 shows that the mean size for cohorts of entrants is increasing one and two years after their establishment.

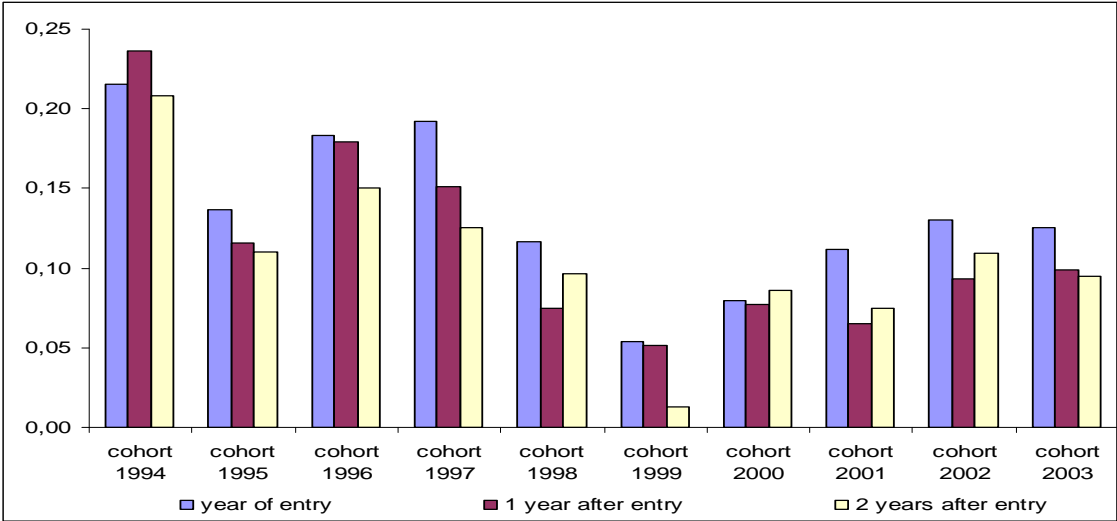
**Figure 8: Average productivity for entrants in the year of entry, 1 and 2 years after entry:**



Note: The average productivity for the cohorts of entrants are non-weighted averages

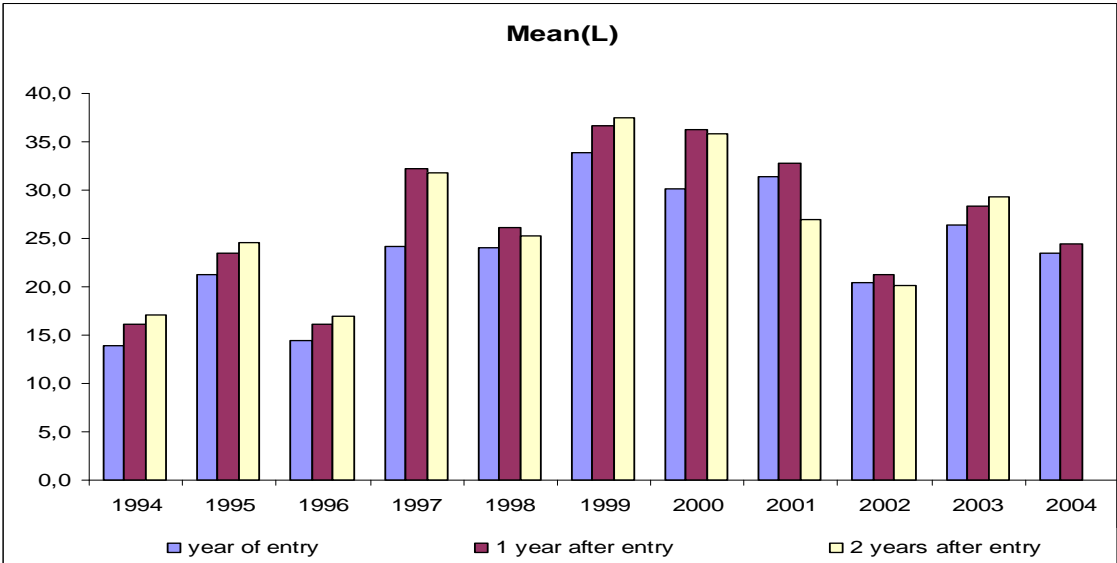
<sup>27</sup> See Figure A1 and Figure A2 in Appendix.

