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Firm Lifecycles and External Restructuring

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Contents

Abstract

This paper studies how firms contribute to the productivity growth of an industry over their lifecycle. We present a decomposition method that allows us to condition the components of productivity growth on the age of production units. We find evidence for a prolonged positive exit effect that mirrors market selection during the early stages of firms' lifecycle. This effect is tightly related to the negative initial productivity effect of entry. We also find some evidence that productivity-enhancing reallocation of resources between firms is concentrated on the middle aged firms.

Key words: Productivity, decomposition, lifecycle, entry, exit

JEL: O12, O14, O47

Tiivistelmä

Tutkimuksessa selvitetään, miten yritykset vaikuttavat toimialan tuottavuuskasvuun elinkaarensa yli. Esitämme hajotelmamenetelmän, jonka avulla tuottavuuskasvun komponentteja voidaan tarkastella yrityksen iän mukaan jaoteltuna. Havaitsemme, että markkinoilta poistumisen positiivinen tuottavuusvaikutus on suurinta heti elinkaaren alussa, mutta vaikutus pysyy merkittävänä useiden vuosien ajan. Tämä heijastaa markkinoilla tapahtuvaa tuottavuuteen perustuvaa valikoitumista, mitä tapahtuu vähitellen yritysten elinkaaren alkuvaiheessa. Tämä kytkeytyy läheisesti siihen, että uusien yritysten välitön vaikutus toimialan tuottavuuteen on negatiivinen. Havaitsemme myös, että toimialan tuottavuutta vahvistava tuotantotekijöiden uudelleen kohdentuminen on painottunut yritysten elinkaaren keskivaiheille.

Asiasanat: Tuottavuus, hajotelma, elinkaari, markkinoille tulo, markkinoilta poistuminen

1 Introduction

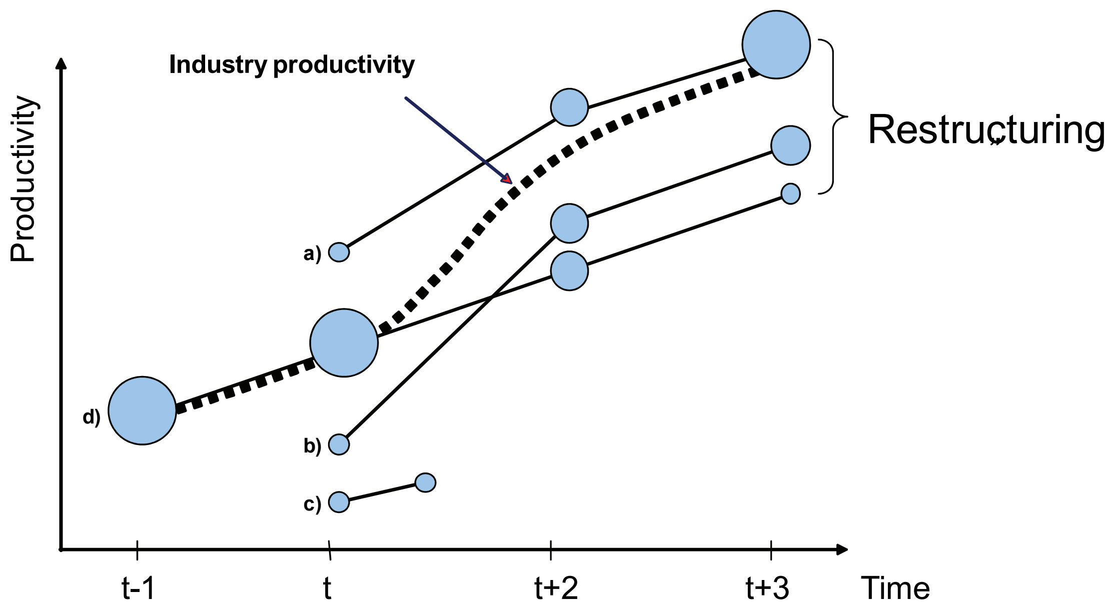
A growing number of theoretical and empirical analyses stress the importance of selection- and reallocation-driven aggregate (industry) productivity growth.[1] How individual firms contribute to the productivity growth of an industry *over their lifecycle* has however received only relatively little attention. This paper augments the earlier literature by presenting a decomposition method that allows a lifecycle analysis of the micro-level dynamics of productivity growth.

Figure 1 illustrates our lifecycle approach and thinking. There are three entrants (firms *a*, *b* and *c*), which form an age group and which enter the market at time *t*, and an incumbent (firm *d*), in the graph. The solid lines mirror the productivity development of these four firms over time and the dots their size (i.e., command of resources). The firms constitute an industry and the thick dashed line shows its productivity development. The incumbent can be thought as a composite whose productivity development represents the contra-factual of how the industry would develop if there were neither entry nor exit.

Albeit highly simplified, Figure 1 is capable of reflecting *experimentation*, *selection*, *reallocation* of resources, and (firm-level) *productivity growth*, which the previous literature considers the four key components of industry productivity growth.

Experimentation is about the entry of new firms that have heterogeneous but unknown productivity. The new firms learn their productivity (potential) after entry and test their technology and/or business model in the market (see, e.g., Jovanovic 1982 and Brynjolfsson, Mcafee,

Figure 1 Sources of aggregate productivity growth



[1] Bartelsman and Doms (2000) and Syverson (2011) provide excellent surveys on the topic.

Sorell and Zhu 2008). An important consequence of experimentation is that it can initially lower the aggregate productivity growth: If the average productivity of the entrants, such as that of firms *a*, *b* and *c* in Figure 1, is lower than that of the incumbent(s), the industry's productivity growth rate would have been higher, had none of the firms entered the market.

Selection is a lagged by-product of experimentation (see, e.g., Vickers 1995 and Jensen, McGuckin and Stiroh 2001). In competitive markets selection is at work when firms with low productivity and slow productivity growth, like firm *c* in Figure 1, are forced to exit (Bellone, Musso, Nesta and Quere 2008). The sooner such firms exit, the faster the industry's productivity grows.[2]

The third key component of micro-level productivity dynamics is *reallocation* of resources (or markets shares) between firms that pass through the initial market selection and that manage to stay in the market. In Figure 1, firms *a* and *b* grow at the expense of firm *d*, as shown by the growth of their dots over time. As drawn, the graph shows that the productivity of the industry grows more rapidly than it would if the resources were not reallocated (from the incumbent) to the more productive firms.[3]

The fourth component of industry productivity growth is the average *firm productivity growth* due to the internal restructuring of (surviving) firms. This restructuring can be driven for example by successful R&D efforts (innovation), implementation of new technologies (Parente 1994) and training and recruitment of personnel (see, e.g., Zwick 2005 and Dearden, Reed and Reenen 2006). Fast productivity growth may also reflect catching-up potential and successful imitation by firms with lower initial productivity (Abramovitz 1990) and learning-by-doing of younger firms during the early phases of their life cycle (Bahk and Gort 1993). While we have not drawn all these possibilities in Figure 1, this component of productivity growth is captured by the (weighted) average of the positive slopes of the solid lines of individual firms.

Many productivity decompositions used in the prior literature aim at capturing micro-economic sources of industry productivity growth (see, e.g., Foster, Haltiwanger and Krizan 2001). The method that this paper uses explicitly gauges the contributions to the industry productivity growth of all the four components that Figure 1 illustrates. The method is based on a formula initially proposed by Vainiomäki (1999), who used it for analyzing skill upgrading, and later (independently) used by Diewert and Fox (2009).[4] The Vainiomäki-Diewert-Fox (VDF) decomposition allows a consistent measurement of how the four components – experimentation (entry component), selection (exit component), reallocation (between component) and firm productivity growth (within component) – contribute to productivity growth. It differs from the methods proposed by Baily, Hulten and Campbell (1992), Griliches and Regev (1995) and Haltiwanger (1997) in three important ways: The productivity of firms that enter

[2] The process of exit is often gradual so that even (older) firms with low productivity may stay in the market for long. As Hjalmarsson (1973) puts it, "as long as firms find themselves having non-negative quasi-rent, they have their raison d'être with their past choice". This may lead to a gradual decline in performance and to the "shadow of death" that are observable several years before the final exit (Griliches and Regev 1995).

[3] While IT technology may have enhanced the speed of this reallocation process (Brynjolfsson, McAfee, Sorell, and Zhu 2008), frictions in the labor and/or financial markets, adjustment costs and rigid demand responses (see, e.g., Autor, Kerr and Kugler 2007, Bartelsman, Haltiwanger and Scarpetta 2009b, Bartelsman, Gautier and deWind 2010, and Petrin and Sivadasan 2010) slow it down.

[4] Closely related variants of this method have been used in Maliranta (1997, 2003) and Böckerman and Maliranta (2007). Melitz and Polanec (2009) have recently proposed a dynamic Olley-Pakes decomposition method. Its measure of the contribution of entries and exits is very similar to that we present here, but the authors do not consider age-group specific contributions.

the industry at a given period is compared to that of incumbents in the same period; the between component measures productivity-enhancing restructuring among the incumbents only; and the within component is a proper (weighted) average of the productivity growth of the incumbents.[5]

The earlier literature acknowledges that how a firm contributes to the productivity growth of an industry may depend on the stage of the firm's lifecycle (see, e.g., Foster, Haltiwanger and Krizan 2001, Aw, Chen and Roberts 2001, Foster, Haltiwanger and Syverson 2008, and Bellone, Musso, Nesta and Quere 2008). However, such lifecycle-specific contributions have not typically been measured as a part of coherent productivity decompositions. We start filling this gap by introducing an extended VDF formula that shows how different age-groups of firms contribute to the different components of industry productivity growth. The method explicitly accounts for the micro-level dynamics of productivity over the lifecycle of firms, providing us with a window on the channels through which entrepreneurship and growing firms contribute to aggregate productivity growth.

We apply the VDF decomposition and its extension to business-level microdata from Finnish manufacturing and service sectors from 1995 to 2007. Our application focuses on the micro-level components of the aggregate labor productivity growth of these two sectors. We do so for two main reasons: First, labor productivity is directly linked to nations' material standards of living, as typically measured by the ratio of GDP to capita. Second, it is an indicator of efficiency that can be measured *over the lifecycle of firms* more consistently and reliably than, e.g., total or multifactor factor productivity (TFP, MFP).

Our main findings are as follows: First, we find that the labor productivity of new firms is, on average, substantially lower than that of the incumbents, implying a negative initial effect on industry productivity and supporting the idea of experimentation at the entry stage of firms' life cycle. Second, our age-group-decompositions show that there is a positive exit effect that gradually declines over the lifecycle of firms. This effect is still visible as late as ten years after the entry. This positive exit effect mirrors market selection during the early stages of firms' lifecycle and is tightly related to the negative initial productivity effect of the entrants. Third, we find some evidence that productivity-enhancing reallocation of resources between firms is concentrated on the middle aged firms. An exploratory analysis of cross-plant price variation using a Finnish product-specific database suggests that these results are not driven by price differences between the age-groups of plants.

