Allocation and industry productivity: accounting for firm turnover [*]

PRELIMINARY

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Abstract

We study the link between resource allocation and industry productivity paying special attention to the role of firm turnover. We develop an augmented Olley-Pakes productivity decomposition method which allows examining how entrants and exits contribute to the covariance component of industry productivity and apply the method to rich data covering essentially all firms and plants in the Finnish business sector. We then build a model of firm dynamics that is consistent with the main patterns of our empirical results. We use the model to examine the mechanisms through which certain allocation distortions influence aggregate productivity. Changes in firms' entry and exit behavior turn out to be important for understanding changes in aggregate productivity. We also show how and why the standard Olley-Pakes decomposition fails to capture the effect of certain distortions.

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1 Introduction

It has been demonstrated that a substantial part of industry productivity growth can be attributed to factor reallocation from low to high productivity firms.[1] Lentz and Mortensen (2008) argue that 53 per cent of aggregate labor productivity growth among Danish firms can be attributed to such reallocation. It has also been argued that differences in resource allocation between firms explain a large part of cross-country variation in aggregate productivity levels (Hsieh and Klenow 2009, Banerjee and Duflo 2005, Comin and Hobijn 2004). Related to this, the model-based analyses in Restuccia and Rogerson (2008), and Bartelsman, Haltiwanger and Scarpetta (2009b) show that certain allocation distortions may lower aggregate productivity substantially by making resource allocation between firms less efficient.

In our view, a shortcoming of this important literature is that often the role of firm turnover has often been neglected. The first issue is how to empirically measure the efficiency of resource allocation between firms. An increasingly popular measure is the Olley-Pakes (1996) covariance component, i.e. the covariance between firm size and productivity. It is an appealing measure because it is simple and intuitive. Clearly, starting from a fixed set of firms with varying labour productivity levels, aggregate output increases if some of the workers in low productivity firms move to high productivity firms. At the same time, both aggregate labour productivity and the covariance between firm size and labour productivity increase. Furthermore, the covariance component seems to do a good job in explaining development in transition countries or the effects of allocation distortions (Bartelsman et al. 2009b).

However, as pointed out by Bartelsman et al. (2009a), the method does not allow examining how entrants and exits contribute to the aggregate productivity level or its components. This is unfortunate since many policy distortions can be expected to influence aggregate productivity level especially through their effects on firm entry and exit. Moreover, when we allow for entry and exit, it is no longer clear

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

that productivity increasing changes in resource allocation always increase the OP covariance component. For instance, if a low productivity firm makes an exit and its workers move to higher productivity firms, the covariance between firm size and productivity may well decrease.

The second issue is that models of firm microstructure used in this literature feature limited dynamics with respect to entry and exit. In the stationary equilibrium analysed in Restuccia and Rogerson (2008) firms stay in the market forever. In Bartelsman et al. (2009a), there is entry and exit but exit is exogenous. This is unfortunate since firm exit is a key part of the process of creative destruction. Moreover, many policy distortions can be expected to influence firms' exit decisions. Abstracting from the entry or exit margin may therefore yield misleading results regarding the effects of allocation distortions. This conjecture is confirmed by Fattal Jaef (2011). He analyses allocative distortions with a model that features both entry and exit decisions and shows that both these margins are indeed important.

In this paper, we consider the role of allocation distortions paying special attention to the role of firm turnover. Our first contribution is to develop an augmented OP productivity decomposition method and apply it to data. This decomposition allows us to examine how entrants and exiting firms contribute to the covariance component of the industry productivity level. Our second contribution is to build a model of firm dynamics that can be calibrated to roughly match the role of entrants and exiting firms for aggregate productivity as observed in the data. As in Fattal Jaef (2011), both entry and exit decisions are endogenous. However, an important feature of our model is that the correlation between firm age and productivity arises endogenously through firms' R&D investments. In Fattal Jaef (2011), firm level productivity process is governed by an exogenous process.

Our third contribution is to study the mechanisms through which different distortions influence aggregate productivity with our calibrated model. We also test whether the standard OP covariance component captures the distortions in a set-up with endogenous firm turnover.

We describe the role of entrants and exiting firms for aggregate productivity using data that covers basically all firms (and plants) in the Finnish business sector for 1995-2008. We show how entrants and exiting firms contribute to the aggregate productivity level. We also develop an augmented OP productivity decomposition method that allows us to examine how entrants and exiting firms contribute to the OP covariance component of the aggregate productivity level.

More specifically, we classify firms into four mutually exclusive groups: long-lived entrants, short-lived entrants, exiting firms, and stayers. The distinction between long-lived entrants (that stay at least five years) and short-lived entrants (that exit in five years) is useful in getting a richer account of the firm dynamics. We refer to short-lived entrants as visitors[2] and long-lived entrants as just entrants.

The decomposition of aggregate productivity level shows that the contribution of the new firms (i.e. entrants and visitors) is minus 2.1 percentage points in the manufacturing sector industries and minus 3.5 percentage points in the service sector. These negative numbers indicate that the new firms have a lower productivity level than the old firms, and thus the industry productivity level would be higher in the absence of them.[3] The exiting firms in turn have a negative contribution to the aggregate industry productivity level. Technically, that is to say that if these firms had made their exit already, the current industry productivity level would be higher.

