ETLA

ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Anni Nevalainen

LABOUR PRODUCTIVITY AND FIRM ENTRY AND EXIT IN MANUFACTURING

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ABSTRACT: This paper investigates the connection between firm entry and exit and labour productivity growth. The study has its theoretical foundations in modern Schumpeterian growth theory, distance to frontier model and vintage capital models. The importance of productivity enhancing restructuring has been increasingly acknowledged and all these theories depict the productivity enhancing effects that external restructuring - in particular firm entry and exit – may have. Despite the vast theoretical discussion there is only a little empirical research on the subject. Thus, this study aims at contributing to the existing empirical literature by utilizing panel data that contain information on all manufacturing subsectors from eight EU member states between 1997 and 2004. Empirical analysis is conducted with fixed effects panel regression. It is noted that firm turnover, especially firm entry enhances productivity growth, but the effects appear with a lag. Productivity enhancing effects of firm entry are the strongest three years after the initial entry. The effects of firm exit on labour productivity growth are also positive but more modest than the effects of firm entry. Results of the analysis suggest that the population of firm entrants is extremely heterogeneous.

KEY WORDS: Labour productivity, manufacturing, firm entry, firm exit, modern Schumpeterian growth theory

JEL codes: L6, O4

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TIIVISTELMÄ: Tutkimuksen tarkoituksena on selvittää yhteyttä yritysten vaihtuvuuden ja työn tuottavuuden kasvun välillä. Tutkimuksen teoreettinen viitekehys muodostuu modernista schumpeteriläisestä kasvuteoriasta, eturintaman etäisyys –mallista ja vuosikertamalleista. Tuottavuutta vahvistavan rakennemuutoksen merkitys talouskasvulle on alettu tunnustaa enenevissä määrin ja tutkimuksen perustana olevat teoriat kuvaavatkin yritysten vaihtuvuuden aikaansaamia tuottavuutta vahvistavia vaikutuksia. Huolimatta laajasta teoreettisesta keskustelusta aiheesta on aiemmin toteutettu vain vähän empiiristä tutkimusta. Tutkimuksen tavoitteena on tuottaa kontribuutio jo olemassa olevaan empiiriseen kirjallisuuteen hyödyntämällä paneeliaineistoa, joka sisältää tietoja kahdeksan EU-maan teollisuuden alatoimialoista vuosina 1997-2004. Empiirinen analyysi toteutetaan kiinteiden vaikutusten regressiomallilla. Yritysten vaihtuvuuden – erityisesti yritysten markkinoille tulon – havaitaan vaikuttaneen tuottavuuskasvua vahvistavasti, mutta kolmen vuoden viipeellä. Yritysten markkinoilta poistumisen tuottavuusvaikutukset ovat myös positiiviset, mutta yrityssyntymien vaikutuksia vähäisemmät. Tulokset vahvistavat osaltaan käsitystä markkinoille tulevien yritysten heterogeenisyydestä.

AVAINSANAT: Työn tuottavuus, teollisuus, yrityssyntymät, yrityspoistumat, moderni schumpeteriläinen kasvuteoria

JEL-koodit: L6, O4

1 Introduction

Productivity has been a widely discussed and researched topic ever since new growth theories emerged in the 1980s following the works of Romer (1986) and Lucas (1988). New sources behind productivity growth have been increasingly acknowledged as the attention of researchers has gradually shifted towards micro level determinants of productivity growth. Certain themes have received a lot of attention. The importance of internal and external restructuring of firms has been discussed in several studies (e.g. Campbell 1998; Davis & Haltiwanger 1992; Disney, Haskel & Heden 2003b; Wheeler 2005). The rapid development of information and communication technology (ICT) has led to discussion on its role as an engine of economic growth (Atkeson & Kehoe 2007; Jovanovic & Rousseau 2005). Also research and development (R&D) and innovations (e.g. Acemoglu, Aghion & Zilibotti 2006; Gust & Marquez 2002; Maliranta 2005b) have received attention in literature.

Globalization and economic integration have shaped general economic conditions. Enterprises face new challenges in more turbulent operational environment. The current stage of the economy can be characterized by Schumpeterian creative destruction – new, competing innovations are developed continuously and obsolete, unprofitable technologies and firms producing them are forced either to renew or to exit the market. When economy undergoes such structural changes the maintenance and improvement of productivity growth require that enterprises should be able to both innovate and implement. Under these conditions, successful experimentation and selection demand constant micro level restructuring (Maliranta 2005a). Internal restructuring affects individual workers, their tasks and job descriptions within firms. External restructuring happens when plants are opened or closed or when firms enter or exit the market or when market shares of firms change. In other words external restructuring means resource reallocation between firms (e.g. Caballero & Hammour 1996).

This study focuses on the effects that external restructuring – namely firm entry and firm exit – has on labour productivity growth. The study has its theoretical foundations in modern Schumpeterian growth theory, which suggests that increased competition and firm entry should spur innovative activity and have productivity enhancing effects (Aghion & Howitt 1992). In addition to that distance to productivity frontier (Acemoglu et al. 2006) and vintage capital models are utilized. Despite the vast theoretical discussion only a little empirical research on the subject exists. Thus the aim of the study is to contribute to the existing empirical literature by utilizing a panel dataset that contains information on every manufacturing subsector in several EU countries between 1997 and 2004. The empirical analysis is conducted with fixed effects regression model and besides firm entry and exit rates several control variables are included in regressions. The main results of the econometric analysis support the hypothesis that more external restructuring is beneficial for labour productivity growth. However, results also suggest that productivity enhancing effects of firm turnover may appear only after a significant amount of time.

This paper has the following structure. First, relevant theories and findings from previous studies are presented in section 2. In the third chapter, the data and variables included in the empirical modelling of this study are described. In the fourth chapter, descriptive findings from the data and the results of the econometric analysis are presented. Finally, the fifth chapter of this paper concludes.

2 Theoretical Background and Previous Studies

This study has its theoretical foundations in the modern Schumpeterian growth theory which belongs to endogenous growth theories. Modern Schumpeterian growth theory differs from other endogenous growth theories by assuming that enterprises are heterogeneous. Competition has a central role in the theory. It is viewed as a dynamic struggle where only the strongest firms, in fact those who are able to create new innovations or improve existing technologies, survive (Maliranta & Ylä-Anttila 2007). New innovations make old technologies obsolete and their developer is entitled to all resulting profits (Aghion & Howitt 1992). The pace of firm entry and exit indicates the intensity of competition in an industry. On the one hand intense competition encourages firms to innovate and accelerates productivity growth. On the other hand competition speeds up the process of creative destruction, or in other words productivity enhancing restructuring. Creative destruction makes workers and other factors of production move from enterprises with weak productivity to enterprises that have higher productivity (Maliranta & Ylä-Anttila 2007).