Our analysis augments the earlier literature on the drivers of aggregate *labor* productivity in three ways: First, our results complement the findings of Bartelsman, Haltiwanger and Scarpetta (2009), who study the importance of labor allocation in explaining cross-country differences in the level and growth of aggregate labor productivity. In particular, our analysis indicates that the positive productivity effects of policies which boost entry may come about with a substantial lag and through an intensive selection and reallocation process. Second, our findings bear on those of Baily, Bartelsman and Haltiwanger (2001) and Carreira and Teixeira (2008), who study cyclical variation in the micro-level components of aggregate labor productivity growth. We confirm that there is another temporal dimension in the micro-level components that ought not to be overlooked. Third, our study adds to the recent analyses that ex-

[5] As pointed out by Diewert and Fox (2009), the VDF decomposition can also be linked to the index theory (see also Diewert 2005).

plore the micro-level dynamics of labor productivity growth in the service sector, such as Foster et al. (2001), who study automotive repair shops in the U.S., and Foster, Haltiwanger and Krizan (2006) and Baldwin and Gu (2011), who study the retail sector in the U.S. and Canada, respectively. Our analysis highlights certain differences and similarities between the manufacturing and service sectors, some familiar from the literature, others new to it. In particular, our analysis shows that in service industries, the market induces a lot of entry by firms that subsequently turn out to have low productivity firms. This leads to intensive rotation and exit. Further, the negative contribution of the reallocation (between) component in the service industries can largely be attributed to young firms, implying that at this stage of their lifecycle, growth of employment is typically associated with a low productivity level.

The remainder of this paper is organized as follows. In Section 2, we present the VDF decomposition and show how it can be extended to allow for age-group specific contributions. In Section 3 we present our main empirical findings. Section 4 is devoted to discussion and robustness analyses. We offer concluding remarks in Section 5, where we discuss briefly some of the (measurement) hurdles that ought to be overcome if one wanted to analyze how firms contribute to the growth of aggregate TFP or MFP over their lifecycle.

2 Decomposition method

2.1 Vainiomäki-Diewert-Fox decomposition

We consider an index of industry-level productivity

$$\Phi_t = \sum\nolimits_{i \in I} w_{it} \varphi_{it} \tag{1}$$

where φ_{it} is an index for the productivity of firm (plant) i at time t, w_{it} is the weight of firm i, as measured by the share of the firm of the industry (e.g., input share), and where I denotes the set of firms that are active and constitute the industry during period t. In all what follows, we assume that productivity is measured in log-units. The first difference of the industry productivity $\Delta\Phi_t = \Phi_t - \Phi_{t-1}$ index gauges therefore the growth rate of productivity of the industry.

The VDF decomposition of the growth rate of industry productivity is given by

$$\Delta\Phi_t = EN_t + EX_t + BW_t + WH_t \tag{2}$$

where EN_t refers to the entry component, EX_t to the exit component, BW_t to the between component and WH_t to the within component of the decomposition. The first three of these components measure how external restructuring – experimentation, selection and reallocation – contribute to the industry productivity growth, whereas the last term measures the effect of firms' internal restructuring on the growth rate.

To develop explicit expressions for the four components of the VDF decomposition, let the sub-group of continuing firms (incumbents) that are present in periods t–1 and t be denoted C, the sub-group of entrants that are present in period t (but not in t–1) E, and the sub-group of exiting firms that are present in period t–1 (but not in t) D. Moreover, let

$$w_{it}^{X} = \frac{L_{it}}{\sum_{i \in X} L_{it}}$$

denote the (labor) input share of firm *i* in sub-group $X \in \{C, E, D\}$ in year *t*, and let

$$S_{t}^{X} = \frac{\sum_{i \in X} L_{it}}{\sum_{i \in X \cup C} L_{it}}$$

denote the (labor) input share of sub-group $X \in \{E, D\}$ among all the active firms in year *t*.

Following Vainiomäki (1999) and Diewert and Fox (2009), we can write

$$EN_{t} = S_{t}^{E}\left[\Phi_{t}^{E} - \Phi_{t}^{C}\right] \tag{3a}$$

$$EX_{t} = S_{t-1}^{D}\left[\Phi_{t-1}^{C} - \Phi_{t-1}^{D}\right] \tag{3b}$$

$$BW_{t} = \sum_{i \in C} \Delta w_{it}^{C} \cdot \left[\overline{\varphi}_{it} - \overline{\Phi}_{t}^{C}\right] \tag{3c}$$

$$WH_{t} = \sum_{i \in C} \overline{w}_{it}^{C} \Delta \varphi_{it} \tag{3d}$$

where $\Phi_{t}^{X} = \sum_{i \in X} w_{it}^{X} \varphi_{it}$ is the aggregate productivity of sub-group $X \in \{C, E, D\}$ in year *t* and where $\Delta w_{it}^{C} = w_{it}^{C} - w_{i,t-1}^{C}$, $\overline{\varphi}_{it} = \frac{1}{2}\left(\varphi_{it} + \varphi_{i,t-1}\right)$, $\overline{w}_{it}^{C} = \frac{1}{2}\left(w_{it}^{C} + w_{i,t-1}^{C}\right)$, and

$\Delta \varphi_{it} = \varphi_{it} - \varphi_{i,t-1}$.

The first component, (3a), is the entry component. Its contribution is positive (negative) if the weighted average productivity of the entrants is higher (lower) than that of the continuing firms in period *t*. The magnitude of the contribution depends on the labor input share of the new firms among all active firms in period *t*, S_{t}^{E}. The second component, (3b), is the exit component. Its contribution is positive (negative) if the weighted average productivity of the exiting firms is lower (higher) than that of the continuing firms in year *t*–1. The magnitude of the contribution depends on the (labor) input share of the exiting firms among all active firms in period *t*–1, S_{t-1}^{D}. The third component, (3c), is the between component. It can be positive in two cases. On the one hand, it is positive if firms with increasing input share ($\Delta w_{it}^{C} > 0$) are more productive than the weighted average of the incumbents (i.e., if $\overline{\varphi}_{it} > \overline{\Phi}_{t}^{C}$). On the other hand, the component is be positive if firms with decreasing input share ($\Delta w_{it}^{C} < 0$) are less productive than the weighted average of the continuing firms (i.e., if $\overline{\varphi}_{it} < \overline{\Phi}_{t}^{C}$).[6] The final component, (3d), is the within component. It weights the productivity growth of a firm by its average input share, treating the adjacent periods *t*–1 and *t* symmetrically. It is thus a weighted average of the productivity growth rates of continuing firms in the industry.[7]

[6] Note that term $\overline{\Phi}_{t}^{C}$ in the between component is redundant, because among the continuing firms, the average of Δw_{it}^{C} is by definition zero. We keep it in the expression, as it helps in interpreting the component. For instance, a firm contributes positively to the between component if its average productivity exceeds that of the continuing firms in the industry ($\overline{\Phi}_{t}^{C}$) and if the firm also increases its input share.

[7] This definition of the within component builds on a discrete Divisia index and links the productivity decomposition to the index number literature (see e.g. Diewert and Fox 2009).

2.2 Lifecycle decomposition

The productivity contributions of continuing and exiting firms can be further analyzed by the age-groups to which they belong. Let K denote the number of such groups and assign each firm to one of them, Ω_k, k = 1, 2, …, K, on the basis of the age of the firm.

The age-group decomposition is

$$\Delta\Phi_t = EN_t + \sum_{k=1}^{K} EX_{k,t} + \sum_{k=1}^{K} BW_{k,t} + \sum_{k=1}^{K} WH_{k,t} \tag{4}$$

where EN_t is the entry component and $EX_{k,t}$, $BW_{k,t}$ and $WH_{k,t}$ are the exit, between and within components of age-group k, respectively. This formula shows that the contribution of the exit, between and within components to aggregate productivity growth can be written as a sum of age-group specific contributions. Term $EX_{k,t}$ describes, for example, how the firms that belong to age-group Ω_k and exit by period t contribute to the aggregate productivity growth.

The formulas for the age-group specific contributions are

$$EX_{k,t} = S_{k,t-1}^{D}\left[\Phi_{t-1}^{C} - \Phi_{k,t-1}^{D}\right] \tag{5a}$$

$$BW_{k,t} = \sum_{i\in C\cap\Omega_k} \Delta w_{it}^{C}\cdot\left[\overline{\varphi}_{it} - \overline{\Phi}_{t}^{C}\right] \tag{5b}$$

$$WH_{k,t} = \sum_{i\in C\cap\Omega_k} \overline{w}_{it}^{C}\Delta\varphi_{it} \tag{5c}$$

where $S_{k,t-1}^{D} = \sum_{i\in D\cap\Omega_k} L_{i,t-1} \Big/ \sum_{i\in C\cup D} L_{i,t-1}$ is the (labor) input share of the exiting firms that belong to age-group k, $\Phi_{k,t}^{D} = \sum_{i\in D\cap\Omega_k} w_{it}^{D\cap\Omega_k}\varphi_{it}$ is the productivity of exiting firms belonging to age-group k, and where the summation of both the between and within components are now defined over the age-group.

We consider both *absolute* and *normalized* components. The former refers to (5a) – (5c). They allow us to examine how age-group Ω_k contributes over its life cycle to the different components of productivity growth of the industry. The exit component of an age-group is positive if the weighted average productivity of the exiting firms that belong to the age-group is higher than that of the continuing firms in year t–1. The between component of an age-group is positive if the firms of an age-group with increasing (decreasing) input share are more (less) productive than the weighted average of the continuing firms. The within component of an age-group is positive if the weighted average of the productivity growth rates of the firms that belong to the age-group is positive.

The *normalized* components reflect the contributions of age-groups that take into account differences in the input shares between the age-groups. They allow us to examine how "typical" firms of different age-groups contribute to the productivity growth via the exit, between and within components. The normalized components are obtained by dividing (5a) by $S_{k,t-1}^{C\cup D}$, which is the employment share of age-group k among all the firms present at time t–1, and by scaling (5b) and (5c) by $\sum_{i\in C\cap\Omega_k} \overline{w}_{it}^{C}$, which is the average employment share of age-group k among all continuing firms. The age-group specific normalized components have the property that if we weight them by the employment share of the age-group (and sum them up), we obtain the corresponding absolute component. The normalizations can be used to examine if the apparently small (large) contributions of certain firm age-groups can be explained by their small (large) input shares.

3 Empirical analysis

3.1 Data sources

Our empirical analysis focuses on productivity developments in the Finnish manufacturing and (market) service sectors from 1995 to 2007. These two sectors constitute the Finnish business sector, whose aggregate productivity has developed very favorably during our sample period; see Appendix 1, which shows how the productivity of the two sectors has developed before and during our sample period.

Our analysis relies on two alternative sources of data, the Structural Business Statistics data on firms (the SBS data), and the Business Register on establishments (the BR data). The former allows a firm-level and the latter a plant-level decomposition analysis. In what follows, decompositions of labor productivity are presented: Output is measured by value added (gross output) in the firm-level (plant-level) analysis and the input index refers in both cases to labor input, measured by the number of persons (in full-time equivalent units).

Appendix 2 describes the data sets in greater detail, explains how we have solved certain measurement issues and gives the descriptive statistics. Our main analysis covers fifteen manufacturing and twelve service industries, measured (mostly) at the 2-digit level of the NACE 2002 classification. Because of the special role of the electronics industry (mobile-manufacturer Nokia Ltd in particular) in the Finnish manufacturing, we present below separate analysis for the manufacturing sector that excludes the electronics industries, for the electronics sector (consisting of electrical machinery and telecommunications equipment) and for the service sector. We acknowledge that measuring productivity in services is a difficult and mostly unsolved problem and stress already here that all of our findings for the services sector should be considered exploratory.

3.2 Results: Components of productivity dynamics

We decompose the annual productivity growth rates of all the industries separately for each pair of consecutive years between 1995 and 2007 using formula (2). Our baseline results are obtained by averaging the different components of the decomposition over the sample period.