**Figure 9: Difference in average productivity between cohorts of Stayers and Entrants:**



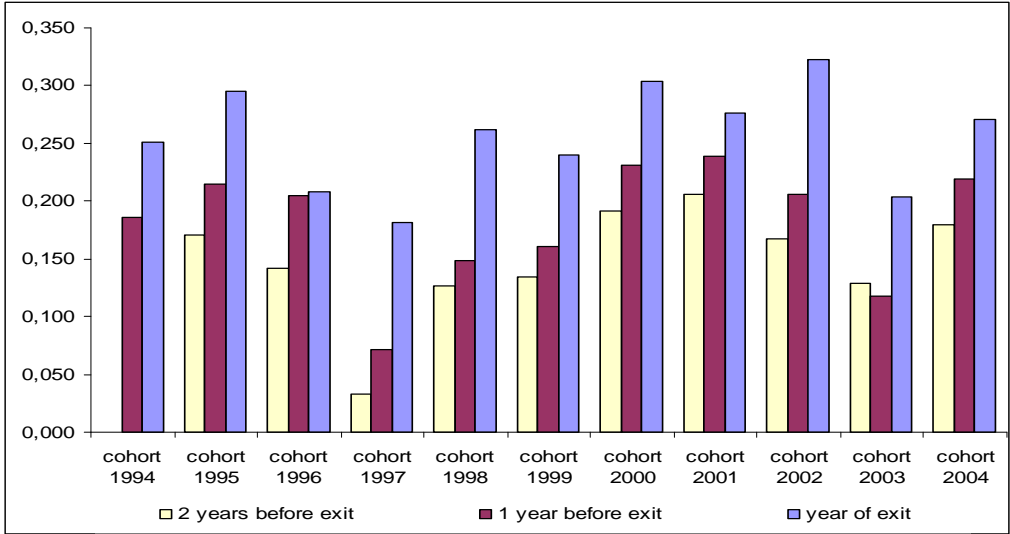
Note: The average productivity for the cohorts of entrants and stayers are non-weighted averages

**Figure 10: Average number of employees for entrants:**



For exiting firms we must follow the firms back in time, looking at the average productivity of the firms one and two years before closure compared to surviving stayers in the same years. Figure 11 presents the difference between cohorts of exiting and continuing firms for each year. The difference is by far largest in the last year for the exiting firms for all cohorts. Further the average productivity for exiting firms is decreasing as the firms get closer to their time of closure. The difference is largest for the cohorts of 2000, 2001 and 2002 supporting the result of recessions’ cleaning mechanism.

**Figure 11: Difference in average productivity between cohorts of Stayers and Exiters**



Note: The average productivity for the cohorts of entrants and stayers are non-weighted averages

**8 Discussion: factors behind productivity growth: (Preliminary!)**

Some of the factors that are thought to be important to productivity growth include ownership, quality of workforce, technology, innovation and R&D, international influence and the regulatory environment. It would be interesting to analyze further how these factors have contributed differently to the productivity growth in the Norwegian manufacturing industry for the period analyzed. How much of the documented productivity variability is due to measurement errors is not known. However, there are reasons to believe that at least a good portion of the dispersion is real. One considerable drawback for the method of measuring productivity used in this analysis is the potential influence from different prices. Without access to firm level prices, the firms’ output is measured as revenue divided by a common industry-level deflator. Therefore within sector price differences are embodied in output and productivity measures. If prices reflect different demand shift or market power variation rather than quality of production differences, then high productivity firms may not be particularly efficient.

Klette and Griliches (1996) provided a paper identifying some problems of interpretation of the production function parameters when deflated sales is used instead of real output as the dependent variable. The problem arises in situations where the firms are faced with imperfect competition and have differentiated products, where prices will reflect idiosyncratic differences in cost. Klette and Griliches argue that such models suffer from the fact that when

deflated sales replace the unobserved output variable in the estimation the effect from different prices will be buried in the residual.