Distance to frontier –model is described in Acemoglu et al. (2006). The model argues that the dynamics of productivity growth differ depending on the relative position of an industry in terms of technology. According to the model, the narrower the gap between an industry and the international technology frontier, the more important selection of firms and innovations become. Technological advancement is measured with relative productivity levels. Industries close to the international productivity frontier tend to be innovation-intensive and the industries far from the frontier usually base their productivity growth on investments and imitation instead. When productivity growth is driven by intensive innovation, there tends to be more competition and firm turnover. Instead in the laggard industries where investments and imitation of the most advanced technologies are emphasized, firm population is usually more static. For a growth strategy to be successful, institutions and their attitudes towards competition policies play an essential role. Legislation that limits competition can be especially harmful for economic growth if a country or an industry is close to the international productivity frontier.

Vintage capital models have several formulations. In these models it is assumed that the newest technical knowledge is embodied in the capital at the moment when it is taken to use. It is also assumed that the newest capital is always the most efficient (Solow 1962). The diffusion of the technologies is not instantaneous. Since the implementation of a new technology is costly, at least some of the incumbent firms continue to use older, less efficient technologies (Chari & Hopenhayn 1991). This gives start-up firms an advantage in implementing more productive technologies since they are not committed to outdated human or physical capital (Power 1998). The age structure and renewal rate of capital affect productivity growth through these mechanisms. Ageing capital slows down productivity growth the more the faster the capital obsolescence rate is (Gittleman, ten Raa & Wolff 2006). Since there can only be a limited number of capital vintages in use at the markets simultaneously, it is the oldest vintages and firms using them that become obsolete and get replaced by the firms that utilize both more modern and more efficient technologies.

Some vintage capital models incorporate Schumpeterian creative destruction. Models find positive connections between both the renewal rate of capital and productivity, and firm entry and productivity. Since the newest firms and plants use the most efficient technologies, it can be assumed that in industries where investment rates and firm entry rates are the highest, productivity growth should be the fastest (Caballero & Hammour 1994; Chari & Hopenhayn 1991; Jensen, McGuckin & Stiroh 2001).

Despite the vast theoretical literature only a little empirical research on the topic exists (Disney et al. 2003b, 666-667). Previous studies have usually been done with firm or plant level panel datasets and they have focused on the productivity performances of individual countries. In that sense this study differs from those. However, some previous findings on the characteristics of entering and exiting firms and the interplay between productivity and firm entry and exit should be mentioned before proceeding.

Baldwin, Beckstead and Girard (2002) find with Canadian data that only a marginal proportion of workforce is employed in start-up enterprises. They also find that the majority of firm entries happen in service sector instead of manufacturing. However, the survival rate of new enterprises tends to be higher in manufacturing than in service sector. Dunne, Roberts and Samuelson (1988) and Baily, Hulten and Campbell (1992) find support for the idea that entering firms are heterogeneous and often subject to early failure. In addition to that Dunne et al. (1988) find a positive correlation between firm entry and exit. In industries where a lot of firms are born also a lot of firms die.

Baily et al. (1992) find that at the times of more rapid productivity growth also the pace of external restructuring has accelerated. Campbell (1998) finds that rise in firm exit rates precedes acceleration of productivity growth, while entry rates rise simultaneously with productivity growth. Disney et al. (2003b) state that firm entry and exit have explained about 50 per cent of the labour productivity growth between 1980 and 1992 in Great Britain. Aghion, Blundell, Griffith, Howitt and Prantl (2006) examine the effects of foreign entry on productivity performance. They find that foreign entry can be harmful for productivity growth if the productivity gap between an industry and the international productivity frontier is large. Instead increased international competition is beneficial for productivity growth if an industry or a firm is relatively close to the international productivity frontier.

Previous studies have also focused on other possible determinants of productivity. The effects of R&D, technology and innovations have been the centre of attention in numerous studies (e.g. Acemoglu et al. 2006; Gust & Marquez 2002; Maliranta 2005b). Studies have found that the more effective use of ICT spurs productivity growth. R&D has been noted to be beneficial for productivity growth. However, productivity gains from R&D activities may not appear immediately. Exposure to international competition has been modelled in some empirical studies. Previous studies on the matter suggest that more intense international competition -

especially in the form of imports - benefits productivity growth (Gersbach 2002; Maliranta 2005b). The effect that the characteristics of the workforce have on productivity has been discussed. This is likely owing to the changing structure of workforce in the Western Europe. Studies have mainly focused on the age and education structures of the workforce (e.g. Ilmakunnas, Maliranta & Vainiomäki 2004; Maliranta 2003; Feyrer 2007). Also the effects that entrepreneurs have on productivity growth have been previously discussed (Audretsch & Sanders 2007).

3 Data

The dataset used in this study contains information on eight EU member states: Belgium, Finland, Italy, Spain, Sweden, the Czech Republic, the Netherlands and the United Kingdom. The data have information on all subsectors of manufacturing measured at the two-digit NACE Rev. 1 code level between 1997 and 2004. Some subsectors have been combined in order to maintain the structure of the EUKLEMS database.[1] Data have been collected from several sources. Data on labour productivity and some control variables have been obtained from the EUKLEMS database[2]. Data on firm entry and exit come from Structural Business Statistics (SBS) database compiled by the Eurostat. In addition to those, some control variables have also been obtained from the STAN Structural Analysis database which is compiled by OECD.

The choice of productivity measure can be justified by the close connection between labour productivity and the most common measure of living standard – gdp per capita. Even if total factor productivity would be more comprehensive measure of economic growth it requires often problematic measurement of the capital stock (Maliranta 2005b). Output measure is gross value added. Labour input has been measured with the hours worked by persons engaged. This labour input measure takes into account industry specific differences for example in shares of part-time workforce. Labour productivity growth has been calculated by

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1 Manufacturing of textiles and textile products (NACE DB) and manufacturing of leather, leather products and footwear (NACE DC) have been combined. Also manufacturing of coke, refined petroleum products and nuclear fuel (NACE DF), manufacturing of chemicals and chemical products (NACE DG) and manufacturing of rubber and plastics products (NACE DH) have been combined.