Table 1 reports the results when the production unit is a firm (the SBS data) and Table 2 the results when the production unit is a plant (the BR data). In both tables the reported numbers refer to the annual averages, calculated separately for each manufacturing (Panel A), electronics (Panel B) and service (Panel C) industry over the sample years. The lower part of the tables also displays the annual averages of the sector-level decompositions (Panel D), aggregated using each industry's labor share in period t, as the weight.

The main findings are the following: First, as a comparison of Tables 1 and 2 shows, firm- and plant-level analyses yield similar results. Second, the average annual labor productivity growth in the manufacturing is about 3 percentage points, in the electronics over 10 percentage points and in the services around 1 percentage points. Third, the entry component is neg-

Table 1 : VDF-decomposition by industry (firm-level data, %)

Panel A: Manufacturing (excl. electr.)	$\Delta\Phi$	Entry	Exit	Between	Within
Food & tobacco	6.15	-0.40	0.58	-0.10	6.07
Textiles & leather	3.44	-0.67	1.06	1.10	1.95
Wood products	3.72	-0.35	0.35	0.08	3.65
Pulp & paper	3.11	-0.44	-0.22	-0.48	4.26
Publishing and printing	1.77	-0.08	0.33	0.24	1.28
Chemicals	2.89	0.14	-0.18	-0.17	3.09
Plastics	1.47	-0.21	0.47	0.41	0.79
Other non-metal	3.05	-0.09	0.07	0.12	2.95
Basic metals	5.48	-0.28	0.69	0.11	4.96
Metal products	1.31	-0.30	0.49	0.30	0.83
Machinery	3.44	-0.42	0.12	0.26	3.48
Vehicles etc.	-1.77	-0.42	0.07	0.38	-1.81
Furniture & cycling	3.12	-0.61	0.66	0.83	2.24
Unweighted average	2.86	-0.32	0.35	0.24	2.60
Standard deviation	1.96	0.22	0.37	0.41	2.06
Correlations		-0.54		-0.48	
Panel B: Electronics	$\Delta\Phi$	Entry	Exit	Between	Within
Electrical machinery	12.29	0.40	0.22	-0.45	12.12
Telecomm. equipm.	12.21	-1.21	1.55	1.51	10.36
Unweighted average	12.25	-0.41	0.89	0.53	11.24
Standard deviation	0.06	1.14	0.94	1.39	1.24
Correlations		-1.00		-1.00	
Panel C: Services	$\Delta\Phi$	Entry	Exit	Between	Within
Trade	1.70	-1.44	1.09	0.06	1.99
Hotels and restaurants	-0.42	-1.72	1.35	-0.33	0.28
Transport & travels	0.17	-0.98	0.67	-0.33	0.81
Post & telecommun.	7.49	0.43	-0.68	-0.15	7.89
Leasing	0.45	-2.63	1.68	0.14	1.25
Computer services	1.97	-1.63	0.74	-0.18	3.04
R&D	-2.45	-0.82	0.78	-0.05	-2.36
Business services	1.28	-1.40	1.02	-0.10	1.77
Technical services	0.20	-0.83	0.55	-0.09	0.56
Other services	-0.45	-0.30	0.52	-0.58	-0.10
Movies and radio	-0.79	-0.50	0.63	0.77	-1.68
News etc.	-1.50	-7.18	5.60	-0.93	1.01
Unweighted average	0.64	-1.58	1.16	-0.15	1.21
Standard deviation	2.51	1.93	1.51	0.41	2.58
Correlations		-0.99		-0.17	
Panel D: Sectors (weighted averages)	$\Delta\Phi$	Entry	Exit	Between	Within
Manufacturing, excluding electr.	3.05	-0.33	0.31	0.17	2.91
Electronics	12.31	-0.72	1.15	0.86	11.01
Services	1.24	-1.17	0.87	-0.12	1.66

Notes: The numbers refer to the annual averages of period 1996-2007, calculated using the firm-level (BR) data. In Panel D, the weighted average uses the employment share of each industry as the weight.

ative. This finding suggests that the productivity growth would have been higher, had no new entry taken place. It means that the contribution of experimentation to productivity growth is initially negative. Fourth, the exit component is positive. The component mirrors selection on (revenue) productivity and suggests, in particular, that the firms that exit are less produc-

Table 2 : VDF-decomposition by industry (plant-level data, %)

Panel A: Manufacturing (excl. electr.)	ΔΦ	Entry	Exit	Between	Within
Food & tobacco	3.24	-0.79	0.77	0.29	2.97
Textiles & leather	4.04	-0.61	1.13	0.25	3.27
Wood products	3.28	-0.78	1.02	-0.18	3.22
Pulp & paper	4.75	-0.46	0.46	-0.29	5.04
Publishing and printing	3.22	-0.48	0.54	0.78	2.37
Chemicals	3.66	0.26	0.28	-0.22	3.34
Plastics	1.90	-0.11	0.51	0.01	1.50
Other non-metal	2.37	-0.41	0.47	0.13	2.18
Basic metals	4.14	-0.47	0.07	-0.29	4.82
Metal products	2.17	-0.62	0.73	-0.09	2.14
Machinery	2.87	-0.82	0.55	0.41	2.72
Vehicles etc.	3.19	-0.57	0.01	0.52	3.23
Furniture & cycling	2.27	-0.37	0.66	1.20	0.78
Unweighted average	3.16	-0.48	0.55	0.19	2.89
Standard deviation	0.85	0.30	0.32	0.45	1.18
Correlations		-0.41		-0.64	

Panel B: Electronics	ΔΦ	Entry	Exit	Between	Within
Electrical machinery	11.37	-0.60	0.67	-0.53	11.83
Telecomm. equipm.	14.21	-1.16	1.18	1.92	12.27
Unweighted average	12.79	-0.88	0.93	0.70	12.05
Standard deviation	2.01	0.40	0.36	1.73	0.31
Correlations		-1.00		1.00	

Panel C: Services	ΔΦ	Entry	Exit	Between	Within
Trade	0.22	-2.06	1.82	-0.02	0.48
Hotels and restaurants	-0.09	-1.03	0.88	-0.04	0.09
Transport & travels	0.81	-1.22	0.72	-0.36	1.67
Post & telecommun.	6.62	0.74	-0.20	-1.70	7.78
Leasing	-0.38	-2.38	1.83	-0.17	0.35
Computer services	0.72	-1.40	1.48	-1.04	1.68
R&D	2.72	-0.38	0.63	-0.65	3.12
Business services	-0.17	-0.72	1.12	0.25	-0.82
Technical services	0.38	-0.39	0.46	-0.13	0.44
Other services	-0.96	-0.49	0.83	-1.25	-0.04
Movies and radio	0.79	-0.71	0.36	0.67	0.47
News etc.	-1.15	-3.01	2.56	-0.70	0.00
Unweighted average	0.79	-1.09	1.04	-0.43	1.27
Standard deviation	2.09	1.02	0.76	0.67	2.30
Correlations		-0.95		-0.65	

Panel D: Sectors (weighted averages)	ΔΦ	Entry	Exit	Between	Within
Manufacturing, excluding electr.	3.14	-0.56	0.57	0.20	2.93
Electronics	13.07	-0.93	1.04	1.12	11.85
Services	0.37	-1.36	1.24	-0.33	0.81

Notes: The numbers refer to the annual averages of period 1996-2007, calculated using the plant-level (SBS) data. In Panel D, the weighted average uses the employment share of each industry as the weight.

tive than the continuing firms. Fifth, the between component is positive in the manufacturing and negative in the service sector.[8] Sixth, the within component is often the largest component in absolute terms, but the relative size of the components vary quite a bit between the industries.[9] The within components of the electronics industries are exceptionally large and explain a large part of their very favorable productivity development. Finally, the entry and exit components have a strong negative (industry-level) correlation both in the manufacturing and in the service sector.[10]

The numbers presented in Tables 1 and 2 mask a great deal of temporal and age-group specific variation.[11] Unlike the earlier analyses (see, e.g., Bailey et al. 2001), we focus on the latter in what follows.

3.3 Results: Age-group contributions

Our age-group decompositions use formula (4) and set the length of age-groups to five years. The number of distinct firm-age groups in our age-group analysis is five: We identify separately the contributions of entrants (that is, firms which are less than 1 years old), firms that are 1-5 years old, firms that are 6-10 years old, firms that are 11-15 years old and the rest, i.e., those 16 years or more. As before, the decompositions are made at the industry-level and the results are aggregated to the sector level using employment shares as the weight. In our baseline analysis that uses the firm-level data, the age of a firm is defined on the basis of the average age of the plants that the firm owns in period *t* (see the robustness analyses for further discussion of this choice).

The main results of the age-group decompositions are shown in Table 3 (firm-level data) and in Table 4 (plant-level data). Both tables display the absolute components, calculated using formulas (5a)-(5c), the corresponding input shares, as well as the normalized components separately for the manufacturing sector that excludes the electronics industries (Panel A), for the electronics sector (Panel B) and for the service sector (Panel C). Each table has six Sub-panels A1-A3, B1-B3, and C1-C3, with the sectors and age-groups listed vertically and the components and input shares horizontally. We focus on commenting Table 3, as most of the findings are robust to the unit of analysis and thus confirmed by the numbers presented in Table 4.

Firm lifecycles in manufacturing and electronics

It is useful to start from the first rows of Sub-panels A1 and B1, as they display the weighted results for the manufacturing and electronics and correspond exactly to the numbers reported earlier in Panel D of Table 1. The Sub-panels present a further decomposition of these numbers.

8 The components have relatively strong positive correlations between the two data sets. For example, the correlation of the entry components in the manufacturing sector is 0.59. In the service sector, the corresponding number is even higher, 0.83.

9 In the standard representative firm model industry productivity growth is by definition equal to the within component.

10 Using the industry averages as the unit of analysis, the coefficient of correlation between the entry and exit components is -0.70 (the firm-level data) and -0.57 (the plant-level data) in the manufacturing sector. The corresponding numbers for the service sector are - 0.99 (firm-level data) and -0.95 (plant-level data).

11 Appendix 3 illustrates temporal variation by displaying how the components have annually developed over our sample period.

The first column of Sub-panels A1 and B1 in Table 3 shows that both in the manufacturing and electronics, entrants slow down the average growth rate of industry labor productivity. The entry component, which can be interpreted to reflect mostly experimentation, is for example -0.33 percentage points in the manufacturing. This (absolute) component is due to the new manufacturing firms being 8.84% less productive than the continuing firms in year *t* (reported in the last column of the table), and due to their employment share being 3.76%, which can be read from Sub-panel A2 displaying the input shares. These numbers are linked by definition, so that -0.33% = -8.84% × 3.76%. Similar observations can be made for the electronics sector.

After the experimentation (entry) phase, firms contribute to industry productivity growth through the remaining three components. The exit component corresponds to market selection and is 0.31 percentage points in the manufacturing sector. In manufacturing, the youngest age-group of continuing firms (i.e., those who are 1-5 years old at each point in time) contribute most to this component, as they account for a major fraction of the exit component (0.13/0.31). The importance of the youngest age-groups for the exit component becomes more visible if their relative size (input share) is taken into account. The normalized components of age-groups, displayed in Sub-panels A3 and B3, do this. These components take into account differences in the input shares between the age-groups, allowing thereby an analysis of how the contributions of "average" (typical) firms of different age-groups look like. The normalized components of the youngest age-groups are much bigger than that of the older firms, both in manufacturing and in electronics. These patterns suggest that market selection is particularly intensive at the beginning of firms' life cycle: the contribution of the youngest age-groups to the exit component exceeds that which would be predicted on the basis of their share of inputs. The age-group decomposition of the exit component thus suggests that market selection concentrates on low productivity firms (the component is positive) and, in particular, on the beginning of the firms' lifecycle (the normalized components of the youngest age-groups are large).