Recently Foster, Haltiwanger and Syverson (2007) presented an analysis where they have access to data where producer level quantities and prices are observed separately. Accordingly they could directly measure physical efficiency, the quantity of physical units of outputs produced per unit of inputs. They use these measures to look at the independent contributions of technology and demand heterogeneity on producer dynamics and within industry reallocation. Their results are consistent with earlier literature in the regard that exiting business have lower prices and lower productivity, either revenue or physical quantity based, than continuing firms or entrants. They also find that entrants have a weak productivity advantage relative to continuing firms using revenue based productivity measures. Further they show that this is in part a result of entrants having lower prices than the continuing firms, and they argue that revenue based measures understates entrants' productivity advantages.

Furthermore they argue that the existing literature on decomposing aggregate productivity growth may understate the contribution of entry to aggregate growth and overstate the contribution of continuing business. The reason for this is the relationship between prices in continuing and entering business, diminishing entrants' true impact on productivity levels.

Their study support earlier work in the regard that revenue based and physical productivity are found to be highly correlated. Nevertheless they argue that the between prices and physical productivity which is large enough to make it important to decompose revenue productivity into its price and productivity components. Although this critique is relevant for my analysis I cannot separate the price effect do with my micro data at hand.

## 9 Conclusions

This paper presents an analysis of aggregate productivity in the Norwegian manufacturing industry from 1993 to 2005. The main objective is to see whether the factors behind productivity growth contribute differently to aggregate growth through this period depending on the state of the economy. In that regard the study entails an analysis of improved performance and the reallocation of resources for the continuing firms as well as the contribution of firm entry and exit to productivity growth.

The contribution of the different components to aggregate productivity growth seems to vary over time and apparently over the business cycle. We have seen exiting firms have lower average productivity relative to stayers in the recession period compared to the periods with expansion. In addition the entrants have higher average productivity relative to stayers in the contraction period compared to the first period with expansion. These results support the theory of a “cleansing effects” of recessions where low productive firms are forced to leave the market and release resources to new more productive firms to establish. Furthermore, we observe that while booms give grounds for high productivity growth within continuing firms, this productivity growth stagnates in the recession period. This leads to the result that the reallocation process of entrants replacing exiting firms, seems to be more important for aggregate productivity growth in contraction than in expansion periods. In addition the findings indicate that the market conditions provided in expansion periods are very important to ensure productivity growth within continuing firms.

It is difficult to find convincing results related to whether different economic conditions at the sector level have different implications for productivity growth. A consistent trend in the results is that entrants in expanding industries have higher average productivity than entrants in declining industries. Furthermore, this difference in productivity between entering firms in the two groups of sectors seems to be higher in the contraction period. In addition, we have seen that the low productivity growth within continuing firms seems to be due to negative productivity growth within firms in the declining sectors.

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## **Appendix:**

### **List A1: Standard Industrial Classification (SN2002)**

#### **D Manufacturing**

- 15** Manufacture of food products and beverages
- 16** Manufacture of tobacco products
- 17** Manufacture of textiles
- 18** Manufacture of wearing apparel, dressing and dyeing of fur
- 19** Tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear
- 20** Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials
- 21** Manufacture of pulp, paper and paper products
- 22** Publishing, printing and reproduction of recorded media
- 23** Manufacture of coke, refined petroleum products and nuclear fuel
- 24** Manufacture of chemicals and chemical products
- 25** Manufacture of rubber and plastic products
- 26** Manufacture of other non-metallic mineral products
- 27** Manufacture of basic metals
- 28** Manufacture of fabricated metal products, except machinery and equipment
- 29** Manufacture of machinery and equipment n.e.c.
- 30** Manufacture of office machinery and computers
- 31** Manufacture of electrical machinery and apparatus n.e.c.
- 32** Manufacture of radio, television and communication equipment and apparatus
- 33** Manufacture of medical, precision and optical instruments, watches and clocks
- 34** Manufacture of motor vehicles, trailers and semi-trailers
- 35** Manufacture of other transport equipment
- 36** Manufacture of furniture, manufacturing n.e.c.
- 37** Recycling