The standard OP method shows that the covariance component within manufacturing industries is 33.9 %-points. Our augmented OP productivity decomposition method allows examining how visitors, entrants and exiting firms contribute to the covariance component of the industry productivity level through a within group and a between-group effect. The within group effect of entrants, for instance, depends on how much the covariance component among the entrants differs from

[2] Visitors could also be described as immediate exits.

[3] It should be noted that here we ignore possible indirect effects on the productivity level of the stayers that the entrants might have. On the other hand, our approach seems well justified here as we are focusing on the allocative effects.

that among the stayers. The between group effect in turn depends on the size and productivity of the entrants relative to the size and productivity of the stayers.

Our augmented OP decomposition method shows that 18.3 per cent of this component can be attributed to the fact that the new firms[4] are, on average, small and their productivity level is low. The corresponding number in the service sector is no less than 75.8 per cent. Further, more than one half of these effects on the covariance component can be attributed to the visitors. Also exiting firms have a positive impact on the overall covariance component.

These results imply that the covariance component is likely to be sensitive to changes in firm turnover. The main patterns of these decomposition results are similar across 27 different industries and three sectors (manufacturing, construction, services). The results are also robust to the use of plant level data instead of firm data.

We want our model to be able to account for the fact that young firms are typically relatively small and have a low productivity. First, following Bartelsman et al. (2009b), we assume that production requires overhead labour. This implies that small firms tend to have a lower labour productivity than smaller firms. Second, following all and Hayashi (1989) and Jones (1995), among others, we assume that firms need to invest in 'knowledge capital' in order to grow. Increasing knowledge capital requires both R&D investments and existing knowledge capital. As a result, firms grow only gradually. This implies young firms are, on average, relative small. Together with overhead labour, this in turn means that young firms have relatively low labour productivity, as observed in the data.

We experiment with three stylized allocation distortions in the model economy: entry cost, exit cost, and a tax and subsidy scheme that favours low productivity firms over high productivity firms. The tax and subsidy scheme has also the potential to lower aggregate productivity substantially. In contrast, exit and entry costs can only have a very limited effect on aggregate productivity. The effects of entry and exit cost are mitigated by that the fact they reduce the negative contribu-

[4] Including visitors and entrants.

tion of non-stayer firms on aggregate productivity. By reducing firm turnover, these distortions decrease the employment share of young firms that typically have relatively low productivity. In contrast, the tax and subsidy scheme increases firm turnover.

We find that the standard OP covariance component captures well the distortions that are created by the tax and subsidy scheme. As we increase this distortion, the covariance component declines in line with aggregate productivity. Entry or exit costs in contrast increase the covariance component. The reason is that these distortions extend firms' life-cycles. As a result, the group of stayer firms includes more firms that are both small and have a low labor productivity. Hence the covariance between firm size and productivity increases.

The result that certain distortions increase the covariance component suggests caution in interpreting empirical OP decompositions. The covariance component is not always a reliable indicator of allocative efficiency. At the same time, this result provides an explanation for the fact that the covariance component is actually quite high in a number of poor countries including Chile, Columbia, Portugal, Indonesia and Estonia and relatively low in some richer countries like Germany and the United Kingdom (Bartelsman et al. 2009a). A combination of relatively high covariance component and relatively low productivity may simply be the result of several distortions, all of which lower aggregate productivity and some of which increase the covariance component. In other words, one should not interpret countries with high OP covariance and low productivity as evidence against the conjecture that differences in resource allocation explain a large part of cross-country variation in aggregate productivity.

We proceed as follows. In section 2, we describe the augmented productivity decomposition method, the data and the empirical results. In section 3, we specify and calibrate the model. In section 4, we use the model to analyse different allocation distortions. We conclude in section 5.

2 Decomposition method and empirical results

2.1 Decomposition of industry productivity

Ultimately we are interested in the mechanisms underlying the industry productivity level that can be defined as follows:

$$\Phi_t = \sum_{i \in \Omega} s_{it} \varphi_{it} \tag{1}$$

where s_{it} and φ_{it} are the labour share of firm i in an industry and its productivity level, respectively, in year t defined as:

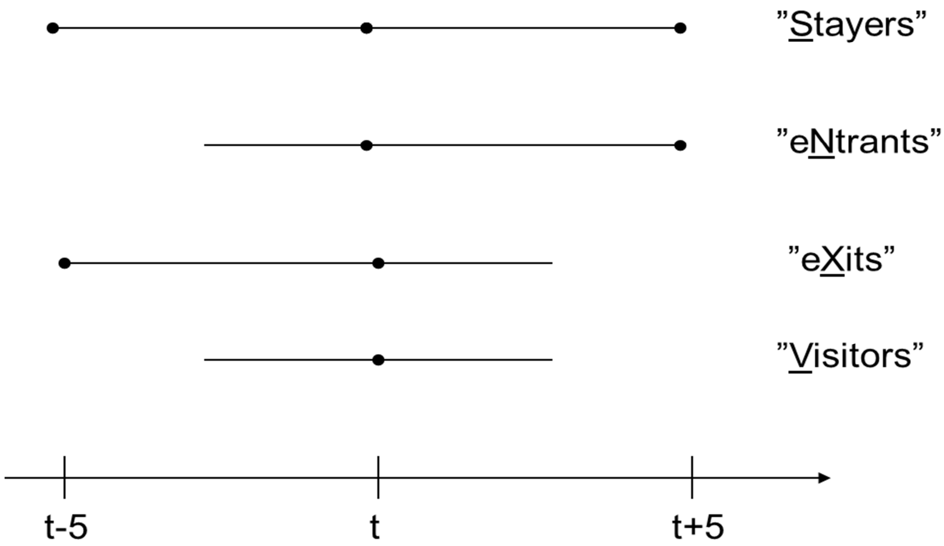
$$s_{it} = \frac{L_{it}}{\sum_{i \in \Omega} L_{it}} \tag{2}$$

$$\varphi_{it} = \ln \frac{Y_{it}}{L_{it}} \tag{3}$$

with L_{it} and Y_{it} denoting labour input and output, respectively, and Ω refers to all active firms in this period.

To analyze the role of firm dynamics for industry productivity we classify the firms in year t into four categories in a way illustrated in Figure 1 (see Hyytinen et al. 2010). The first group, called "stayers" (this set of firms is denoted by Ω_S), consists of the continuing firms that also appear in year $t-5$ and $t+5$. The second category is the "entrants" (Ω_N) that do not exist in year $t-5$ but exist in $t+5$. The third group is the "exits" (Ω_X) that exist in $t-5$ (and t) but not in $t+5$. Finally, the fourth group consists of the firms that exist in t but not either $t-5$ or $t+5$. These short-lived entrants (or young exiting firms) are called "visitors" (Ω_V). The groups are thus mutually exclusive and it holds that $\Omega_S \cup \Omega_N \cup \Omega_X \cup \Omega_V = \Omega$.

Figure 1. Classification of firms that are active in year t



We assess the contribution of the non-stayers (i.e. the entrants, exits and visitors) to industry productivity using two decompositions that are closely interrelated in a manner shown below.

The first productivity decomposition gauges *the effect of the non-stayers on the industry (or aggregate) productivity level*. We measure this effect as the difference between the aggregate productivity of all firms and the aggregate productivity of the stayer firms.[5] This productivity difference provides an answer to the counterfactual question how much higher (or lower) the industry productivity level would be in the absence of the non-stayer firms in year t; to be more precise, if none of the entries had taken place and all the exiting firms had already made their exit before year t.[6] Accordingly, the effect can be expressed as follows[7];

$$\Phi_t - \Phi_t^S = \sum_{j=N,X,V} \frac{L_t^j}{L_t} \left(\Phi_t^j - \Phi_t^S \right) \tag{4}$$

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[5] A similar idea of measuring the productivity difference between all firms and the staying firms for gauging the effects of entries and exits is applied, explicitly or implicitly, in some dynamic productivity decompositions, i.e. decomposing the micro-level sources of productivity *growth*, including Maliranta (1997), Böckerman and Maliranta (2007), Diewert and Fox (2009), and Melitz and Polanec (2009). Vainiomäki (1999, page 127) proposes a decomposition formula for detecting the forms of skill-upgrading that has the same idea. As for a static setting, see also Ottaviano, Kangasharju and Maliranta (2009).

[6] Note that the purpose of this accounting exercise is to measure allocative effects and therefore here we assume that the entrants (or exiting firms) do not have any indirect effect on the productivity level of the entrants.

[7] For derivation of this equation, see Appendix 1.

where $L_t^j = \sum_{i\in\Omega_j} L_{it}$, $L_t = \sum_{i\in\Omega} L_{it}$, $\Phi_t^S = \sum_{i\in\Omega_S} \frac{L_{it}}{\sum_{i\in\Omega_S} L_{it}} \varphi_{it}$ and

$\Phi_t^j = \sum_{i\in\Omega_j} \frac{L_{it}}{\sum_{i\in\Omega_j} L_{it}} \varphi_{it} = \sum_{i\in\Omega_j} \frac{L_{it}}{L_t^j} \varphi_{it}$.

According to Equation (4) the effect (or contribution) of the non-stayers, $\Phi_t - \Phi_t^S$, is dependent on the magnitude of the productivity gaps of the employment weighted average productivity level between the non-stayer firm groups Ω_j , $j \in \{N, X, V\}$, and the stayers, i.e. $\Phi_t^j - \Phi_t^S$, as well as the employment shares of the non-stayer firm groups, i.e. L_t^j / L_t, $j \in \{N, X, V\}$.