The between component reflects the reallocation of resources between continuing firms and is small, only about 0.17 percentage points per year in the manufacturing and 0.86 percentage points per year in the electronics.[12] The break-down of the between component by firm age-groups indicates that the youngest continuing firms contribute less to the between component than older firms. The normalized between components reveal less systematic patterns, though there is some evidence for an inverted U-shape over the lifecycle in the between component (see Sub-panels A3 and B3 of Table 3 and 4).

The within component is by far the largest component of industry productivity growth, both in the manufacturing and electronics. Our break-down of the within component by age-groups shows that most of the within component can be attributed to the older age-groups of firms. The development of the input shares and normalized components suggests that the most important reason for this is not their faster productivity growth, but their ability to command a large fraction of the industry inputs.

The first column of Panels A and B, titled $\Delta\Phi$, sums up how the different age-groups of firms contribute to the growth of aggregate labor productivity: The contribution of entrants is nega-

[12] These numbers are small when compared to the between component calculated by Maliranta (2009) for period 1983-1993. This suggests that productivity-enhancing reallocation have slowed down after the mid-1990s in the Finnish manufacturing industries.

Table 3 : Age group decomposition (firm-level data, %)

Panel A: Manufacturing (excl. electr.)		A1: Absolute components				A2: Input shares				A3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	3.05	-0.33	0.31	0.17	2.91	3.76	4.24	100.00	100.00	0.31	0.17	2.91	-8.84
Entrants	-0.33												
1-5 yrs.	0.25		0.13	-0.06	0.18		0.34	5.83	5.74	2.24	-1.01	3.10	
6-10 yrs.	0.37		0.08	0.02	0.27		0.39	8.58	8.55	0.92	0.18	3.18	
11-15 yrs.	0.44		0.08	0.04	0.33		0.50	10.59	10.54	0.71	0.40	3.08	
16- yrs.	2.32		0.02	0.17	2.13		3.01	75.00	75.17	0.03	0.22	2.83	

Panel B: Electronics		B1: Absolute components				B2: Input shares				B3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	12.31	-0.72	1.15	0.86	11.01	3.49	4.11	100.00	100.00	1.15	0.86	11.01	-20.49
Entrants	-0.72												
1-5 yrs.	0.93		0.25	0.05	0.63		0.59	6.06	5.70	4.20	0.79	11.10	
6-10 yrs.	2.12		0.15	0.13	1.85		0.48	13.72	13.81	1.09	0.91	13.39	
11-15 yrs.	3.51		0.15	0.01	3.34		0.98	23.29	23.27	0.65	0.06	14.35	
16- yrs.	6.46		0.60	0.68	5.19		2.07	56.94	57.22	1.05	1.19	9.06	

Panel C: Services		C1: Absolute components				C2: Input shares				C3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	1.24	-1.17	0.87	-0.12	1.66	5.74	5.36	100.00	100.00	0.87	-0.12	1.66	-20.46
Entrants	-1.17												
1-5 yrs.	0.87		0.47	-0.22	0.62		1.49	16.92	16.31	2.80	-1.33	3.78	
6-10 yrs.	0.71		0.23	0.08	0.40		1.23	21.77	21.71	1.06	0.35	1.85	
11-15 yrs.	0.40		0.09	0.01	0.29		1.04	21.55	21.68	0.44	0.03	1.36	
16- yrs.	0.43		0.07	0.01	0.35		1.61	39.75	40.30	0.19	0.03	0.86	

Notes: The numbers refer to the annual averages of period 1996-2007, calculated using the firm-level (SBS) data. Firm age is defined on the basis of the age of the plants it owns in period t. "Absolute components" refer to equations (3a)-(3d) and (5a)-(5c) in the main text. "All in t-1" refers to the employment share of cohort k among all the firms present at time t-1, and "Average" to the average employment share of cohort k among all continuing firms. "Normalized compotents" are obtained by dividing the cohort-specific absolute components by the relative size of the cohorts. Their weighted average matches the sector-level totals (the first rows of sub-panels A3-C3) when the input shares of the cohorts are used as the weights. "Gap" refers to the difference in the productivity between the entrants and continuing firms in period t.

Table 4 : Age group decomposition (plant-level data, %)

Panel A: Manufacturing (excl. electr.)		A1: Absolute components				A2: Input shares				A3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	3.14	-0.56	0.57	0.20	2.93	1.79	1.97	100.00	100.00	0.57	0.20	2.93	-30.95
Entrants	-0.56												
1-5 yrs.	0.39		0.22	-0.06	0.23		0.52	8.29	7.92	2.66	-0.76	2.89	
6-10 yrs.	0.30		0.11	0.02	0.17		0.35	9.29	9.11	1.15	0.23	1.84	
11-15 yrs.	0.31		0.06	0.07	0.18		0.24	9.09	9.03	0.68	0.72	2.00	
16- yrs.	2.70		0.18	0.17	2.35		0.86	73.34	73.94	0.25	0.23	3.18	
Panel B: Electronics		B1: Absolute components				B2: Input shares				B3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	13.07	-0.93	1.04	1.12	11.85	2.78	1.96	100.00	100.00	1.04	1.12	11.85	-33.54
Entrants	-0.93												
1-5 yrs.	1.45		0.25	0.05	0.63		0.58	11.48	11.11	2.18	-1.79	12.58	
6-10 yrs.	1.91		0.15	0.13	1.85		0.37	14.17	14.07	1.23	2.28	10.06	
11-15 yrs.	2.12		0.15	0.01	3.34		0.32	13.74	13.69	1.62	2.36	11.51	
16- yrs.	8.53		0.60	0.68	5.19		0.68	60.61	61.13	0.64	1.11	12.20	
Panel C: Services		C1: Absolute components				C2: Input shares				C3: Normalized components			Gap
	$\Delta\Phi$	Entry	Exit	Between	Within	Entrants	Exits	All in t-1	Average	Exit	Between	Within	Entry
	0.37	-1.36	1.24	-0.33	0.81	5.92	4.77	100.00	100.00	1.24	-0.33	0.81	-22.95
Entrants	-1.36					-0.56							
1-5 yrs.	0.96		0.66	-0.21	0.51		2.02	23.39	22.44	2.84	-0.95	2.25	
6-10 yrs.	0.24		0.29	-0.01	-0.04		1.13	19.69	19.49	1.49	-0.03	-0.22	
11-15 yrs.	0.22		0.10	-0.03	0.14		0.57	16.08	16.29	0.65	-0.17	0.89	
16- yrs.	0.30		0.18	-0.08	0.20		1.05	40.84	41.78	0.44	-0.19	0.49	

Notes: The numbers refer to the annual averages of period 1996-2007, calculated using the plant-level (BR) data. "Absolute components" refer to equations (3a)-(3d) and (5a)-(5c) in the main text. "All in t-1" refers to the employment share of cohort k among all the firms present at time t-1, and "Average" to the average employment share of cohort k among all continuing firms. "Normalized compotents" are obtained by dividing the cohort-specific absolute components by the relative size of the cohorts. Their weighted average matches the sector-level totals (the first rows of sub-panels A3-C3) when the input shares of the cohorts are used as the weights. "Gap" refers to the difference in the productivity between the entrants and continuing firms in period t.

tive and that of the youngest age-groups mostly small. The contribution to industry productivity growth appears to increase over the lifecycle and is the largest for the oldest (and, as measured by their input share, largest) age-group. The oldest firms account for more than half of the industry productivity growth both in the manufacturing and electronics industries.

Before turning to the services sector, we take a closer look at the exit component. For age-group *k*, it is a product of two factors, i) the productivity gap between the age-group's exiting firms and the continuing firms (all age-groups) and ii) the input share of the age-group's exiting firms among all the firms of the age-group. Figure 2 displays an age-group analysis of these factors, using the firm-level data: The displayed input shares can be obtained from Table 3 by dividing the input share of the exiting firms of a given age-group by the corresponding share of all the firms of the age-group. The productivity gap refers to $\Phi_{t-1}^{C} - \Phi_{k,t-1}^{D}$. It can be obtained by calculating the ratio of the normalized exit component of an age-group to the input share of the age-group's exiting firms among all the firms of the age-group (i.e., the exit rate of the firms in the age-group in terms of employment).

Figure 2 shows that the youngest age-groups have a large normalized exit component both because the employment share of exiting firms is large and because the productivity level of the exiting firms is relatively low (i.e., there is a large negative productivity gap). The normalized exit component gradually declines over the lifecycle both because the employment share of exiting firms declines and because the productivity of exiting firms increases relative to that of the incumbents. Figure 3 displays the corresponding age-group analysis based on the plant-level data. It portrays a similar picture, except for the electronics industry.[13]

In sum, our findings suggest that selection is concentrated on low productivity firms and particularly on the first phases of firms' lifecycle. The positive exit component is the flip side of the (initially) negative entry component. This mechanism is a revolving-door at work: Each year a bulk of low productivity firms enter and then exit subsequently. The mechanism is not, however, immediate, as the exit process is gradual.

Firm lifecycles in services

Industry productivity growth has been considerably slower in the service sector than in the manufacturing sector. Despite some similarities between the manufacturing and service sectors, the mechanisms at work are also somewhat different. Some of them are familiar from the literature, others new to it.

Like in manufacturing, the entry component is negative in the service sector and the productivity gap between the entrants and continuing firms quite large (see the last column of Panel C). The exit component is positive, with the youngest age-group of continuing firms contributing most to it (Sub-panel C1). The size of the normalized exit component decreases as we move towards the older age-groups (Sub-panel C3), suggesting again that the contribution of the youngest age-groups to the exit component exceeds that which would be predicted on the basis of their command of inputs.

[13] This finding may reflect the specific role of Nokia Ltd in this sector over our sample period, but due to data confidentiality reasons, we cannot explore this conjecture further.