**Table A1: Average annual shares of total number of firms**

	L<5	5≤L<20	20≤L<100	L≥100	Total
Exiters	3,9	3,0	1,5	0,4	8,7
Entrants	4,8	3,4	1,2	0,3	9,8
Stayers, Base year	21,6	43,4	20,8	5,7	91,4
Stayers, End year	20,4	43,1	21,0	5,7	90,2
Total share	25,3	46,5	22,2	6,0	100

**Table A2: Unweighted average TFP, index**

	L<5	5≤L<20	20≤L<100	L≥100	Total
Exiters	-4,3	-1,3	2,1	6,2	-1,8
Entrants	-2,9	0,1	3,7	7,4	-0,7
Stayers, Base year	-1,8	0,4	3,5	7,3	1,0
Stayers, End year	-1,8	0,4	3,6	7,5	1,1

Note: <sup>1</sup> The average TFP are unweighted averages. Index: relative to unweighted average TFP for stayers for all firms in each period, calculated for the base year

**Table A3-1: Estimation results**

Variable	FE	br15	br17	br18	br19	br20	br21	br22	br24
lnK	0.1569	0.1851	0.1678	0.1126	0.0937	0.1154	0.1536	0.1891	0.1976
	0.002	0.006	0.011	0.019	0.034	0.006	0.023	0.004	0.017
lnL	0.6518	0.5732	0.6310	0.5421	0.7868	0.6744	0.5634	0.5577	0.6124
	0.004	0.011	0.024	0.040	0.062	0.013	0.053	0.009	0.036
year2	0.0415	0.0335	0.0553	0.0373	0.0668	0.0825	0.0804	0.0038	0.0426
	0.006	0.017	0.035	0.057	0.105	0.018	0.054	0.013	0.049
year3	0.0574	0.0073	0.0579	-0.0377	-0.1206	0.0773	0.2257	0.0867	0.1438
	0.006	0.018	0.035	0.058	0.106	0.018	0.056	0.013	0.050
year4	0.0910	0.0313	0.1052	0.0646	0.0073	0.1196	0.1346	0.1320	0.2092
	0.006	0.018	0.036	0.058	0.107	0.018	0.057	0.013	0.050
year5	0.0967	0.0016	0.0671	-0.0275	0.0823	0.1083	0.2349	0.1555	0.1763
	0.006	0.018	0.035	0.059	0.110	0.018	0.058	0.013	0.050
year6	0.1085	0.0367	0.0691	-0.0633	0.0294	0.1264	0.1654	0.0755	0.1533
	0.006	0.018	0.035	0.060	0.114	0.018	0.057	0.013	0.050
year7	0.1005	0.0378	0.0665	-0.0634	-0.0086	0.1628	0.1176	0.0425	0.1817
	0.006	0.018	0.036	0.062	0.113	0.018	0.057	0.013	0.050
year8	0.0648	0.0519	0.0795	-0.0368	-0.1216	0.2134	0.1272	-0.0183	0.1149

	0.006	0.019	0.035	0.064	0.120	0.018	0.058	0.013	0.050
year9	0.0779	0.0706	0.0627	-0.0463	-0.1018	0.2109	0.0728	-0.0623	0.0374
	0.006	0.019	0.036	0.065	0.125	0.018	0.058	0.014	0.051
year10	0.1156	0.0686	0.0718	-0.0976	-0.0749	0.2591	0.0851	0.0125	0.1123
	0.006	0.019	0.036	0.066	0.127	0.018	0.059	0.014	0.051
year11	0.1189	0.1310	-0.0260	-0.0241	-0.2048	0.2232	0.1679	0.0648	0.1444
	0.006	0.019	0.036	0.069	0.124	0.018	0.059	0.014	0.051
year12	0.1585	0.1803	0.0922	0.0642	-0.0283	0.3170	0.1704	0.1064	0.1250
	0.006	0.019	0.036	0.070	0.125	0.019	0.059	0.014	0.051
year13	0.1785	0.1592	0.1747	0.0942	-0.1469	0.3699	0.1678	0.1405	0.1070
	0.006	0.020	0.037	0.070	0.133	0.019	0.061	0.014	0.053
_cons	5.7328	5.7135	5.5543	6.0531	5.7191	5.6669	6.3451	5.8593	5.9863
	0.013	0.043	0.078	0.143	0.228	0.039	0.220	0.028	0.145