2 The database can be found at www.euklems.net.

logarithmic difference following the example of Inklaar, Timmer and van Ark (2008) and Stiroh (2002).[3]

Entry and exit rates have been calculated as for instance Disney, Haskel and Heden (2003a) and Dunne et al. (1988) have done before. Since we can only say that a firm has entered the market at some point between consecutive years $t - 1$ and t, the right way to calculate the entry rate at moment t is to divide the number of entered firms in an industry in year t by the total number of firms in an industry in year $t - 1$. Exit rate is calculated by dividing the number of exited firms in an industry in year t by the total number of firms in an industry in year t, because that is the last time exited firms can be observed. The magnitude of entry and exit rates depends on the definitions used for entering and exiting firms. This data exclude firm entry and exit resulting for instance from mergers, acquisitions or other kind of restructuring of enterprises. As a result only genuine start-up firms are included in the data. It should be borne in mind that sometimes the exact moment of firm exit may be hard to determine. This may result in some measurement error in firm exit rates (Eurostat 2006).

Since productivity growth is a process where many factors are likely to matter, several control variables are included in the data. The choice of control variables is based on previous studies and their findings on determinants of productivity growth. As a control for capital formation investment rate is used. This choice can be justified by the theoretical background of the study. As was noted earlier, both distance to frontier and vintage capital models accent especially the role of new capital as a determinant of productivity growth. Distance to frontier measure takes into account the effects that a country's relative position in terms of productivity level has on productivity growth. Variable is calculated following the approach of Acemoglu et al. (2006). It is the relationship between a country's labour productivity level and the highest labour productivity level in the world in that industry at that moment. If variable equals 1, then the country is the current productivity leader in the industry. When relative productivity levels are calculated, all countries from EUKLEMS database are included in calculations. Prices are adjusted by using international industry-specific purchasing power parities from EUKLEMS database. Price adjustments are mostly done with producer prices[4].

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[3] More detailed information on the construction of the variables can be found in Appendix 1.

[4] The only exceptions where consumer prices are used instead are manufacturing of machinery nec. (NACE DK), manufacturing of electrical and optical equipment (NACE DL) and manufacturing of transport equipment (NACE DM), see Timmer, Ypma & van Ark (2007).

R&D intensity is added into data as an indicator for innovation activity. Variable is calculated as nominal R&D expenditure per value added following Maliranta (2005b). The intensity of international competition in an industry is, following Maliranta (2005b), controlled for with export and import intensities. As a control for workforce characteristics, age and education shares of workers are added in the data. Also the shares of entrepreneurs are controlled for as is suggested in Audretsch and Sanders (2007). Since the hours worked by entrepreneurs have to be estimated by utilizing numerous sources, it is likely that this variable includes some bias.

4 Empirical Findings

Descriptive Statistics

Before descriptive statistics are presented and their implications discussed, general structure of manufacturing sector in the sample is described. Manufacturing subsectors are compared with respect to their shares of workforce and enterprises[5]. It can be easily noted that sectors seem to differ notably with respect to the number of enterprises and persons employed. Manufacturing of metals and fabricated metal products and manufacturing of textiles, textile products, leather and footwear are the two largest manufacturing subsectors both in terms of workforce and enterprises. On the other hand manufacturing of non-metallic mineral products is characterized both by low shares of firms and persons employed. Perhaps the most striking finding is that manufacturing of chemical, rubber, plastics and fuel products and manufacturing of transport equipment have the lowest shares of firms, but their shares of workforce are notably higher. This indicates that in these industries the number of firms operating is small but their size is large. Furthermore, this implies that there may exist economies of scale in these industries. The opposite holds for other manufacturing and recycling, which is an industry characterized by numerous small firms. It seems that the height of barriers to entry varies from one industry to another, which may also affect not only the entry and exit rates but also the effect that firm entry and exit have on productivity growth.

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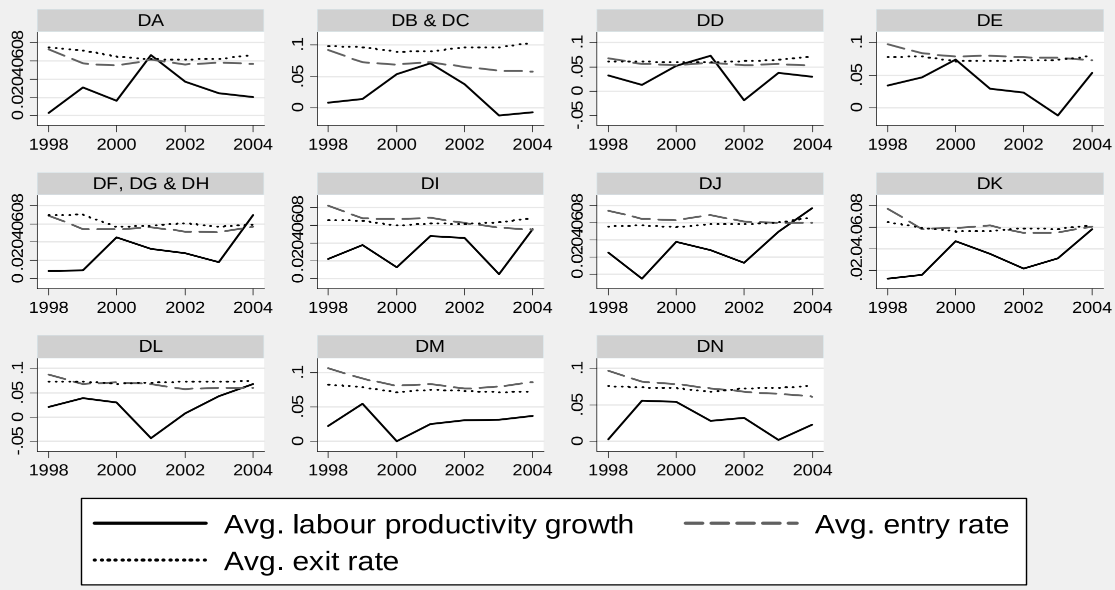
[5] The graph presenting sectoral shares of enterprises and workforce can be found in Appendix 2.