In what follows, we propose an augmented Olley-Pakes productivity decomposition method. It examines how the different non-stayer firm groups contribute to the aggregate productivity level via *the covariance component of industry productivity level*. To do so, we combine the idea used in Equation (4) and the popular cross-sectional Olley and Pakes (1996) decomposition of the industry productivity level into the average productivity and the covariance component. This component indicates the covariance between employment share and productivity;

$$\begin{aligned} \Phi_t &= \bar{\varphi}_t + \sum_i \left(s_{it} - \bar{s}_{it}\right)\left(\varphi_{it} - \bar{\varphi}_{it}\right) \\ &= \bar{\varphi}_t + \operatorname{cov}\left(s_{it}, \varphi_{it}\right) = \bar{\varphi}_t + \operatorname{cov}_t . \end{aligned} \tag{5}$$

Obviously, the same decomposition can be defined separately for each firm group. Hence we have $\Phi_t^j = \bar{\varphi}_t^j + \operatorname{cov}_t^j$, $j \in \{S, N, X, V\}$.

Thus, the aggregate productivity gap between all firms and the stayers can be presented, analogously to (4), as

$$\Phi - \Phi^S = \bar{\varphi} - \bar{\varphi}^S + \operatorname{cov} - \operatorname{cov}^S \tag{6}$$

This gives us an expression for the covariance gap between all active firms and the stayers in year t. It indicates how much higher or lower the covariance component would be without the entrants, exiting firms and visitors[8];

$$\operatorname{cov}_t = \operatorname{cov}_t^S + \sum_{j=N,X,V} \frac{L_t^j}{L_t}\left(\operatorname{cov}_t^j - \operatorname{cov}_t^S\right) + \sum_{j=N,X,V} \frac{N_t^j}{N_t}\left(\frac{\bar{L}_t^j}{\bar{L}_t} - 1\right)\left(\bar{\varphi}_t^j - \bar{\varphi}_t^S\right) \tag{7}$$

[8] Derivation of this equation is shown in Appendix 1.

within effects *between effects*

where N_t is the total number of firms active in year t and $\overline{L}_t = \frac{L_t}{N_t}$. N_t^j denotes the number of firms in the firm group Ω_j, $\overline{L}_t^j = \frac{L_t^j}{N_t^j}$ and $\overline{\varphi}_t^j = \frac{\sum_{i \in \Omega_j} \varphi_{it}}{N_t^j}$, $j \in \{N, X, V\}$

Equation (7) shows that each of the non-stayer firm groups (*j=N, X, V)* contributes to the covariance component by a within effect, whose sign depends on the term $\left(\text{cov}^j - \text{cov}^S\right)$, and by a between effect, whose sign depends on the product $\left(\frac{\overline{L}_t^j}{\overline{L}_t} - 1\right)\left(\overline{\varphi}^j - \overline{\varphi}^S\right)$. The latter effect is positive, for example, if the average firm size is relatively small, $\frac{\overline{L}_t^j}{\overline{L}_t} < 1$, and the average productivity is low, $\overline{\varphi}^j < \overline{\varphi}^S$. The magnitude of the within effect depends on the employment share of the firm group, i.e. $L_t^j / L_t, j \in \{N, X, V\}$, and the magnitude of the between effect depends on the share of the firms, i.e. $N_t^j / N_t, j \in \{N, X, V\}$.

2.2 An empirical illustration

Figure 2 provides a graphical illustration of the intuition behind the decomposition formulas (4) and especially (7) by use of a firm-level data set on the food industry in year 2003. Tables 1 and 2 report the productivity decomposition results.[9] The vertical axis represents the log of employment and the horizontal axis the log of the productivity level. The figure displays four important aspects. First, firms are very heterogeneous both in terms of size and productivity level. Second, there is a clear positive relationship between the size and productivity especially among the stayer firms that is indicated by a dashed fit line. Indeed, the covari-

[9] It should be emphasised that although we use here real data (that will be described in greater detail below) the main purpose of this analysis at this point is to illustrate the intuition behind these productivity decomposition. Here we have excluded firms whose log of labor productivity is less than 9 or more than 12. In order to prevent indirect disclosure of individual observations we have also added some noise to the data presented in Figure 2.

ance component among the stayer firms is 22.2 %-points (see Table 2). The figure provides some indication that he covariance terms are not greater among the non-stayer firm groups. Computations confirm this by indicating that the covariance components among the entrants, exits and visitors are 4.5 %-points, 5.7 %-points and 16.4 %-points, respectively. These values imply that the within effects of the non-stayer firm groups are negative as shown in Table 2. Third, both the average size and productivity level of the stayers is larger than those of the non-stayer firm groups and the visitors in particular. The horizontal solid lines indicate the log of the average size and the vertical solid lines the average of the log productivity level by firm group. The very small average size and low average productivity level explains the large positive contribution of the visitors to the between component (3.0 %-points) shown in Table 2. Other non-stayer firm groups have negative within effects as well. Fourth, the stayer firms have a much larger size dispersion (the standard deviation is 246.1) than the entrants (17.5) or the visitors (11.5) but productivity dispersion is somewhat larger among the entrants (0.46) and the visitors (0.44) than the stayers (0.42) (see also Haltiwanger et al. 2003). Fifth, since both the average productivity level and the covariance component of the non-stayer firm groups is lower than those of the stayer firm group, the non-stayer firm groups have a negative contribution to the industry productivity level. Without non-stayer firm groups the aggregate productivity level would have been 4.7 percent higher as shown in Table 1. For example, if the exiting firms had made their exit before year 2003 the industry productivity would have been 2.1 percent higher.