Figure 2 Exit component (firm level data, %)

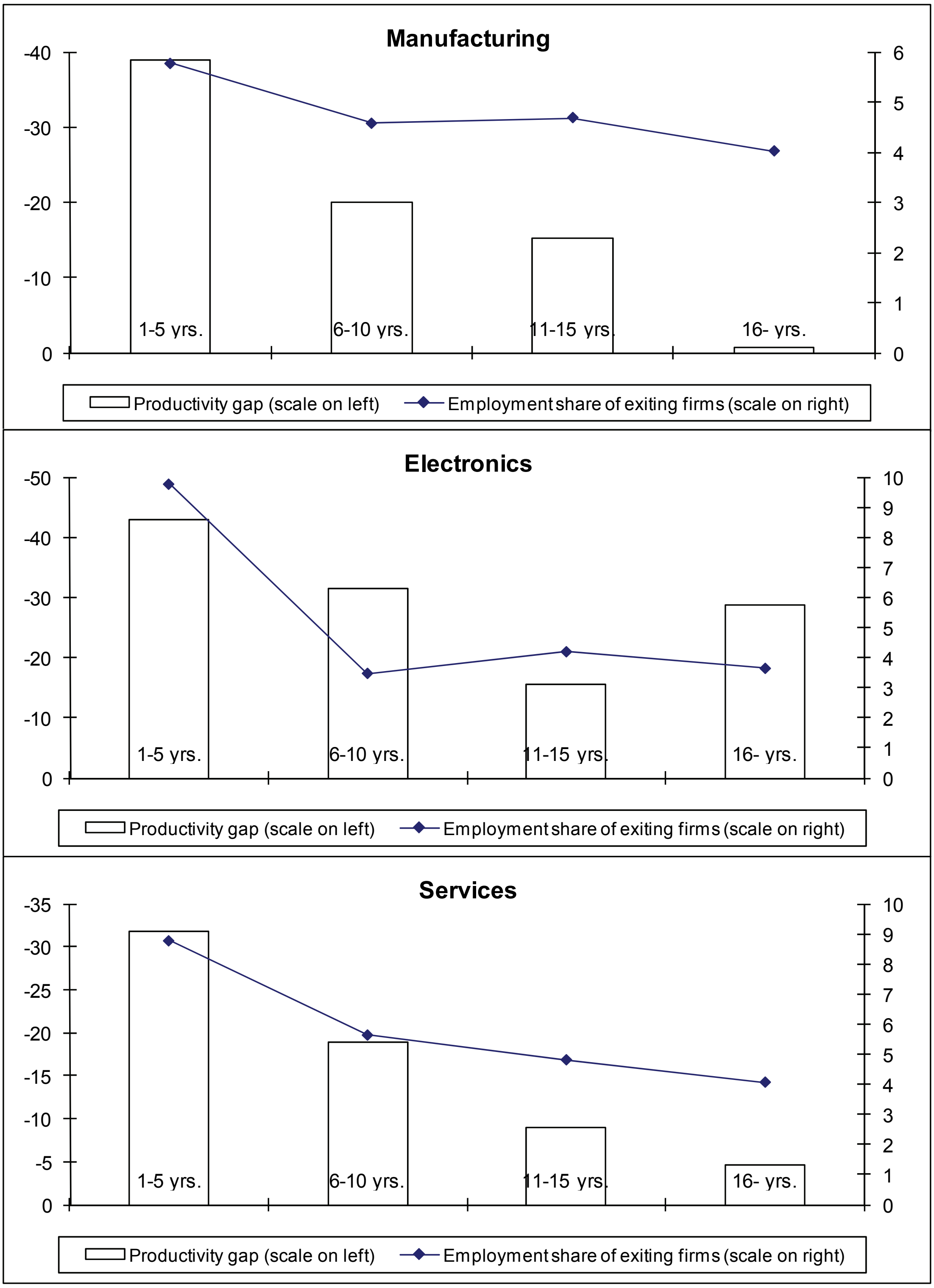
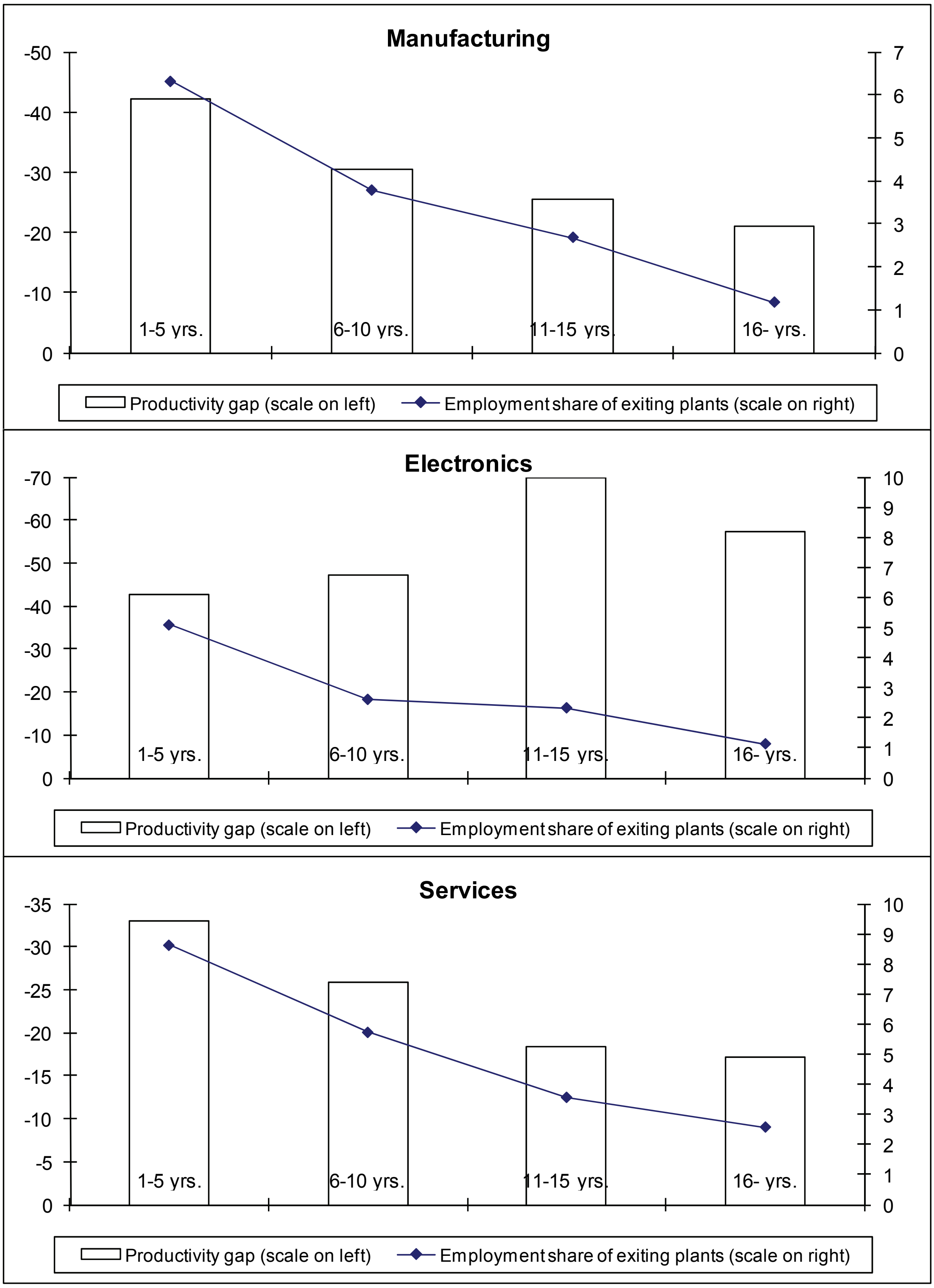


Figure 3 Exit component (plant level data, %)



When compared to the manufacturing, the mechanisms at work are different at least in four ways: First, the negative effect of the entry component is much larger in the services than in the manufacturing (and electronics). Second, reallocation of employment between the continuing firms has a (small) negative impact on the productivity growth. Third, the ratio of the within component to $\Delta\Phi$ is larger than one, suggesting that external restructuring, as captured by the sum of the entry, exit and between components, has as a whole slowed down the growth rate of productivity. Finally, the first column of Panel C, titled $\Delta\Phi$, shows that the contribution of the youngest age-group is much larger in the service sector. As a comparison of the last columns of Sub-panels A2 and C2 shows, this finding is largely explained by the relative large employment share of these firms in the service sector.

4 Discussion and robustness analyses

4.1 Measurement and data issues

Firms vs. plants as the unit of analysis

So far, we have mostly commented the decompositions that use firms as the unit of analysis. Firm-level data may be problematic, as the decompositions using such data ignore restructuring that takes place within multi-plant firms, such as entries and exits of plants and reallocation of resources between continuing plants (see, e.g., Disney, Haskel and Heden 2003).

As we have hinted already, most of our findings are robust to the unit of analysis and particularly to using plants as the unit of production (Table 4) instead of firms (Table 3). The most notable difference is that the productivity gap between the entrants and the incumbents is much larger in the manufacturing (more than three-fold) and electronics (about 1.5-fold) in the plant-level data. As a result, the entrants have a more negative impact on industry productivity growth in the plant-level data than in the firm-level data. However, the input share of the entrants is much smaller in the plant-level data, which mitigates the difference between the two data sets.

Measuring firm age

Measuring the age of firms is not trivial for the purposes of productivity decompositions and lifecycle analyses. Is the correct age of a firm its administrative age, the age of its oldest plant, or perhaps the average age of the plants it owns? We suspect that there is no correct definition, as ownership changes, mergers, acquisitions, split-ups and plant sales all complicate the measurement.

To check whether our results are sensitive to this measurement issue, we use the administrative age of a firm in place of the average age of the plants. The administrative age is potentially an inferior measure, because firm identity codes may change or be renewed for reasons that have little (if anything) to do with, e.g., economic entry and exit (Bartelsman et al. 2009). When we use the administrative age of firms, we find that the administrative age makes the firms look younger, perhaps artificially so. As a result, the employment shares of the youngest age-groups (1-5 and 6-10 years) increase considerably both in the manufacturing and service sectors. Despite this change in the input shares, most of our qualitative findings do not change considerably when replicate our firm-level decomposition analysis. However, using the administrative age does change the way in which the normalized exit component evolves over the lifecycle of firms: Its lifecycle profile becomes rather erratic in the manufacturing sector (and is thus no longer similar to that obtained using the plant-level data or when the average plant age is used) and is less steep in the service sector.

Sub-periods

Our baseline results refer to the averages of the different components of the decomposition, calculated over the sample period from 1995 to 2007. The period covers about two business cycles. While it is likely that averaging over the two cycles smoothes out the effects of business conditions on our results, it is prudent to inspect the stability of our results in greater detail. We therefore replicate our analyses separately for two sub-periods, 1995-2001 and 2002-2007. For brevity, we do not present these results in detail; suffice it to note that the results indicate that the lifecycle patterns of micro-level dynamics of industry productivity growth are relatively stable over time.

Greenfield entry

In our firm-level analysis the entry of a firm is determined by how its business identity code appears in the data: If the firm's code appears in the data in year *t* but not in year *t*-1, it is considered an entrant. This method of indentifying entering firms is clearly a potential source of measurement error, as some of the entrants may not be genuinely new firms.[14] Our plant-level analysis suffers less from this problem.

To explore the importance of (true) greenfield entry in greater detail, we make in our firm-level analysis a distinction between those entrant firms that have only new plants and those who also have older plants. The former firms are called greenfield entries. Echoing our findings with plant-level analysis, we find that the greenfield entrants account for a remarkably small fraction of employment. In the manufacturing sector, the share is 0.43%.[15] The productivity of the greenfield entrants is 26.64% lower than that of the continuing firms. In the electronics (service) sector, the employment share of the greenfield entrants is 0.55% (1.66%) and the productivity gap -53.58% (-25.92%). If anything, these numbers suggest that the (initial) contribution of entry to the aggregate productivity growth is indeed negative.

4.2 Prices over the lifecycle

Our measure for the performance of a firm (and plant) has so far been its *revenue* labor productivity (Foster et al. 2008), deflated by the relevant industry-level price index. This method implicitly assumes that all firms (and plants) in an industry share the same price level each

[14] It is worth pointing out that the VDF decomposition is not sensitive to arbitrary mistakes (e.g. due to random errors in longitudinal linkages) in the classification of firms between the entrants and continuing firms. The entry component can be computed as a difference between the aggregate productivity level of all firms and that of the continuing firms. Mistakes in the classification of firms into the entrants and continuing firms do not have an effect on the former and the same holds true for the latter as long as the firms mistakenly classified as entrants have the same (expected) productivity level as the continuing firms. This is what we should expect if the change in the firm code has nothing to do with economic entry. A similar argument applies to the exit component.

[15] Note that the corresponding number in the plant-level data is 1.97 %. This number is much larger than that of the greenfield entrants because new plants are often established by a continuing firm.

year. However, if prices co-vary with the age of firms, the interpretation of our decompositions would no longer be straightforward.