Figure 1 gives weighed yearly sample averages for the dependent variable labour productivity growth and firm entry and exit rates. Weighing of labour productivity growth has been done with respect to annual hours worked. More detailed information on country and industry specific productivity and firm entry and exit rates can be found in Appendices 4, 5 and 6.[6]

It has been noted in many occasions that productivity growth slowed down in Europe in 1990s while it simultaneously accelerated in the US (e.g. Daveri 2004; Gust & Marquez 2002; Inklaar et al. 2008; Maury & Pluyaud 2007). However, when the situation is examined on a finer level of aggregation, it can be found that there are significant differences in productivity performance between countries, industries and even individual firms in Europe. In this sample labour productivity growth has been the strongest in manufacturing of transport equipment, where labour productivity has grown on average 3.3 per cent per year. In terms of productivity growth, the weakest industry has been manufacturing of textiles, textile products, leather and footwear, where growth has remained on average at 2.1 per cent per year. These sample averages cover up quite a lot of variation. As also figure 1 shows labour productivity growth has been quite volatile. When labour productivity growth is compared between countries, growth has been the weakest in Italy and Spain. They lower sample averages due to both their rather poor performance and their large weights in the sample. Still, also in Italy and Spain some industries – for example manufacturing of basic metals and fabricated metal products – have experienced quite strong productivity growth. Labour productivity growth has been the most rapid in the Czech Republic, Sweden and Finland. Finland has managed to achieve especially rapid labour productivity growth in manufacturing of electrical and optical equipment. However, for Finland labour productivity growth has been problematic in manufacturing of textiles, textile products, leather and footwear where growth has remained approximately at 1.4 per cent per year.

[6] For control variables descriptive statistics can be found in Appendix 3.

Figure 1 Yearly sample averages of labour productivity growth, firm entry rate and exit rate.



Sources: EUKLEMS, SBS
DA=Food, beverages, tobacco, DB & DC=Textiles, leather & footwear, DD=Wood, wood & cork products, DE=Paper products; printing, publishing, DF, DG & DH=Chemical, rubber, plastics, fuel products, DI=Non-metallic mineral products, DJ=Basic metals & metal products, DK=Machinery nec., DL=Electrical & optical equipment, DM=Transport equipment, DN=Other manufacturing; recycling

The development of firm entry and exit rates has been more stable than labour productivity growth. In the sample exit rates are usually higher than entry rates. The most turbulent industries are manufacturing of textiles, textile products, leather and footwear and manufacturing of transport equipment. However, the direction of development in these industries has been quite different. Manufacturing of transport equipment is the only industry where firm entry rate has been higher than exit rate. In the industry average entry rate has been 7.3 per cent per year and average exit rate 7.0 per cent per year. Instead in manufacturing of textiles, textile products, leather and footwear the average exit rate has exceeded entry rate by over three percentage units. This finding is probably owing to the fact that textile industry has been subject to significant outsourcing where production units have been transferred to countries with lower labour costs, especially to Asia. The least turbulent industry in the sample is manufacturing of chemicals, rubber, plastics and fuel products, where entry rate remains on average at 4.0 per cent and exit rate at 5.0 per cent. This indicates that there probably exists some kind of entry barriers – such as large initial investments – in this industry. Firm entry and exit rates vary also by country. The largest entry and exit rates in the sample are in the Czech Republic and in the United Kingdom, whereas in Finland, Sweden and Belgium firm entry and exit rates are on average the lowest in the sample.

Some previous findings on the characteristics of entering and exiting firms are supported also according to these data. New enterprises are inclined to be vulnerable and subject to early failure and bankruptcy. Two years after entry about 20 per cent of new firms had exited the market. Almost half of the new enterprises in the sample did not live long enough to see their fifth birthday. The employment effect of new firms seems to be quite marginal as Gust and Marquez (2002) suggest in their study. In the sample entering firms employ on average 1.2 per cent and exiting firms 1.4 per cent of workforce. The data allow population of new firms to be divided in four groups according to their size. First group consists of firms that only employ the entrepreneur. To the second group belong firms that have one to four employees. The third group consists of firms that employ five to nine people, and to the last group belong the firms that have more than ten employees. In about 60 per cent of new firms the only worker is the entrepreneur. Only a marginal proportion of entering firms employs more than 10 people. Among exiting firms the share of the biggest firms is slightly higher than in entering firms, but still also the majority of exiting firms solely employ the entrepreneur. Similar positive correlation between entry and exit rates can be found with this data as Dunne et al. (1988) find in their study. Sample correlation coefficient is 0.6. This suggests that in industries where a lot of firms are born also a lot of firms die.

Some evidence on the positive effects of firm entry and exit on labour productivity growth can be obtained based on the descriptive analysis of the data. In manufacturing of transport equipment and manufacturing of pulp, paper, paper products and publishing both labour productivity growth and firm turnover have been high. In manufacturing of food products, beverages and tobacco both labour productivity growth and firm entry and exit rates have instead been modest. However, there are also some contradictory findings. In manufacturing of textiles, textile products, leather and footwear high entry and exit rates have not spurred labour productivity growth. In Finland and Sweden labour productivity growth has been strong even if entry and exit rates are among the lowest in the sample. These findings accent the assumption that several factors matter in the process of productivity growth. However, observed heterogeneity and relatively low surviving rates of entering firms indicate that it is possible that the productivity enhancing effects of firm entry and exit may appear with a lag.

Econometric Results

Econometric modelling in this study is done with fixed effects panel regression model[7]. The choice of econometric method can be motivated with the notion that it gives consistent regression estimates even if unobserved individual heterogeneity is correlated with regressors (Cameron & Trivedi 2005). Data are structured in such a way that each country-industry pair is treated as one observational unit[8]. In other words for example Finland and manufacturing of machinery constitute one observational unit. This way mechanisms that affect productivity growth differently from one country to another within the same industry or from one industry to another within the same country can be identified.