legend:  
b/se

**Table A3-2: Estimation results**

Variable	br25	br26	br27	br28	br29	br30	br31	br32	br33
lnK	0.1748	0.1808	0.1321	0.1447	0.1427	0.2499	0.1266	0.1277	0.1605
	16.693	20.783	7.293	29.530	25.961	3.609	12.150	5.759	12.586
lnL	0.7170	0.6244	0.6926	0.6895	0.6960	0.6784	0.7064	0.7908	0.5702
	32.350	32.460	18.128	65.858	52.531	4.731	30.706	17.058	19.720
year2	0.0059	0.0240	0.0125	0.0454	0.0658	0.0221	0.0386	0.0319	-0.0159
	0.200	0.897	0.228	2.962	3.380	0.117	1.180	0.454	-0.400
year3	-0.0335	0.0954	0.0058	-0.0019	0.0965	0.0533	0.0984	-0.0414	-0.0181
	-1.119	3.508	0.108	-0.125	4.988	0.265	2.953	-0.571	-0.455
year4	0.0355	0.0663	0.0957	0.0890	0.1047	0.2967	0.1171	0.1092	-0.0003
	1.197	2.387	1.783	5.735	5.374	1.361	3.542	1.460	-0.008
year5	0.0157	0.0967	0.1240	0.0847	0.1146	-0.0370	0.1499	0.2116	-0.0077
	0.530	3.469	2.296	5.424	5.841	-0.158	4.531	2.717	-0.193
year6	0.0253	0.0760	0.1577	0.1632	0.1034	0.4424	0.2091	0.1911	0.0835
	0.839	2.711	2.933	10.341	5.215	1.880	6.210	2.399	2.071
year7	0.0283	0.1121	0.0963	0.1251	0.0897	0.1441	0.2139	0.1474	0.0956
	0.937	3.961	1.796	7.867	4.469	0.505	6.300	1.883	2.374
year8	-0.0208	0.1222	-0.0601	-0.0409	0.0872	0.2562	0.1787	0.1159	0.0681
	-0.687	4.303	-1.130	-2.550	4.307	0.932	5.144	1.475	1.678
year9	0.0523	0.1194	0.0470	0.0669	0.0982	0.3314	0.2193	0.1282	0.1011
	1.699	4.212	0.867	4.093	4.788	1.183	6.259	1.594	2.502
year10	0.0622	0.1509	0.0885	0.2012	0.0448	0.2633	0.2278	0.1224	0.1859
	2.032	5.256	1.600	12.387	2.149	0.905	6.475	1.491	4.613
year11	0.0626	0.1626	0.1351	0.1348	0.0154	0.4029	0.2602	0.2110	0.1758
	2.027	5.623	2.424	8.256	0.733	1.375	7.280	2.619	4.384
year12	0.1027	0.2590	0.1069	0.0424	0.0698	0.3897	0.3249	0.2448	0.2687
	3.247	8.823	1.879	2.586	3.296	1.344	8.996	2.951	6.596
year13	0.1172	0.2787	0.0631	0.0480	0.1096	0.4787	0.3801	0.3049	0.2675
	3.638	9.409	1.103	2.871	5.091	1.497	10.319	3.607	6.479
_cons	5.4634	5.6538	6.1607	5.7438	5.7564	5.0648	5.7633	5.7061	5.9223
	77.169	94.449	39.798	181.576	158.380	13.236	85.622	35.835	71.913