We tackle this potential problem in two ways. First, we check whether our findings for the manufacturing sector would hold if we adjusted the decompositions on the basis of the results reported in Foster et al. (2008) for the U.S. manufacturing sector. Second, we make an effort to study price differences between the age-groups of plants using a Finnish product-specific database. This data enable us to check whether the results for the U.S. manufacturing are representative for Finland and also whether they hold for a larger set of industries than those considered in Foster et al. (2008).

Foster et al. (2008, Table 4) find that for the specific set of physically homogenous products which they consider, the entrants (less than 5 years old) have a price level that is lower than that of an average incumbent. The price gap is -0.15% on the basis of an unweighted regression (statistically insignificant) and -3.9% on the basis of a revenue weighted regression (statistically significant). The price gap between exiting and incumbent plants is pretty close to zero. Moreover, Foster et al. (2008, Table 5) find that the average price that the plants are able to charge increases gradually with the age of plants. In particular, it seems that the young (middle-aged) plants, which are from 5 to 9 years old (10-14 years old), charge prices that are about 2% (1%) higher than that of the entrants. The oldest plants (older than 15 years) have the highest price level, which roughly matches with that of the exiting plants.

If plants' prices increased similarly with age in Finland, these numbers would have three implications for our decomposition results. First, the absolute value of the contribution of the entrants, as measured with the plant-level data, would be slightly smaller than what we report above. The reason for this is that the gap in the revenue labor productivity between the entrants and older incumbent plants is as large as -30.95 percentage points in the manufacturing sector. A price gap of about 4% would have a minor effect on the measured labor productivity gap. Second, allowing lifecycle contingent prices would not have an important effect on the exit component of productivity growth, as the price level of the exiting plants is close to that of the (older) continuing plants. Third, the age-group-specific within components would be biased slightly upwards, especially at the early part of the firms' lifecycle. The extent of this bias is directly related to how rapidly prices increase as plants become older. Again, the findings reported in Foster et al. (2008) suggest that the effect would be moderate, perhaps only about half a percent (per year). While this discussion suggests that our main qualitative findings are not driven by price differences between the groups of plants of different age, it should be noted that in the study by Foster et al. (2008), entrants referred to the plants that are less than five years old. In our decomposition the entrants are less than one year old.

To check whether the results for the U.S. manufacturing are representative for Finland and apply to a wider set of industries, we make a preliminary effort to study how prices vary with the age of plants using Finnish product-level data from PRODCOM database. The sample available to us covers 38.8% of the value of the total deliveries in the manufacturing sector excluding electronics.[16] The unit of observation is a manufacturing product produced by a plant in a given year and the unit prices that the plants charge are approximated by the ratio of quantity to value of the products sold.[17]

[16] We have to drop telecommunication industry from the analysis due data confidentiality reasons.

[17] For a more detailed description of the PRODCOM product classification, see http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction and http://www.stat.fi/meta/luokitukset/cpa/001-2008/kuvaus_en.html (accessed 16 May, 2011). To match data on the age of plants with the product-level data, we link the PRODCOM data to the plant-level BR data.

Our econometric analysis of price profiles is exploratory and inspired by that of Foster et al. (2008): We run regressions where the dependent variable is the log of the unit value and use as the explanatory variables binary dummies for each product, year dummies and the complete set of interactions between the product and year dummies. We consider two different specifications for the age of plants. The first, corresponding (roughly) to that of the Foster et al. (2008), includes separate categorical dummies for young, middle-aged and old plants. The second uses a polynomial in plant age. Like Foster et al. (2008), we also consider alternative weighting schemes: We either use no weights, or use as the weight the total value of deliveries or employment of the plant.[18] As a reference group for the entrants we use both the oldest plants (at least 15 years old) and, more in accordance with our productivity decomposition formula, an average incumbent that is a weighted average of the coefficients of the different age-groups.

The main findings of our exploratory analysis with the categorical variables are reported in Table 5. They are as follows: First, we do not find robust evidence that the entrants have a price level that is lower than that of the older incumbents (i.e. at least 16 years old) or an average incumbent. This may be due to the small number of the observations for the young entrants (96 observations), which is likely to lead to imprecise estimates. Second, the young incumbent

Table 5 : Price level regressions (plant-level data)

	Unweighted	Weighted	
		Revenue	Labor
	(1)	(2)	(3)
Entrants	-0.111	0.077	0.008
	(0.123)	(0.116)	(0.103)
1-5 yrs.	0.026	0.120	0.096
	(0.053)	(0.063)	(0.068)
6-10 yrs.	0.060	0.053	0.046
	(0.049)	(0.057)	(0.061)
11-15 yrs.	0.041	0.016	0.008
	(0.041)	(0.044)	(0.059)
16- yrs.	[omitted]	[omitted]	[omitted]
Exit	0.029	-0.06	-0.023
	(0.055)	(0.094)	(0.100)
Price gap	-0.125	0.064	-0.002
	(0.097)	(0.115)	(0.102)
Number of observations	23206	23206	23206
Number of plants	2258	2258	2258
Number of product-plants	4278	4278	4278

Notes: Data are constructed by linking the BR and PRODCOM data by plant codes. Data include years 2001-2006 and refer to manufacturing (excluding electronics). Standard errors are clustered at the plant level. "Price gap" refers to the test of the difference in price level between entrants and continuing firms, where the price level of continuing firms is the weighted average of the different age-groups (with weights: 5% for 1-5 yrs., 10% for 6-10 yrs., 15% for 11-15 yrs., and 70% for 16- yrs.).

[18] The employment weights are equal to the number of employees of the plant multiplied by the value share of the product in the plant.

plants (1-5 years old) do not seem to have a low price level either.[19] If anything, these plants have higher prices than the oldest plants (but the differences are not statistically significant). Third, the price level of the exiting plants does not seem to differ from that of the older incumbents. This implies that there is no price-induced bias in the exit component in the decompositions that rely on revenue labor productivity. Our analysis with continuous age variables echo, by and large, these main findings.[20]

In sum, our analysis of cross-plant price variation suggests that our main decomposition results are not driven by price differences between the age-groups of plants. Yet, we acknowledge that our analysis is exploratory at best and that this issue calls for a more systematic analysis.

5 Conclusions

We have analyzed how firms contribute to the aggregate labor productivity growth of an industry over their lifecycle. We have found that besides experimentation (entry component), there is a lifecycle dimension to the other key components of industry productivity growth, particularly selection (exit component) and reallocation (between component): First, the labor productivity of new firms is, on average, substantially lower than that of the incumbents, implying a negative initial effect on industry productivity. Second, our age-group-decompositions show that there is a prolonged but positive exit effect that gradually declines over the lifecycle of firms. This effect is still visible as late as ten years after the entry. This positive exit effect mirrors market selection during the early stages of firms' lifecycle and is tightly related to the negative initial productivity effect of the entrants. Third, we find some evidence that productivity-enhancing reallocation of resources between firms is concentrated on the middle aged firms.

These results bear on the earlier literature in a number of ways: On the one hand, they suggest that the positive productivity effects of policies which boost entry may come about with a substantial lag and through an intensive selection and reallocation process. On the other hand, our results show that besides cyclical variation, there is another temporal dimension in the micro-level components that ought not to be overlooked. For example, it seems that in service industries, the market induces a lot of entry by firms that subsequently turn out to have low productivity firms. This leads to intensive rotation of the firms through entries and exits. Further, the negative contribution of the reallocation (between) component in the service industries can largely be attributed to young firms, implying that at this stage of their lifecycle, growth of employment is typically associated with a low productivity level.

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19 It should be noted that including the entrants in the youngest age-group (i.e., forming an age-group for those plans that are from 0 to 5 years old) have a negligible impact on the price level of the youngest age-group. The reason for this is that there are only 96 observations for the entrants but 1 143 observations for those plans that are from 1 to 5 years old.

20 The small sample size among the new plants is one of the reasons why our analysis does not focus selectively on those product categories that can be considered physically homogenous. We acknowledge that this is problematic. To check whether our results are driven by this choice we introduce simple (and admittedly subjective) controls for the nature of the products: These controls are dummies, coded by the authors, which try to capture whether or not vertical and/or horizontal differentiation is an important aspect of the product. Restricting the sample to the "more homogenous", horizontally differentiated products halves its size and reduces the number of entrants to only 25 observations. If we replicate our price regressions using this smaller but potentially more homogenous sample, we find that the standard errors of the coefficients of the different age-groups are generally substantially smaller than those shown in Table 5. However, we do not find statistically significant differences in the price levels between the age-groups. These findings suggest that the price profile over the firms' lifecycle is reasonably flat, at least in the sample available to us.

We have focused solely on labor productivity. An important advantage of this measure is that it can be measured relatively consistently for all firms and plants in our data, covering basically all production units – small and large – from the very beginning of the unit's lifecycle. Furthermore, labor productivity is directly linked to GDP per capita, which is a standard measure of the material standard of living. As a measure of productive efficiency labor productivity is however coarse, because it ignores other factors of production, capital input in particular.

It appears that an obvious extension to our analysis would be to use alternative performance measures, such as TFP, in which the output in measured by value added and the input is an index of labor and capital, or MFP, in which the output is measured by gross output and the input is an index of labor, capital and intermediate input. There are, however, several issues which complicate the measurement of TFP and MFP over the lifecycle of firms and which such an extension should somehow deal with.

The most important of hurdle to overcome is the measurement of capital, as there are a number of problems both with using the traditional perpetual inventory method (PIM) and the book value of capital: First, rented (leased) capital is not taken into account (directly), albeit it is arguably important for younger firms. It is therefore likely that the relative TFP/MFP level of the young firms gets overstated in a lifecycle analysis. Second, young firms are often argued to have access to more modern and efficient vintages of capital. If this qualitative difference is not fully captured by the price index (that is used to deflate the capital series), the relative TFP/MFP level of the young firms is overestimated. Third, when capital is measured by the traditional PIM-method, the data ought to capture the investments made in the very beginning of a firm's life cycle. Because new firms and plants often enter register-based data sets with a lag, it is possible that the traditional PIM-method underestimates the amount of capital that the entering and young firms command. If that is the case, the relative TFP/MFP level of the younger firms may, again, be overestimated.

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Appendix 1 Productivity growth in Finland

This appendix describes the development of aggregate labor productivity in the Finnish business sector from the 1970s onwards. Figure A1 displays the productivity development of the Finnish and U.S. business (non-financial) sectors, Figure A2 that of the Finnish, Swedish and U.S. manufacturing sectors and Figure A3 that of the service sectors of the same countries. Two findings stand out: First, the productivity of the Finnish business sector has developed very favorably, mostly driven by the productivity improvements in the manufacturing. As Figure A2 shows, the Finnish manufacturing reached the global labor productivity frontier (the U.S.) around the mid-1990s. Second, the productivity improvements have been much more modest in the service sector: The productivity gap to the United States and Sweden narrowed until the mid-1990s but then the gaps began to widen again (see Maliranta et al. 2010).