The example of Inklaar et al. (2008) is utilized as a starting point for econometric analysis. Dependent variable in the regression models is labour productivity growth measured as logarithmic difference between years *t – 1* and *t* and all independent variables included in the regression models are measured without lags. Standard errors are allowed to be both heteroscedastic and autocorrelated within each country-industry pair. Country-industry pairs are assumed to be independent. Inklaar et al. (2008) include separate dummies for country, industry and year in their regressions. In this study every regression model contains dummy variables for year and each country-industry combination instead. In following regression

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[7] Following Cameron and Trivedi (2005) the general form of fixed effects regression model can be specified as $y_{it} = \alpha_i + x_{it}'\beta + \varepsilon_{it}$, where α_i denotes the country-industry specific effects that measure unobserved heterogeneity. In this regression equation x_{it}' denotes the *K* independent variables, β the *K* slope parameters and ε_{it} are the iid error terms. The α_is are often viewed as nuisance parameters that potentially prevent the estimation of β. In short panels the estimates for these nuisance parameters are not consistent, but they do not affect the consistency of the slope parameter estimates. The within model for fixed effects is obtained by subtracting the time-averaged model form the original model. This eliminates the fixed effect parameters and yields $y_{it} - \bar{y}_i = (x_{it} - \bar{x}_i)'\beta + (\varepsilon_{it} - \bar{\varepsilon}_i)$. Fixed effects estimator $\hat{\beta}_W$ is obtained by ordinary least squares $\hat{\beta}_W = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it} - \bar{x}_i)(x_{it} - \bar{x}_i)'\right]^{-1} \sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it} - \bar{x}_i)(y_{it} - \bar{y}_i)$. Consistency of fixed effects estimator requires that the country-industry specific effect α_i is time-invariant. The effect that explanatory variables have on dependent variable is conditional on the observation specific variation. In addition to that correlation between the error term and any past, present or future value of independent variables is not allowed. When estimation is done with fixed effects regression model, results cannot be generalized outside the sample.

[8] Since the data include 11 industries and eight countries, the number of observational units adds up to 88.

model specification coefficient D_2 gives the individual specific effects. When regression models are constructed without lags they can be written as

$$(1)\quad \begin{aligned} \Delta LP_{it} &= \alpha + \beta_1 \times ENT_{it} + \beta_2 \times EXT_{it} + \sum_{n=3}^{k} \beta_n \times X_{it} + D_1 \times YEAR_t + \\ & D_2 \times COUNTRY\_INDUSTRY_i + \varepsilon_{it} \end{aligned}$$

Now ΔLP denotes labour productivity growth. *ENT* is firm entry rate and *EXT* is firm exit rate. Other control variables are denoted with *X*.

Two types of models are estimated. Concise models include fewer explanatory variables than full models. In addition to entry and exit rates concise models contain control variables only for investment rate and distance to frontier. Full models include all control variables, namely investment rate, distance to frontier, R&D intensity, import and export intensities, the share of entrepreneurs and age and education shares of workforce.

In concise model without lags regression coefficient for firm entry rate is positive and statistically significant (10 per cent level). The value of the coefficient is 0.9. Also firm exit rate gets a positive coefficient, but it is not statistically significant. When all control variables are included in the model also entry rate ceases to be statistically significant and value of the coefficient drops to 0.7. In both models coefficients for entry rate are higher than for exit rate. Distance to frontier variable gets statistically significant and positive values in both concise and full model. This implies that according to the models, laggard countries and industries have not caught up productivity leaders. Current R&D has negative and statistically significant effect on labour productivity growth. Export intensity affects productivity positively and statistically significantly. Other control variables do not affect labour productivity growth statistically significantly in models that do not include lags.

When dependent variable and all explanatory variables are constructed at moment *t*, it is likely that arising endogeneity and simultaneity bias affect the results. Another issue with such models is that possible lagged effects cannot be detected. Findings from both previous studies (e.g. Baily et al. 1992) and the descriptive analysis of this study suggest that new enterprises are often subject to early failure and bankruptcy. Also productivity enhancing effects of some control variables, for example R&D (e.g. Maliranta 2005b), may appear with a lag. However, the availability of data restricts the possibility for utilizing lags to some extent. After lag *t – 3* the number of available observations for firm entry and exit rates drops significantly and thus the accuracy of the estimates is reduced.

To avoid simultaneity bias modelling is expanded into distributed lags direction[9]. Lagged models can be used if it is assumed that modelled effects could reach beyond the current moment. Certain problems may occur with such modelling. Firstly, it is often hard to determine the appropriate number of lags. Secondly, collinearity arises when multiple lags are included in a regression model. Thirdly, when several lags are added into a single model, the interpretation of the results becomes challenging (Greene 1997; Stock & Watson 2003). Another option to avoid simultaneity bias would be to use lagged explanatory variables as instruments for current values of variables[10]. Because labour productivity growth is determined by the values from periods *t – 1* and *t*, from now on explanatory variables are measured at the minimum with lag *t – 2*. Each explanatory variable can be measured at several points of time. In full models only age and education shares are still measured with first differences. Otherwise there are no differences between the models presented earlier and the ones including distributed lags. Again both concise and full models are constructed and results from them are reported.

Table 1 presents the results from regression models where lagged explanatory variables are used. In both concise model 1 and full model 2 independent variables are measured with both lags *t – 2* and *t – 3*. Entry rate has a positive and statistically significant coefficient in both models with lag *t – 3*. In concise model p-value of the coefficient is less than 5 per cent and in full model less than 1 per cent. In the concise model, one percentage unit higher firm entry rate in year *t – 3* has spurred labour productivity growth in year *t* by 1.6 percentage units. In

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[9] The general form of distributed lags regression model can be expressed with following regression equation $y_t = \alpha + \sum_{i=0}^{q} \beta_i x_{t-i} + \varepsilon_t$, where q indicates the number of the lags. If q is known, the model simplifies to classical regression model (Greene 1997). Distributed lags models assume that the explanatory variable x is exogenous. This can be expressed with $E(\varepsilon_{it} \mid x_t, x_{t-1}, \ldots) = 0$. In addition to that the lags are not allowed to be perfectly multicollinear. The distribution of both dependent and independent variables should be stationary. Distributed lags models can be generalized to include several lagged independent variables (Stock & Watson 2003).

[10] Instrumental variables method was tried also with this data. However, results that were obtained were not robust and are therefore not reported.

full model the effect of one percentage unit higher entry rate with three years' lag rises to 1.9 percentage units. With lag $t-2$ coefficients for firm entry rate are positive but not statistically significant. Both models give positive coefficients for exit rate both at $t-2$ and $t-3$, but coefficient is statistically significant only in the concise model with lag $t-3$. Even then statistical significance remains at 10 per cent level. Models 1 and 2 suggest that firm entry has statistically significant positive effect on labour productivity growth. However, these effects seem to appear only three years after the initial firm entry. Even though also firm exit affects productivity positively, the effects of firm entry seem stronger.