legend:  
b/se

**Table A3-3: Estimation results**

Variable	br34	br35	br36	br37
lnK	0.0878	0.1171	0.1444	0.1842
	5.772	16.342	21.411	5.645
lnL	0.6445	0.7182	0.6998	0.6105
	16.460	48.785	43.589	10.163
year2	0.0916	0.0945	0.0584	0.2049
	1.803	3.932	2.648	2.068
year3	0.1689	0.1182	0.0366	0.3882
	3.262	4.885	1.656	3.233
year4	0.1835	0.1098	0.0357	0.0906
	3.420	4.485	1.617	0.773
year5	0.2194	0.2021	0.0389	0.1700
	4.132	8.247	1.765	1.443
year6	0.2543	0.2759	0.0679	0.3002
	4.770	11.166	3.054	2.475
year7	0.2231	0.2776	0.0779	0.2998
	4.232	11.198	3.497	2.515
year8	0.1598	0.2314	0.0754	0.3875
	3.008	9.254	3.355	3.250
year9	0.2118	0.2593	0.0281	0.2920
	3.966	10.276	1.225	2.394
year10	0.2100	0.2516	0.0646	0.3231
	3.917	9.813	2.797	2.629
year11	0.2478	0.2314	0.0855	0.3702
	4.605	8.931	3.675	3.019
year12	0.3364	0.2788	0.1512	0.6170
	6.192	10.682	6.464	4.943
year13	0.3513	0.3325	0.1530	0.4863
	6.343	12.557	6.445	3.761
_cons	6.1890	5.7956	5.5240	5.47775
	48.561	113.627	120.000	26.082

legend: b/t

**Table A4: Plant turnover and productivity differences**

	Share of the number of plants			Average number of employees			Weighted average TFP, index		
	1993-1998	1998-2003	2003-2005	1993-1998	1998-2003	2003-2005	1993-1998	1998-2003	2003-2005
<b>Exiters</b>	7,7	9,8	7,8	22,8	24,7	19,9	0,65	0,69	0,68
<b>Entrants</b>	12,0	9,8	4,3	16,7	26,3	17,9	0,71	1,12	1,03
<b>Stayers, Base year</b>	92,3	90,2	92,2	35,3	35,8	33,0	1,00	1,00	1,00
<b>Stayers, End year</b>	88,0	90,2	95,7	30,7	35,1	32,1	1,03	0,99	1,03

Note: Annual identification of entrants, stayers and exiting firms. All firms.

**Table A5: Decomposing productivity, three periods: 1993-1998, 1998-2003 and 2003-2005**

	1993-1998	1998-2003	2003-2005
<b>Stayers within</b>	120,7	-13,3	75,0
<b>Stayers between</b>	13,0	5,1	-1,3
<b>Stayers covariance</b>	-41,4	-11,3	-11,5
<b>Net entry</b>	7,6	119,5	37,9
<b>Entry</b>	-41,3	49,0	6,8
<b>Exit</b>	48,9	70,4	31,1
<b><math>\Delta Pt</math></b>	2,1	1,7	3,8

Note: Annual identification of entrants, stayers and exiting firms. All firms.

**Table A6: Share of surviving entrants, one and two years after entry:**

	year(t+1)	year(t+2)
<b>Entrants in 1994</b>	77,4	62,3
<b>Entrants in 1995</b>	78,9	67,5
<b>Entrants in 1996</b>	79,7	68,8
<b>Entrants in 1997</b>	76,7	58,7
<b>Entrants in 1998</b>	74,0	61,2
<b>Entrants in 1999</b>	82,7	68,9
<b>Entrants in 2000</b>	76,2	62,4
<b>Entrants in 2001</b>	77,6	66,6
<b>Entrants in 2002</b>	85,0	75,4
<b>Entrants in 2003</b>	81,1	71,1
<b>Entrants in 2004</b>	77,3	

**Figure A1 : Average productivity for entrants exiting year t+1 and year t+2 respectively**

(...)

**Figures A3: estimation results**

(...)