Figure 2. Productivity and employment in firms, an illustrative example

Table 1. Decomposition of the contribution to the productivity level (%-points)

Firm group	Contribution (1) = (2) x (3)	Productivity gap (2)	Employment share (3)
Entrants	-1.8	-30.8	5.8
Exits	-2.1	-30.2	6.9
Visitors	-0.9	-34.1	2.5
Total of non-stayers	-4.7		

Note: Decomposition is made by applying (4). Components may not add up due to rounding.

Table 2. Decomposition of the contribution to the covariance component by the augmented Olley-Pakes productivity decomposition, firm data

			Contibution of non-stayers	
	OP(All) (1)= (2)+(3)+(4)	OP(Stayers) (2)	Within groups (3)	Between groups (4)
Total	26.3	22.6	-2.4	6.1
Contributions				
Entrants			*-1.0*	*1.5*
Exits			*-1.2*	*1.6*
Visitors			*-0.2*	*3.0*

Notes: Decomposition is made by applying (7). Components may not add up due to rounding.

2.3 Data

We use the Structural Business Statistics data that exhaustively cover basically all firms in the Finnish business sector in the period 1995-2008.[10] Data are collected directly by surveys from firms (typically for firms employing at least 20 persons) and by exploiting the Tax Administration's corporate taxation records as well as Statistics Finland's Business Register.[11] In our baseline analysis we have included

[10] The main exception is financial intermediation that is not covered in the data. All in all, our analysis covers the following 27 industry groups: food (15-16 according to NACE Rev. 1), textiles (17-19), wood (20), paper (21), printing (22), chemicals (24), rubber (25), non-metallic minerals (26), basic metals (27), metal products (28), machinery (29). electrical machinery (30-31), tele-communication equipment and instruments (32-33), vehicles (34-35), other manufacturing (36-37), construction (45), trade (50-52), hotels and restaurants (55), transport (60-63), post and tele-communications (64), real estate activities (70), renting (71), computer activities (72), R&D (73), legal services (741), engineering services (742-743) and other business services (744-748).

[11] As for more detailed information, see http://www.stat.fi/meta/til/tetipa_en.html (accessed 29 May, 2012)

all firms employing at least one person (measured in full-time equivalent units) and having positive value added, which is needed for measuring a log of labour productivity.

Some descriptive statistics on data are provided Table A.1 in Appendix 2. The table presents the classification of the firms into three sectors (manufacturing, construction and services) and into 27 industries. In our baseline analyses data include 107 082 firms and 1 013 161 persons per year (the average of the years 2000-2003).[12]

Table A.1 shows that the non-stayer firms (i.e. the entrants, exiting firms and visitors) account for a substantial fraction of the total number of firms; 46.5% (= 100% – 53.5%) in the manufacturing and about two thirds in the construction and service sector. Yet, the employment shares of the non-stayers are much smaller; 13.4% (= 5.3% + 5.8% + 2.3%) in the manufacturing and about one third in the construction and service sector. These numbers indicate that the relative size of the non-stayers is quite small.

It should be noted that all sector-level results (i.e. those for the manufacturing, construction[13] and service sector) reported above as well as those that will be shown below are the employment weighted averages of the industry-level results (the first two columns in table A.1 are the exceptions). So, we focus on the effects within a typical industry of the sector and the impact of the industry structures is eliminated.

2.4 Empirical results

As for a background, Table A.2 in Appendix 2 describes some important empirical patterns in our data concerning the heterogeneity in productivity. Variation in productivity levels between firms (within industries) is, indeed, substantial. As shown in the first column, the standard deviation of log productivity (i.e. log of

[12] Note that although our data cover years from 1995 to 2008 we are able to carry out the computations for years 2000-2003 only because we use 5-year windows backward and forward to categorize firms into four firm groups.

[13] However, note that the construction sector consists of a single industry.

value added per person) is 57.6% in the manufacturing sector. The corresponding numbers for the construction and service sectors are 53.5% and 68.1%, respectively. The following columns show that the groups of the non-stayer firms have particularly low productivity. For instance, the gap in the unweighted average productivity level between the entrants and the stayer firms in the manufacturing sector is -15.1 percent (in log-units), and the corresponding gaps for the exiting firms and the visitors are -14.3 and -37.2 percent, respectively. Importantly, the table also shows that these gaps are much larger when measured by a weighted average (that is aggregate) productivity level. The productivity gaps are also large in the construction and service sector.

Table 3 represents the decomposition of productivity levels by use of Equation (4). We find that in all three sectors the non-stayer firms have a negative effect on industry productivity level. This is a consequence of the fact that the non-stayer firm groups have productivity levels that are lower than that of the stayer firms (i.e. they have negative productivity gaps). In manufacturing the effect is -3.4%. This contribution is spread quite evenly between three non-stayers groups. The industry-level results reported in A.3 in Appendix 2 indicate similar patterns but with some variation and with a couple of exceptions. The main exceptions include a few service industries (real estate services and other business services in particular) where the non-stayers positively contribute to industry productivity. However, these findings should be interpreted as an indication of usual measurement problems in the service sector.