Most control variables in models 1 and 2 get qualitatively anticipated coefficients. With lag $t-2$ laggard industries have caught up the frontier. Investments and R&D have had positive effect on productivity growth with both lags. The effects of exports and imports are ambiguous. Their signs vary depending on model specification. The most striking result for control variables is that the coefficient for the share of over 50 year old workforce is positive and statistically significant. Earlier studies imply that the oldest workers should on average have low productivity (e.g. Ilmakunnas et al. 2004). However, the interpretation of age and education variables is somewhat challenging since they are defined at higher level of aggregation than other variables (Timmer, van Moergastel, Stuivenwold, Ypma, O'Mahony & Kangasniemi 2007).

Models 3 and 4 in table 1 are specified following the implications from models 1 and 2. As was noted earlier, especially the effects that firm entry has on labour productivity growth appear strongly with lag $t-3$. That is why in models 3 and 4 all explanatory variables are measured only with lag $t-3$. This also reduces problems caused by multicollinearity since now regressions do not include multiple lags. Again, model 3 is a concise model and includes only firm entry and exit rates, investment rate, distance to frontier variable, country-industry and year dummies. Model 4 is full model and includes all control variables. In general form the regression models can be presented as follows. The only difference between this and previous regression equation (1) is the replacement of time index t with $t-3$.

$$\begin{aligned}(2)\quad \Delta LP_{it} &= \alpha + \beta_1 \times ENT_{i,t-3} + \beta_2 \times EXT_{i,t-3} + \sum_{n=3}^{k} \beta_n \times X_{i,t-3} + D_1 \times YEAR_t \\ &+ D_2 \times COUNTRY\_INDUSTRY_i + \varepsilon_{it}\end{aligned}$$

The concise model 3 gives both firm entry and exit positive coefficients that are statistically significant at 5 per cent significance level. According to the model, one percentage unit higher firm entry rate has resulted in almost 1.8 percentage units higher labour productivity growth three years later, ceteris paribus. For firm exit rate corresponding labour productivity growth enhancing effect is 1.1 percentage units. In the full model 4 the value of the coefficient for firm entry rate rises. According to the full model one percentage unit higher firm entry rate has resulted in 2.1 percentage units higher labour productivity growth three years later. Simultaneously the p-value of the coefficient drops from 5 to 1 per cent. The opposite happens to the coefficient of exit rate. The value of the coefficient drops compared to the concise model and is about 0.9. Also its statistical significance weakens from 5 to 10 per cent. However, both firm entry and firm exit seem to have enhanced labour productivity growth with three years' lag. When the amount of control variables in the lagged variable model is increased, the effect of firm entry is accented. According to both models where explanatory variables are measured only at $t - 3$ it is plausible to assume that productivity enhancing effects of firm turnover – especially firm entry – do appear with a lag.

The results for many control variables are not as unambiguous as for entry and exit rates. In model 1 distance to frontier and investment rate are statistically significant with lag $t - 2$. Coefficient for distance to frontier is negative and for investment rate positive. In other models they cease to be statistically significant and also the signs of their coefficients vary. Moreover the values of these coefficients drop almost to zero. R&D intensity has positive and statistically significant coefficients in model 2 with lag $t - 2$ and in model 4 with lag $t - 3$. Also in other lagged models coefficients for R&D intensity are positive which agrees with earlier findings (e.g. Ali-Yrkkö 2008; Maliranta 2005b). Low skilled labour force has enhanced productivity growth statistically significantly in model 4 when high skilled workforce is treated as the reference group. This result is in line with earlier findings of Maliranta (2003) and Daveri and Maliranta (2007). Again, somewhat surprisingly over 50 year old workforce has been strongly beneficial for productivity growth when the share of under 30 year old workforce is the reference group. Coefficients for the share of over 50 year old workforce are positive and statistically significant in both models 2 and 4.

Table 1 Results from fixed effects regression models with distributed lags.

	(1)	(2)	(3)	(4)
Entry rate (t-2)	1.566	0.647		
	(1.307)	(0.742)		
Entry rate (t-3)	1.625**	1.905***	1.767**	2.082***
	(0.684)	(0.621)	(0.840)	(0.619)
Exit rate (t-2)	0.394	1.028		
	(0.675)	(0.819)		
Exit rate (t-3)	1.455*	0.905	1.094**	0.944*
	(0.752)	(0.615)	(0.549)	(0.537)
Distance to frontier (t-2)	-0.380**	-0.088		
	(0.165)	(0.088)		
Distance to frontier (t-3)	0.029	0.058	-0.154	0.009
	(0.166)	(0.126)	(0.223)	(0.132)
Investment rate (t-2)	0.598*	0.270		
	(0.333)	(0.198)		
Investment rate (t-3)	0.266	0.178	0.273	-0.010
	(0.236)	(0.244)	(0.208)	(0.231)
R&D intensity (t-2)		0.725**		
		(0.282)		
R&D intensity (t-3)		0.453		1.170***
		(0.470)		(0.376)
Export intensity (t-2)		0.321		
		(0.259)		
Export intensity (t-3)		-0.392		-0.277
		(0.303)		(0.282)
Import intensity (t-2)		0.364*		
		(0.205)		
Import intensity (t-3)		-0.014		0.268
		(0.280)		(0.199)
Entrepreneur share (t-2)		-0.103		
		(0.540)		
Entrepreneur share (t-3)		-0.939		-0.831
		(0.702)		(0.728)
30-49 years(1)		0.480		0.780
		(0.514)		(0.502)

	(1)	(2)	(3)	(4)
Over 50 years[1]		2.247*		3.457**
		(1.255)		(1.510)
Low-skilled[2]		1.290		1.861**
		(0.810)		(0.854)
Medium-skilled[2]		-0.073		-0.028
		(0.585)		(0.660)
Number of obs.	259	251	270	262
Number of groups	86	84	87	85
R-squared	0.20	0.48	0.08	0.39

* p-value < 0.1, ** p-value < 0.05, *** p-value < 0.01

(1) Variable is first differential. The control group is the share of total hours worked by under 30 year olds.
(2) Variable is first differential. The control group is the share of total hours worked by high-skilled workforce.
The dependent variable is labour productivity growth between t – 1 and t.
All regressions include a constant and year and country-industry dummies.
For every explanatory variable regression coefficients, standard errors and significance levels are reported.
All explanatory variables have been measured with lags.
Standard errors are heteroscedasticity and autocorrelation robust.