**Test of significance:**

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Mean productivity for each group of firms:

$$t = \frac{\bar{P}^{exit} - \bar{P}^{stayer}}{\sqrt{\frac{s_1^{exit\ 2}}{n_1^{exit}} + \frac{s_1^{stayer\ 2}}{n_1^{stayer}}}} = \frac{\bar{P}^{exit} - \bar{P}^{stayer}}{\delta_1^{exit}}$$

$$\bar{P}^{exit} - \bar{P}^{stayer} = diff^{exit} \Rightarrow t = \frac{diff^{exit}}{\delta^{exit}}$$

$$1993-1998: \bar{P}_{93}^{exit} - \bar{P}_{93}^{stayer} = diff_1^{exit}$$

$$\bar{P}_{98}^{new} - \bar{P}_{93}^{stayer} = diff_1^{entry}$$

$$\bar{P}_{98}^{stayer} - \bar{P}_{93}^{stayer} = diff_1^{stayer}$$

$$1998-2003: \bar{P}_{98}^{exit} - \bar{P}_{98}^{stayer} = diff_2^{exit}$$

$$\bar{P}_{03}^{new} - \bar{P}_{98}^{stayer} = diff_2^{entry}$$

$$\bar{P}_{03}^{stayer} - \bar{P}_{98}^{stayer} = diff_2^{stayer}$$

$$2003-2005: \bar{P}_{03}^{exit} - \bar{P}_{03}^{stayer} = diff_1^{exit}$$

$$\bar{P}_{05}^{new} - \bar{P}_{03}^{stayer} = diff_2^{entry}$$

$$\bar{P}_{05}^{stayer} - \bar{P}_{03}^{stayer} = diff_3^{stayer}$$

$$t_{exit}^1 = \frac{diff_1^{exit} - diff_2^{exit}}{\sqrt{\frac{se_{diff_1}^{exit}{}^2}{n_{diff_1}^{exit}} + \frac{se_{diff_2}^{exit}{}^2}{n_{diff_2}^{exit}}}} = \frac{diff_1^{exit} - diff_2^{exit}}{\sqrt{\frac{(se_1^{exit} + se_1^{stayer})^2}{n_1^{exit} + n_1^{stayer}} + \frac{(se_2^{exit} + se_2^{stayer})^2}{n_2^{exit} + n_2^{stayer}}}} =$$

$$= \frac{(-0,090) - (-0,242)}{\sqrt{\left(\frac{(0,619502 + 0,5531729)^2}{1457 + 3943}\right) + \left(\frac{(0,5811431 + 0,5788934)^2}{2503 + 4313}\right)}} = 7,157$$

$$t_{exit}^2 = \frac{diff_2^{exit} - diff_3^{exit}}{\sqrt{\frac{se_{diff_2}^{exit}{}^2}{n_{diff_2}^{exit}} + \frac{se_{diff_3}^{exit}{}^2}{n_{diff_3}^{exit}}}} = -0,350$$

$$t_{exit}^3 = \frac{diff_1^{exit} - diff_3^{exit}}{\sqrt{\frac{se_{diff_1}^{exit}{}^2}{n_{diff_1}^{exit}} + \frac{se_{diff_3}^{exit}{}^2}{n_{diff_3}^{exit}}}} = 6,353$$

$$t_{new}^1 = \frac{diff_1^{new} - diff_2^{new}}{\sqrt{\frac{se_{diff_1}^{new}{}^2}{n_{diff_1}^{new}} + \frac{se_{diff_2}^{new}{}^2}{n_{diff_2}^{exit}}}} = -2,851$$

$$t_{new}^2 = \frac{diff_2^{new} - diff_3^{new}}{\sqrt{\frac{se_{diff_2}^{new}{}^2}{n_{diff_2}^{new}} + \frac{se_{diff_3}^{new}{}^2}{n_{diff_3}^{exit}}}} = -1,820$$

$$t_{new}^3 = \frac{diff_1^{new} - diff_3^{new}}{\sqrt{\frac{se_{diff_1}^{new}{}^2}{n_{diff_1}^{new}} + \frac{se_{diff_3}^{new}{}^2}{n_{diff_3}^{exit}}}} = -4,432$$

$$t_{stayer}^1 = \frac{diff_1^{stayer} - diff_2^{stayer}}{\sqrt{\frac{se_{diff_1}^{stayer}{}^2}{n_{diff_1}^{stayer}} + \frac{se_{diff_2}^{stayer}{}^2}{n_{diff_2}^{stayer}}}} = 6,501$$