Figure A1 Productivity growth in the Finnish and U.S. non-financial sectors

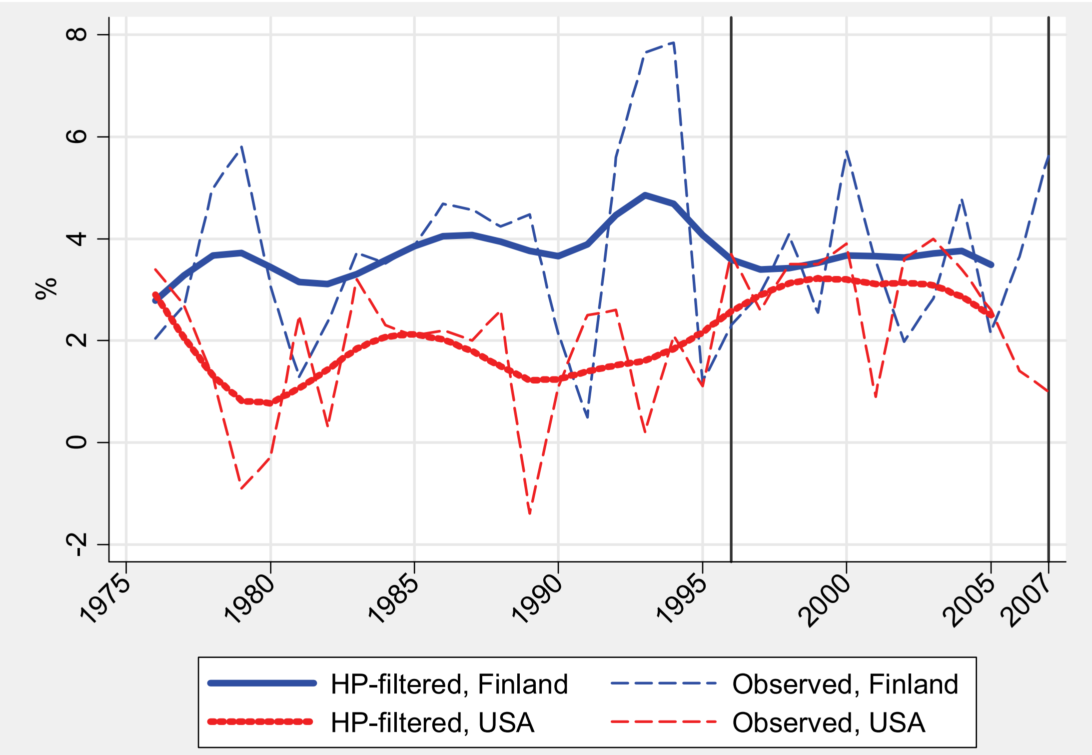


Figure A2 Labor productivity levels in manufacturing (Finland 1995=100)

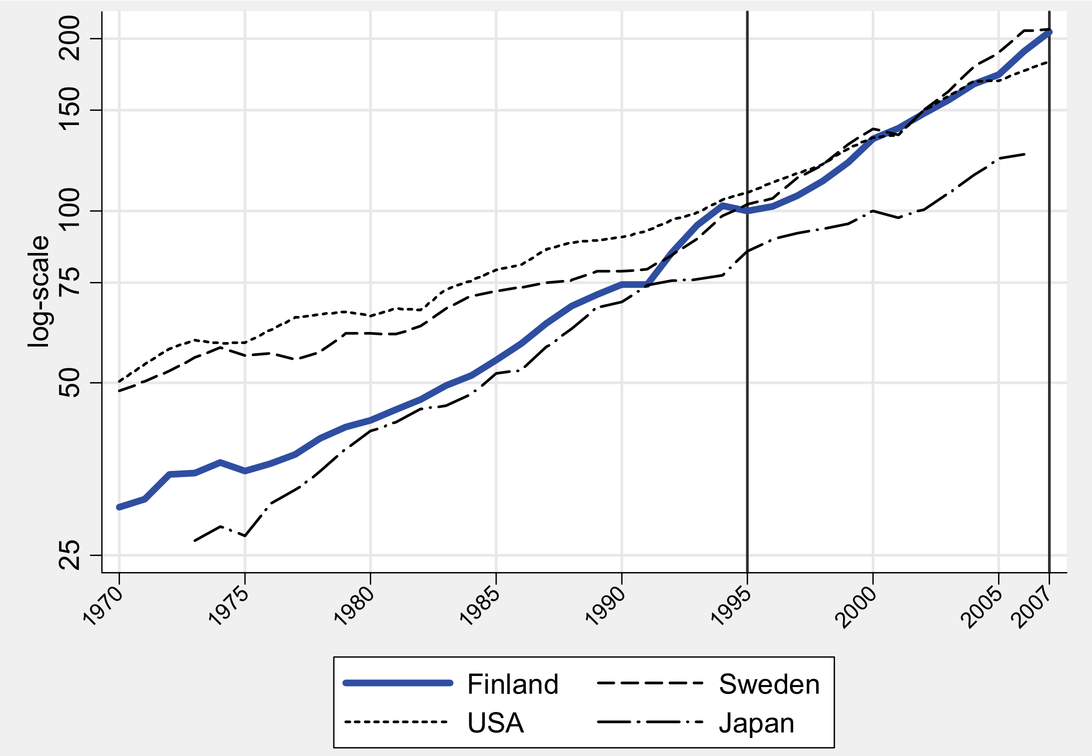
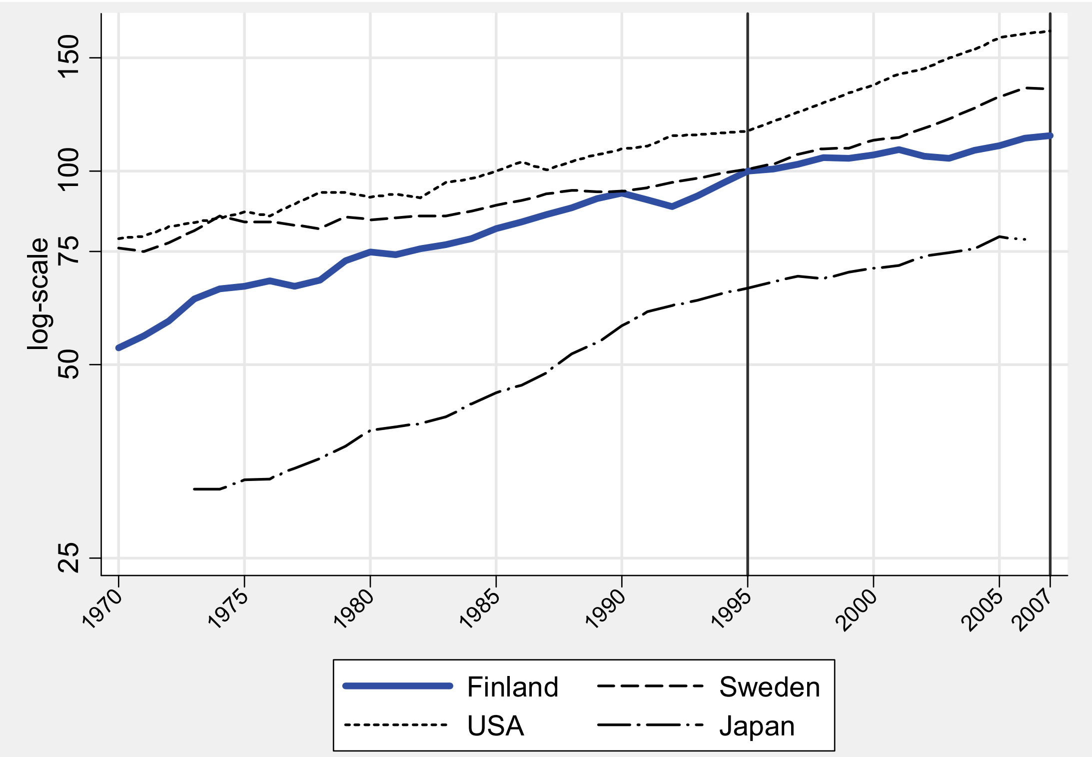


Figure A3 Labor productivity levels in market services (Finland 1995=100)



Appendix 2 Data sources and measurement issues

We use two alternative data sources: the Structural Business Statistics data on firms (the SBS data) and the Business Register on establishments (the BR data).

The SBS data available to us cover (nearly) all firms that do business in Finland and years from 1995 to 2007. The data include information on value added and number of employees for each firm. The second data set available to us is the BR on plants. It starts from 1976 but we focus on the period covered by the SBS data. There are two differences between these two data sets that are worth emphasizing: First, the productivity of a plant in the BR data is measured by gross output per person whereas in the SBS data, it is measured by value added per person. The latter is preferred when analyzing labor productivity, as value added takes into account the use of intermediate inputs. Second, the BR data allow us to assign production units more accurately to industries than the SBS data, where firms have to be assigned to industries on the basis of their main activity.

We deflate the value added and gross output by using the respective implicit industry-level price indexes obtainable from the National Accounts. We trim both data sets as follows: First, due to missing data and certain data quality problems, we drop Agriculture and forestry (01-05 in the NACE 2002 classification), Mining (10-14), Energy sources (23), Utilities (40-41), Construction (45), Financial intermediation (65-67) and Real estate (70) from the analysis. Second, we drop units that employ less than one person. We drop them, because the quality of their data is deemed unreliable and because they account for a very small proportion of the total input usage. Third, we do our best to clean the data from outliers. As there can be outliers both in levels and growth rates, we implement the following two-step procedure: Following Mairesse and Kremp (1993), we start by dropping all observations whose (log) productivity level is more than 4.4 standard deviations from the input-weighted industry average in a given year from the analysis.[21] We then calculate a set of first-round decompositions to examine if the absolute value of the contribution of a single unit to one of the components is greater than two percentage points in the industry. If such units are found, they are considered outliers. This is a conservative criterion, since only a couple of observations per year are removed due to this.

In order to be able to assign firms to age-groups, a measure for the age of firms (or plants) is needed. Our preferred measure is the (employment weighted) average age of the plants that a firm owns. The age of the plant is measured using its first entry in the BR register. The same plant-age is used both when we use the BR data and when we use the SBS data. The plant-based age data is merged to the SBS data by the firm code. We also use the administrative age of a firm as an alternative measure (see the main text for discussion).

Tables A1 and A2 present the descriptive statistics of the SBS and BR data sets for year 2005. The tables also show the industry classifications that we use in the decomposition analyses. We make note of three features of the data sets: First, the coverage of the two data sets is reasonably similar, if judged on the basis of employment. Second, the plant-level BR data include

[21] To be more precise, we perform preliminary decomposition computations for each pair of the consecutive years for each industry. If a firm is classified as an outlier in either the initial (t-1) or the end year (t) it is not included in this particular decomposition computation. The same unit can, however, show up in earlier and/or later periods. Outliers include, for example, firms that have zero or negative value added.

more units than the firm-level SBS data. This is, of course, what one should expect. Third, the number of employees involved in the entering firms is reasonably similar, but the corresponding numbers for exit vary a bit.