Table 3. Decomposition of the contribution to the aggregate productivity level by firm groups

	Contribution of	Contribution of			Productivity gap		
	non-stayers	entrants	exits	visit.	entrants	exits	visit.
	(1)=(2)+(3)+(4)	(2)	(3)	(4)	(5)	(6)	(7)
Manufacturing	-3.4	-1.2	-1.3	-0.9	-30.8	-33.2	-53.0
Construction	-5.4	-2.0	-1.0	-2.3	-12.7	-11.4	-28.2
Services	-4.0	-1.5	-0.5	-2.0	-10.0	-4.3	-26.5

The results obtained by the use of the augmented Olley-Pakes decomposition, i.e. Equation (7) for three main sectors are represented in Table 4. In the manufacturing sector the standard OP covariance component for all firms and the stayer firms is 33.9 %-points and 27.8 %-points, respectively. The difference in these figures (i.e. 6.1 %-points) derives from the within (non-stayer) firm groups component, which is -1.1 %-points and from the between firm groups component, which is +7.2 %-points. The table also shows that the entrants' contribution to the between groups component is 2.5 %-points, the visitors' 3.7 %-points and the exiting firms 1.0 %-points. In other words, 18.3% (= (2.5 %-points + 3.7 %-points)/33.9 %-points) of the standard OP covariance component can be attributed to the between firm groups components of the young firms (less than 5 years old). Our earlier findings concerning their relative size and productivity level imply that the positive contribution is due to the fact that these firms are, on average, small and they have low weighted average productivity levels. The corresponding figures for the construction and service sector are much more striking. Not less than 61.8 % (= (1.6 %-points + 2.6 %-points)/6.8 %-points) of the OP covariance component in the construction sector and 75.8 % (= (4.3 %-points + 5.7 %-points)/13.2 %-points) in the service sector can be attributed to the between components of the young firms.

Table 4. Augmented Olley-Pakes productivity decomposition, firm data

Panel A: Manufacturing

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)= (2)+(3)+(4)	(2)	(3)	(4)
Total	33.9	27.8	-1.1	7.2
Contributions				
Entrants			*-0.4*	*2.5*
Exits			*-0.5*	*1.0*
Visitors			*-0.2*	*3.7*

Panel B: Construction

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)= (2)+(3)+(4)	(2)	(3)	(4)
Total	6.8	4.2	-1.6	4.2
Contributions				
Entrants			*-0.7*	*1.6*
Exits			*-0.2*	*0.0*
Visitors			*-0.7*	*2.6*

Panel C: Services

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)= (2)+(3)+(4)	(2)	(3)	(4)
Total	13.2	-0.4	3.2	10.5
Contributions				
Entrants			*1.5*	*4.3*
Exits			*0.8*	*0.5*
Visitors			*0.9*	*5.7*

Notes: The numbers refer to the weighted average of industries within sector (weighted by the employment share of the industry) and the average of years 2000-2003, calculated by firm data. Components may not add up due to rounding.

The negative within firm groups component of the augmented OP method indicates the relationship between the productivity level and the size is stronger within the stayers than within the non-stayer firm groups. Indeed, while the covariance component is 27.8% among the stayers in the manufacturing sector, the corresponding numbers for the entrants, exits and the visitors are 12.2%, 9.0% and 10.0%, respectively (not reported in the table). However, the contributions to the within component in absolute terms are modest because the employment shares of non-stayer firm groups are rather small especially in the manufacturing sector as documented in Table A.1 in Appendix 2. Table 4 also shows that the non-stayer firm groups contribute negatively to the within groups component in the construction sector but, perhaps a bit surprisingly, positively in the service sector.

Again, the sector level results of Table 4 are the employment weighted averages from the industry-level results that are reported in Tables A.4a and A.4b. Given that, for example, manufacturing industries differ greatly in various ways from one another, the similarity in the basic patterns of the industry-level results is noteworthy. With few exceptions only, the signs and the magnitudes of these decompositions are quite alike.

2.5 Extensions and robustness checks

We have performed a number of additional analyses to complement and check the robustness of our baseline results reported above. An issue of a high importance is the identification of entrants (and exiting firms) that is needed for classifying the firms into the groups of stayers, entrants, exiting firms and visitors. In the course of our empirical analysis we recognized that the entrants and visitors, which are identified by an appearance of a new firm code in the data, included some firms that were much larger than the rest of the new firms. A more careful inspection revealed that the appearance of large new firms seem to be associated with disappearance of large firms in the same industry. Clearly, it appears that that there are some artificial entries and exits of large firms in our data because the firm code has changed when the legal form of the firm has changed.[14] Importantly, we perceived that few artificial entrants may be quite consequential in this context. This is because, unsurprisingly, exceptionally large new entrants usually also have exceptionally high productivity levels. In our baseline analysis we have reclassified an entrant as a stayer if it employs more than 100 persons. This is because it seems highly unlikely that a firm that large makes a genuine entry. In a robustness check we used 250 persons as an alternative criterion and found that the results were quite similar to those of our baseline analysis.[15] These experiments gave

[14] Bartelsman, Haltiwanger and Scarpetta [14] Bartelsman, Haltiwanger and Scarpetta (2009a) make a similar observation concerning the Finnish firm-data in their footnote 17.