As robustness check models 1-4 are calculated with only heteroscedasticity robust standard errors. For the majority of the variables this increases standard errors. However, the rise in standard errors is subtle and affects p-values only slightly if at all. For firm entry the statistical significance drops from 5 to 10 per cent in model 1 with lag $t - 3$. It can be concluded that from this aspect results for firm entry seem quite robust. For firm exit rate only heteroscedasticity robust standard error in model 1 is lower and significance level higher (5 per cent) than when standard errors are controlled for both heteroscedasticity and autocorrelation. In model 3 the significance level of firm exit drops from 5 to 10 per cent. Still, statistically significant productivity enhancing effects for firm exit remain also after this robustness check. The findings for control variables are in line with the findings for the variables of particular interest. Large changes in standard errors do not occur. Statistical significances are lower for R&D intensity and distance to frontier variables in models 1, 2 and 4. For over 50 year old workers significance level rises from 5 to 1 per cent in model 4.

5 Concluding Remarks

This study investigated the interplay between firm turnover and labour productivity growth. Empirical analysis was conducted with a dataset that included information on eight EU member states. The time span of the data was from 1997 through 2004. Information covered all manufacturing subsectors with a two-digit NACE code level and was gathered from several international databases. The service sector was not included in the data since productivity measurement is known to be rather challenging in numerous service industries (Griliches 1994).

Modern Schumpeterian growth theory, distance to frontier model and vintage capital models were used as theoretical background for the study. Theories imply that there should be a positive connection between firm entry and exit and productivity growth. More firm entry and exit should spur productivity growth by creating more competitive pressure. Despite the vast theoretical discussion only a little previous empirical research on the topic exists. Most of the previous analyses have been done with plant and firm level country-specific data and in that sense this study differs from those. However, previous empirical studies have found support for the productivity enhancing effects of firm entry and exit (e.g. Baily et al. 1992; Campbell 1998).

Descriptive findings from the data suggest that both labour productivity growth and firm entry and exit rates vary a lot depending on country and industry. Some industries and some countries have experienced both strong labour productivity growth and firm turnover. In some industries and countries the development has been quite the opposite. Finland for example has experienced steady labour productivity growth in numerous industries. Especially in manufacturing of electrical and optical equipment labour productivity growth has been strong. Despite good development in terms of labour productivity growth firm turnover has remained modest. This implies that productivity growth cannot be explained by only one factor. Previous studies have found that new enterprises are a heterogeneous group. This finding was supported also by these data. Almost half of the new enterprises in the sample did not live for five years. This was the first implication that the effects of firm entry and exit may appear with a lag.

To avoid simultaneity bias the focus of the empirical analysis was on the models that were done with fixed effects panel regression model with distributed lags. Firm turnover – especially firm entry – was found to have productivity enhancing effects but they appeared only with a lag. Models where both lags $t-2$ and $t-3$ were included suggested that the productivity enhancing effects of firm entry and exit appear with three years' lag. When only lag $t-3$ was included in the model, it could be noted that one percentage unit higher firm entry rate had resulted in 2.1 percentage units higher labour productivity growth after three years. Productivity enhancing effects of firm exit were a little less than one percentage unit. The results for firm entry and exit appeared to be rather robust.

Reasons behind the result that firm entry benefits labour productivity growth with a lag can be justified with the notion that new enterprises are a heterogeneous group. Already mentioned low survival rates of new firms imply that market selection separates this way the successful units from the less successful ones. However, this process of Schumpeterian creative destruction takes time and the benefits from the market mechanism are realised only after a while. Selection process seems to benefit from a larger pool of entering firms with competing ideas. It appears to be that both the amount and the quality of fresh ideas play an important part in the process. The results from this study imply that by removing barriers for entry and competition productivity growth could be enhanced.

There are numerous restrictions and other notions worth mentioning about this study. First and foremost, more research on the topic is needed. One aspect that was almost completely overlooked in this study was the effect of competition. Problematic was that there did not exist comprehensive enough data on industrial competition. Furthermore the estimation method in itself imposes restrictions to the generalization of the results. To avoid simultaneity bias analysis was expanded into distributed lags direction. Another method to overcome such problems – namely instrumental variable approach – was also mentioned and tried out. However, due to the small size of the data robust results could not be obtained with that method. Also the results for many control variables were rather ambiguous. Reasons behind those findings are not thoroughly analysed here but in the future they deserve more in depth analysis. One interest of productivity research are service industries and the mechanisms through which their productivity growth is determined. Since it has been discovered that there tends to be more firm turnover in services than in manufacturing it would be interesting to find out how firm entry and exit affect productivity growth in service sector.

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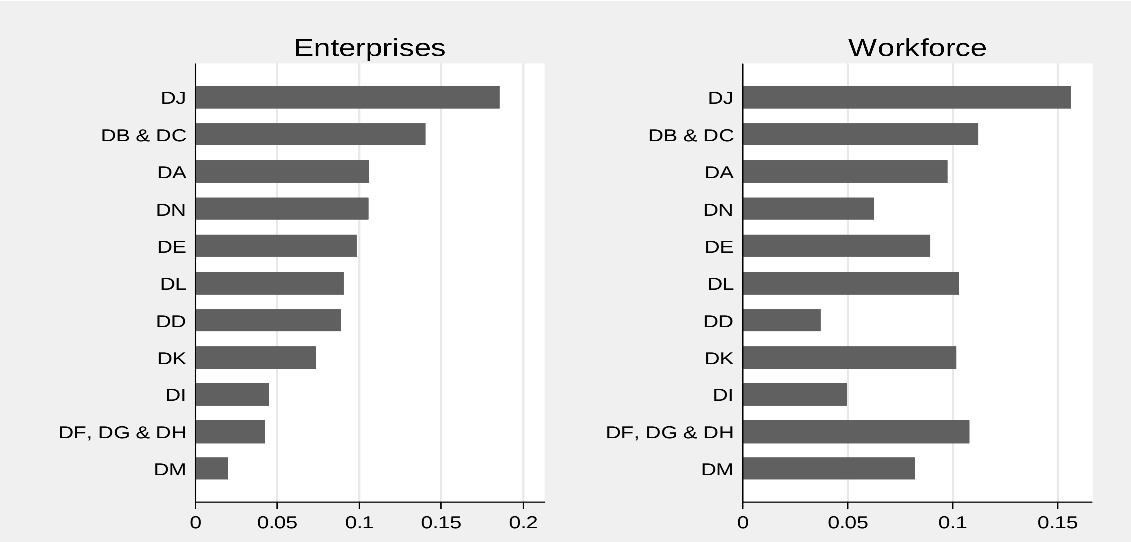
APPENDIX 1 Variables included in the econometric analysis