Table A1 : Descriptive statistics (firm-level data)

		All		Entrants		Exits	
Nace 2002	Industry	Nobs	Emp.	Nobs	Emp.	Nobs	Emp.
Panel A: Manufacturing (excl. electronics)							
15-16	Food & tobacco	1 146	37 243	67	1 098	97	4 413
17-19	Textiles & leather	781	11 215	65	412	77	577
20	Wood products	1 187	30 511	94	606	127	4 761
21	Pulp & paper	140	33 593	8	269	8	33
22	Publishing and printing	1 430	26 289	95	1 267	122	1 005
24	Chemicals	193	17 338	13	74	13	176
25	Plastics	476	14 951	32	645	35	247
26	Other non-metal	477	14 984	35	1 239	40	294
27	Basic metals	105	17 115	5	537	4	21
28	Metal products	2 752	41 780	216	1 388	246	3 399
29	Machinery	1 782	55 869	143	3 396	140	4 168
34-35	Vehicles etc.	485	17 500	41	140	50	561
36-37	Furniture & cycling	1 112	12 697	82	1 191	120	478
	Total (sum)	12 066	331 085	896	12 262	1 079	20 133
Panel B: Electronics							
30-31	Electrical machinery	361	11 517	18	167	27	656
32-33	Telecomm. equipm.	723	45 339	59	1 796	62	423
	Total (sum)	1 084	56 856	77	1 963	89	1 079
Panel C: Services							
50-52	Trade	23 756	222 225	2 494	12 188	2 548	9 134
55	Hotels and restaurants	6 755	46 501	862	2 331	911	2 403
60-63	Transport & travels	16 410	109 678	1 317	3 186	1 364	5 151
64	Post & telecommun.	331	34 780	43	161	44	1 546
71	Leasing	435	3 440	67	89	75	244
72	Computer services	2 061	34 421	298	1 083	276	2 072
73	R&D	157	3 343	21	61	27	101
741	Business services	4 828	21 122	745	1 448	610	1 138
742-743	Technical services	3 566	30 627	532	1 356	468	2 401
744-748	Other services	5 393	68 466	887	2 749	755	2 518
921-922	Movies and radio	368	7 312	62	150	66	241
923-927	News etc.	1 395	8 600	253	541	180	368
	Total (sum)	65 455	590 515	7 581	25 343	7 324	27 317
	Grand total	78 605	978 456	8 554	39 568	8 492	48 529

Notes: The source of the data is the firm-level SBS data. The data refer to 2005.

Table A2: Descriptive statistics (plant-level data)

		All		Entrants		Exits	
Nace 2002	Industry	Nobs	Emp.	Nobs	Emp.	Nobs	Emp.
Panel A: Manufacturing (excl. electronics)							
15-16	Food & tobacco	1 320	30 854	86	287	92	310
17-19	Textiles & leather	852	10 198	65	133.1	74	155.4
20	Wood products	1 369	25 939	106	225.1	123	598
21	Pulp & paper	220	29 684	9	29.6	9	254.5
22	Publishing and printing	1 754	25 044	130	866	139	608
24	Chemicals	292	15 558	14	116.6	10	120.2
25	Plastics	574	15 580	36	189.7	39	227.1
26	Other non-metal	634	14 246	35	71	33	64.9
27	Basic metals	135	15 565	7	287.3	6	143.2
28	Metal products	3 012	37 278	239	1 143	243	868
29	Machinery	2 173	52 821	181	1 853	160	953
34-35	Vehicles etc.	526	19 268	48	134.3	49	285.5
36-37	Furniture & cycling	1 256	12 767	95	724	131	304.9
	Total (sum)	14 117	304 801	1 051	6 058	1 108	4 891
Panel B: Electronics							
30-31	Electrical machinery	432	14 670	22	310.9	34	289.7
32-33	Telecomm. equipm.	860	36 006	57	658	74	949.6
	Total (sum)	1 292	50 676	79	969	108	1 239
Panel C: Services							
50-52	Trade	34 826	219 193	3 372	9 214	3 174	8 453
55	Hotels and restaurants	10 325	51 956	1175	3 131	1138	2 328
60-63	Transport & travels	17 920	96 243	1 423	2 829	1 399	3 554
64	Post & telecommun.	789	19 187	130	1481	125	1 173
71	Leasing	817	3 465	106	197.6	105	226.7
72	Computer services	2 719	37 766	429	2 635	382	3 546
73	R&D	187	1 987	24	53.7	29	53.2
741	Business services	5 324	21 647	846	1 576	650	1 249
742-743	Technical services	4 237	30 548	637	1 545	499	1 321
744-748	Other services	6 135	65 599	1168	4 871	861	3 810
921-922	Movies and radio	498	6 899	68	139.2	79	242
923-927	News etc.	1 742	8 838	288	450	219	379.8
	Total (sum)	85 519	563 328	9 666	28 122	8 660	26 335
	Grand total	100 928	918 805	10 796	35 150	9 876	32 466

Notes: The source of the data is the plant-level SBS data. The data refer to 2005.

Appendix 3 Time-series variation

This appendix describes the time-series development of the entry, exit, between and within components over our sample period for the manufacturing (excluding electronics), electronics and service sectors. Figure A4 is based on firm-level data and Figure A5 on plant-level data. Two patterns stand out: First, firm- and plant-level analyses yield similar results. Second, there is a lot of temporal variation in all components.

Figure A4 Time-series variation of components (firm level data)

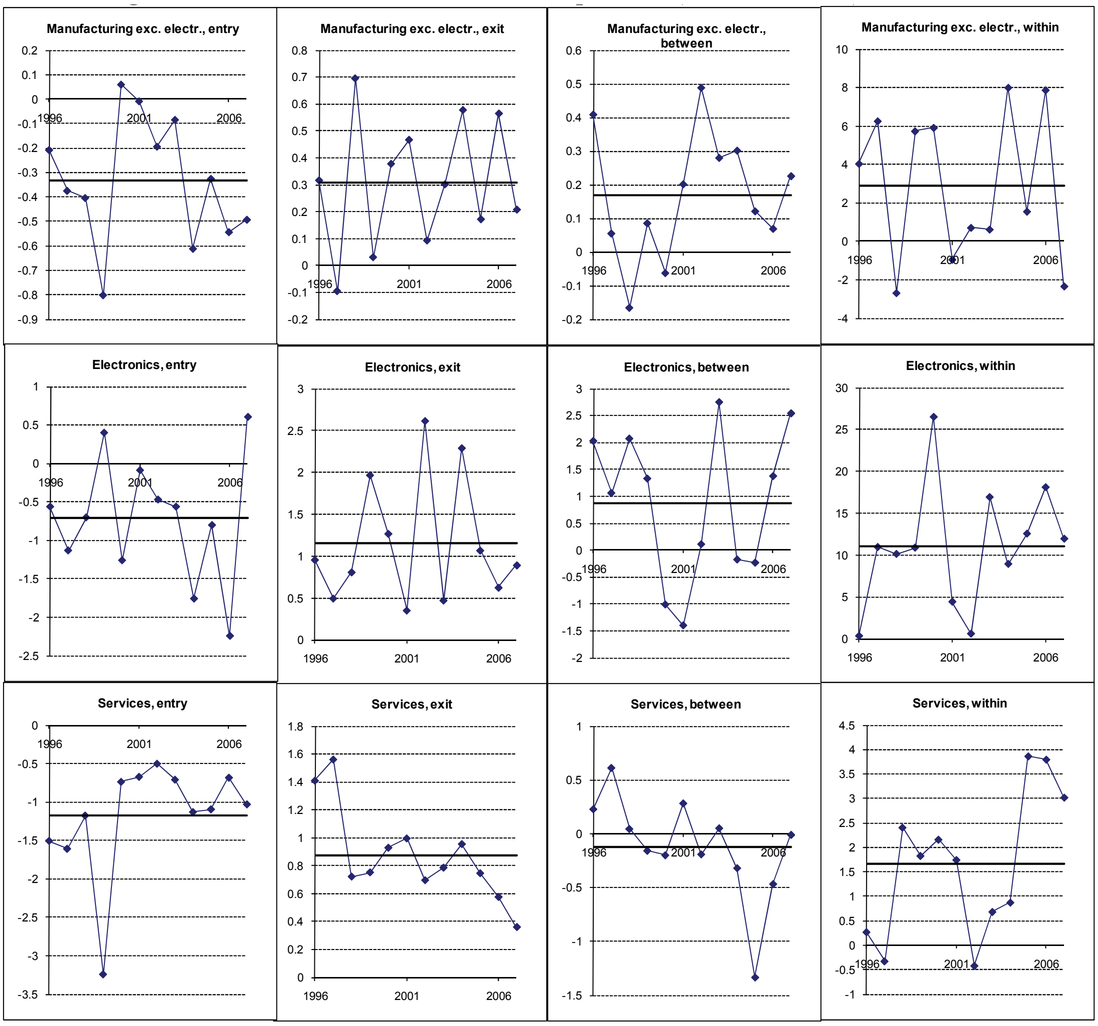
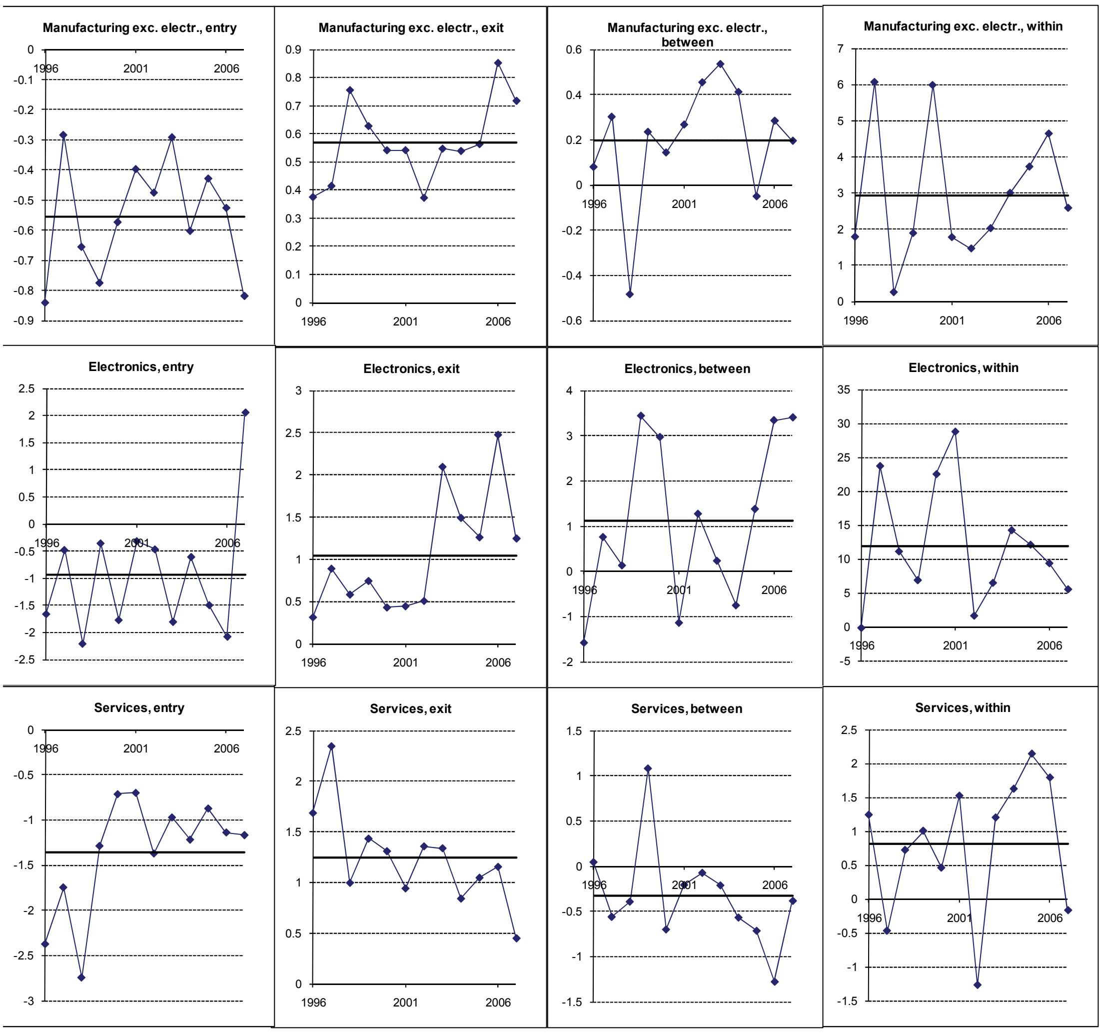


Figure A5 Time-series variation of components (plant level data)



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