[15] In addition to the reclassification we have also experimented with the removal of the suspicious entrant observations. Again, the results were generally consistent with our baseline analysis.

further confirmation to our view that our results are robust when few exceptional new firms are eliminated one way or another.

2.5.1 Analysis with plant-level data

Another approach to testing the robustness of our empirical analysis is the use of plant-level data. The advantage of these data is that the plant code stays intact as long as the location and the industry group do not change. Thus changes in ownership or organization do not lead to a change in the plant code so there should be no need for removing or reclassifying suspicious entrants or visitors. Perhaps the greatest disadvantage of the plant-level data is that the measure of labor productivity (log of sales per person) may not be the best possible.

A less-than-ideal productivity measure notwithstanding, the main results are surprisingly similar to our baseline analysis made with the firm-level data as can be seen by comparing Table 3 with Table A.5 in Appendix 2 and Table 4 with Table A.6. First, the non-stayer firm groups have broadly similar negative contribution to the industry productivity levels. Second, the non-stayers and especially the visitors have a large positive contribution to the OP covariance term via the between groups component. Third, the entrants, visitors and exiting firms negatively contribute to the within groups component the OP covariance term.[16] This is because for example in the manufacturing sector the covariance terms among the entrants, exits and visitors are 16.3%, 24.9% and 13.6% (not reported in the table), respectively, whereas the corresponding number for the stayers is 33.5%. So, the covariance term among the new plants is, as it was in the case of the firm-level data, only one half that of the stayer plants. This means that according to the augmented OP productivity decomposition formula (7) these plant groups have a negative contribution to the overall covariance component via the within groups component.

[16] The entrants in the service sector are the only exception here.

2.5.2 The effect of cut-off limit

Our baseline analysis included all firms that employ at least one person (in full-time units). To check whether our findings are sensitive to this threshold we have replicated the decompositions of productivity levels and covariance term by using alternative thresholds. The results of this experiment for the manufacturing sector are reported in Table A.7 (level decomposition) as well as in Table A.8a and A.8b (covariance decomposition) in Appendix 2. The results for the contribution of the non-stayer groups to industry productivity level are remarkably insensitive to the inclusion threshold. Changes in threshold affect most the covariance term of the stayers, which declines substantially when smaller firms are excluded (see column (2) in Table A.8a). Also the between firm groups component of the OP covariance term goes down. However, the component is relatively high with all alternative thresholds (see column (4) in Table A.8a). As for the within firm groups component of the OP covariance term, the impact of excluding smaller firms is quite inconsequential. Visitors' contribution to the between firm groups component, unsurprisingly, declines quite substantially with the increase of the threshold but is still high even when the analysis covers only the firms employing at least 20 persons (see column (8) in Table A.8b).

2.5.3 Cyclical variation

Our baseline results are computed by averaging over years in order to mitigate the possible effects of the business cycles on the decomposition of productivity level and the covariance term. The results for the decompositions by year are also reported in Table A.7, Table A.8a and Table A.8b in Appendix 2. The table shows that the results vary between years but the basic patterns are unchanged.

2.5.4 Price levels of firms

The measurement of firm/plant performance has been based on an indicator that Foster, Haltiwanger and Syverson (2008) call revenue labor productivity. Obviously, if all firms had identical price levels at each point in time, as usually assumed in the literature, our indicator would be equivalent with that of physical labor productivity. However, if there are systematic differences in the price levels among firms it means that our indicator should be interpreted as rather a measure of profitability than productive efficiency. For instance, Foster et al. (2008) find with the US data on selected manufacturing industries that the entrants (plants that are less than 5 years old) have 1-4 percent lower prices than the stayers. In our analysis a price gap of that magnitude would imply only a modest effect on how the entrants contribute to aggregate productivity. This is because the revenue labor productivity gap to the stayer firms was -30.8 percent for the entrants and -53.0 percent for the visitors.

The impacts on the results with the augmented OP decomposition method are not, however, quite clear. This is true especially for the within firm groups component. This is because the average price level of the firm group (e.g. entrants or stayers) may hide systematic price differences between efficient and inefficient firms *within* the firm group. An important question is whether the relationship between the efficiency (i.e. physical productivity) and the price level is different within different firm groups. For instance, if the relationship between the efficiency and the price level is more negative among the entrants than among the stayers, the contribution of the entrants to the within firm groups component would be less negative than we found above.

3 Model of firm dynamics

3.1 Set-up

Time is discrete and there is a continuum of profit maximizing firms that take prices as given. In the beginning of each period, incumbent firms observe the realization of an exogenous productivity shock. After that, they hire labour for production and R&D. In addition, they decide whether to exit or stay in the market until the next period. There is also a continuum of potential entrants that enter the market if and only if that is profitable in expected terms.