$$t_{stayer}^2 = \frac{diff_2^{stayer} - diff_3^{stayer}}{\sqrt{\frac{se_{diff_2}^{stayer}{}^2}{n_{diff_2}^{stayer}} + \frac{se_{diff_3}^{stayer}{}^2}{n_{diff_3}^{stayer}}}} = -2,812$$

$$t^3_{stayer} = \frac{diff_1^{stayer} - diff_3^{stayer}}{\sqrt{\frac{se_{diff_1}^{stayer 2}}{n_{diff_1}^{stayer}} + \frac{se_{diff_3}^{stayer 2}}{n_{diff_3}^{stayer}}}} = 4,045$$

### Industry by industry:

1) From year to year:

$$\bar{P}_t^{exit} - \bar{P}_t^{stayer} = diff_t^{exit}$$

2) Average over three periods:

$$\bar{P}_{93-98}^{exit} = \frac{1}{5} \times (\bar{P}_{93}^{exit} + \bar{P}_{94}^{exit} + \bar{P}_{95}^{exit} + \bar{P}_{96}^{exit} + \bar{P}_{97}^{exit})$$

$$\begin{aligned} se(P_{93-98}^{exit})^2 &= var(P_{93-98}^{exit}) = var(P_{93}^{exit} + P_{94}^{exit} + P_{94}^{exit} + P_{94}^{exit} + P_{97}^{exit}) \\ &= var(P_{93}^{exit}) + var(P_{94}^{exit}) + var(P_{95}^{exit}) + var(P_{96}^{exit}) + var(P_{97}^{exit}) \end{aligned}$$

$$se(P_{93-98}^{exit}) = \sqrt{var(P_{93}^{exit}) + var(P_{94}^{exit}) + var(P_{95}^{exit}) + var(P_{96}^{exit}) + var(P_{97}^{exit})}$$

$$\bar{P}_{93-98}^{exit} - \bar{P}_{93-98}^{stayer} = diff_{93-98}^{exit}$$

$$\bar{P}_{98-03}^{exit} - \bar{P}_{98-03}^{stayer} = diff_{98-03}^{exit}$$

$$\bar{P}_{03-05}^{exit} - \bar{P}_{03-05}^{stayer} = diff_{03-05}^{exit}$$

$$n_{93-98}^{exit} = n_{93}^{exit} + n_{94}^{exit} + n_{95}^{exit} + n_{96}^{exit} + n_{97}^{exit}$$

$$n_{93-98}^{stayer} = n_{93}^{stayer} + n_{94}^{stayer} + n_{95}^{stayer} + n_{96}^{stayer} + n_{97}^{stayer}$$

$$t = \frac{diff_{93-98}^{exit} - diff_{98-03}^{exit}}{\sqrt{\delta_{93-98}^{exit} + \delta_{98-03}^{exit}}} = \frac{(\bar{P}_{93-98}^{exit} - \bar{P}_{93-98}^{stayer}) - (\bar{P}_{98-03}^{exit} - \bar{P}_{98-03}^{stayer})}{\sqrt{\frac{(seP_{93-98}^{exit} + seP_{93-98}^{stayer})^2}{n_{93-98}^{exit} + n_{93-98}^{stayer}} + \frac{(seP_{98-03}^{exit} + seP_{98-03}^{stayer})^2}{n_{98-03}^{exit} + n_{98-03}^{stayer}}}}$$

**t statistic:**

	Exiters			Entrants			Stayers End year		
	Exp.Ind	Decl.Ind	Total	Exp.Ind	Decl.Ind	Total	Exp.Ind	Decl.Ind	Total
<b>diff1-diff2</b>	2,077	0,253	-0,339	-10,916	-3,099	-11,844	0,500	1,327	1,519
<b>diff2-diff3</b>	-5,241	4,558	1,819	0,813	-3,617	2,583	-1,194	-1,890	-1,753
<b>diff1-diff3</b>	-4,320	2,953	1,461	-7,395	-5,121	-9,219	-0,979	0,231	-0,228