Variable	Definition
Labour productivity growth	log(value added in year t/hours worked in year t) - log(value added in year t-1/hours worked in year t-1)
Firm entry rate	Number of entered firms in year t/Total number of firms in year t-1
Firm exit rate	Number of exited firms in year t/Total number of firms in year t
Distance to frontier	Labour productivity of country i in year t/Labour productivity of the world frontier in year t
Investment rate	Gross investment in year t/Gross output in year t
R&D intensity	Nominal R&D expenditure in year t/Value added in year t
Export intensity	Exports in year t/Gross output in year t
Import intensity	Imports in year t/Gross output in year t
Entrepreneur share	Hours worked by entrepreneurs in year t/Total hours worked by persons employed in year t
Under 30 years old	Hours worked by persons employed aged 15-29 in year t/Total hours worked by persons employed in year t
30-49 years old	Hours worked by persons employed aged 30-49 in year t/Total hours worked by persons employed in year t
Over 50 years old	Hours worked by persons employed aged 50 and over in year t/Total hours worked by persons employed in year t
Low-skilled	Hours worked by low-skilled persons employed in year t/Total hours worked by persons employed in year t
Medium-skilled	Hours worked by medium-skilled persons employed in year t/Total hours worked by persons employed in year t
High-skilled	Hours worked by high-skilled persons employed in year t/Total hours worked by persons employed in year t

APPENDIX 2 Shares of enterprises and workforce by manufacturing subsectors



Source: SBS
DA=Food, beverages, tobacco, DB & DC=Textiles, leather & footwear, DD=Wood, wood & cork products, DE=Paper products; printing, publishing, DF, DG & DH=Chemical, rubber, plastics, fuel products, DI=Non-metallic mineral products, DJ=Basic metals & metal products, DK=Machinery nec., DL=Electrical & optical equipment, DM=Transport equipment, DN=Other manufacturing; recycling

APPENDIX 3 Descriptive statistics of control variables in the data

Variable name	Number of observations	Mean*	Standard deviation
Distance to frontier	704	0.588	0.243
Investment rate	594	0.181	0.074
R&D intensity	580	0.046	0.077
Import intensity	594	0.556	0.503
Export intensity	594	0.537	0.427
Under 30 years old	704	0.246	0.050
30-49 years old	704	0.549	0.052
Over 50 years old	704	0.205	0.068
Low-skilled	704	0.245	0.179
Medium-skilled	704	0.640	0.194
High-skilled	704	0.115	0.073
Entrepreneurs	704	0.093	0.086

* Unweighed sample averages

APPENDIX 4 Average labour productivity growth rates by country and industry between 1997 and 2004.

	Sample	FIN	SWE	ESP	ITA	UK	NLD	BEL	CZE
DA	2.4	2.8	2.8	2.3	1.4	2.1	4.2	3.0	7.6
DB & DC	2.1	1.4	5.3	0.5	2.3	2.6	5.4	2.8	6.1
DD	3.0	3.6	5.2	1.3	2.1	5.8	4.6	5.0	4.7
DE	3.0	3.6	4.3	3.6	1.9	3.2	4.4	2.4	8.0
DF, DG & DH	2.5	6.6	5.8	3.6	0.9	2.8	4.5	3.1	4.6
DI	2.8	4.2	4.9	3.4	1.3	3.5	1.6	3.1	9.5
DJ	3.0	2.1	1.8	4.1	3.0	2.5	3.1	4.2	5.9
DK	3.0	2.7	3.4	2.7	2.6	3.5	4.0	3.8	6.6
DL	2.4	8.7	1.6	-0.2	2.7	2.7	1.3	2.5	6.0
DM	3.3	2.4	4.2	2.8	2.1	3.3	8.4	1.9	10.6
DN	2.7	2.4	4.5	2.6	2.0	2.7	3.7	4.8	6.2

APPENDIX 5 Average firm entry rates by country and industry between 1997 and 2004.

	Sample	FIN	SWE	ESP	ITA	UK	NLD	BEL	CZE
DA	4.6	4.4	3.7	4.5	5.5	8.0	4.2	3.3	7.7
DB & DC	6.0	7.0	7.0	7.9	6.0	8.9	5.9	3.5	8.4
DD	5.0	4.1	5.5	4.5	4.4	7.8	4.0	5.5	10.3
DE	7.0	6.2	5.8	8.8	5.7	9.6	5.6	6.0	16.8
DF, DG & DH	4.0	4.6	3.3	4.7	4.6	6.9	5.1		6.2
DI	5.4	5.5	5.0	5.6	5.3	10.2	6.0	3.7	8.9
DJ	5.6	5.0	4.3	7.3	5.4	7.1	6.3	6.1	9.7
DK	5.4	4.0	3.9	7.8	6.0	6.1	5.9	4.6	6.9
DL	5.7	4.1	3.9	7.6	5.6	8.5	6.5	4.7	6.7
DM	7.3	6.7	5.5	7.9	7.8	10.7	5.9	7.4	7.3
DN	6.0	6.3	6.9	6.8	5.0	10.7	8.3	4.9	7.2

APPENDIX 6 Average firm exit rates by country and industry between 1997 and 2004.

	Sample	FIN	SWE	ESP	ITA	UK	NLD	BEL	CZE
DA	5.5	5.7	5.5	5.0	5.1	9.4	6.6	5.9	8.6
DB & DC	9.2	8.6	6.6	8.6	8.5	14.0	8.1	7.3	13.9
DD	6.4	5.8	4.8	5.5	6.0	7.9	5.3	5.4	8.2
DE	7.1	6.0	5.4	6.0	5.8	9.9	7.3	6.5	8.1
DF, DG & DH	5.0	4.5	3.7	4.4	5.0	8.1	5.2	4.4	6.5
DI	6.0	5.4	4.5	5.1	5.3	9.7	6.7	5.0	10.0
DJ	5.7	4.9	4.0	5.4	4.9	7.6	5.4	5.5	8.7
DK	5.7	4.6	3.6	6.1	5.0	8.4	4.8	4.6	5.9
DL	6.6	4.4	4.3	5.9	6.0	10.4	6.4	5.1	5.7
DM	7.0	6.1	3.9	5.9	6.1	10.7	5.9	6.8	6.5
DN	7.0	6.3	5.8	6.6	5.7	10.2	7.0	6.5	9.9

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THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B,   FIN-00120 HELSINKI

Puh./Tel. (09) 609 900   Telefax (09) 601753
Int. 358-9-609 900   Int. 358-9-601 753
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