Firms' technology depends on their knowledge capital, denoted by a , and an exogenous stochastic productivity state denoted by z .[17] The knowledge capital is restricted to be in the interval $[0,\bar{a}]=A$, where $\bar{a}>0$ will be chosen so that it is never binding in the simulations. The exogenous productivity is restricted to be in the interval $Z=[\underline{z},\bar{z}],\ -\infty<\underline{z<0}<\bar{z}<\infty.$

We denote the number of production workers by l. Output y is determined as

$$y=\exp(z)a^{\alpha}(l-f)^{\gamma-\alpha} \tag{8}$$

where $0<\gamma<1$ and $f>0$ denotes overhead labour. Overhead labour creates a direct link between labour productivity, which we compute as output divided by number of workers $r+l$, and firm size, which we measure by the number of workers. As in Bartelsmann et al. (2009b), overhead labor therefore allows matching the standard OP covariance component.[18] Together with decreasing returns to scale, overhead labour also insures that the distribution of firm size is well defined.

We refer to the term $\exp(z)a^{\alpha}$ as technology. The firm can improve its technology by hiring workers to do R&D. R&D increases firm's knowledge capital. We denote the number of R&D workers by r. Following Hall and Hayashi (1989), Jones (1995), and Klette and Moen (1998), we assume the following accumulation equation for knowledge capital

$$a'=a^{v}r^{1-v} \tag{9}$$

where a' denotes next period knowledge capital.

Klette and Moen (1998) shows that this accumulation equation is compatible with the way that firms react to R&D subsidies. In particular, it results in similar inertia in firms' R&D investments that is observed in the data. For our purposes, the key

[17] Intangible capital, which is essentially the same as our knowledge capital, has been found to be roughly one half of the total capital stock. In addition, an important part of total factor productivity growth (as measured traditionally by ignoring intangible capital) can be attributed to the growth of intangible capital (e.g. Corrado et al. 2009, Jalava et al. 2007)

[18] In a standard model with only production workers and without overhead labour or other type of frictions and distortions, the labour productivity is the same for all firms. In our set up, the existence of R&D workers alone creates a lot of variation in firms' labour productivity when productivity is defined as output per all workers. However, we find that we nevertheless need overhead labour to replicate the empirical covariance component.

implication of this accumulation equation is that it takes time for a new firm to grow. This means that, on average, relatively young firms are smaller than older ones. As we will see, this feature allows the model to replicate certain aspects of the firm dynamics that are crucial for our analysis.

Our model analysis is related to Fattal Jaef (2011) who also studies allocation distortions using model of firm dynamics with endogenous entry and exit decisions. One important difference between our model and his model is that in our set-up, there is systematic correlation between firm age and productivity which arises endogenously through firms' investments in knowledge capital. In Fattal Jaef (2011), firm level productivity process is governed by an exogenous process. We also calibrate the model in more detail with respect to firm turnover.

3.2 Problem of the firm

We normalize the price of one unit of production to one and denote the wage rate, which will be determined via a free entry condition, by w. We can now define the problem of an incumbent firm recursively as follows:

$$\begin{aligned} &V(a,z;w) = \max_{r,l}\{\exp(z)a^{\alpha}(l-f)^{\gamma-\alpha} - w(r+l) + \max[0, \beta EV(a',z';w)]\} \\ &s.t. \\ &a' = a^{v} r^{1-v} \\ &z' = \rho z + \varepsilon \end{aligned} \tag{10}$$

where $0<\rho<1$ and ε is normally distributed with mean zero and standard deviation σ_{ε} The second max-operator relates to the exit decision. The firm exits whenever the expected value of staying in the market is negative. The second constraint is the law-of-motion for the exogenous productivity state. We assume that it follows an AR(1) process.

While the decision related to R&D workers is a dynamic problem, the decision related to production labour is a static one. Given the state variables, the optimal demand of production labour is

$$l = \left(\frac{(\gamma-\alpha)\exp(z)a^{\alpha}}{w}\right)^{\frac{1}{1-\gamma+\alpha}} + f. \tag{11}$$

3.3 Entry

Entry occurs in two stages. Firms that consider entering the market first pay a fixed cost, c_e, to learn their initial exogenous productivity state which is drawn from distribution $\varphi(z)$. We assume that φ is the truncated normal distribution over $Z=\left[-4\sigma_\varepsilon/\sqrt{1-\rho^2}, 4\sigma_\varepsilon/\sqrt{1-\rho^2}\right]$. The standard deviation of the underlying normal distribution is denoted by σ_z.

Once a potential entrant has drawn its initial productivity, it decides whether to enter and start production. All firms start with an initial knowledge capital level $\underline{a}>0$.[19] The free-entry condition reads as

$$\int[\max(0,V(\underline{a},z;w)]\varphi(dz)-c_e\leq 0. \tag{12}$$

As long as there is entry, this equation holds with equality and this equation pins down the wage rate.

3.4 Stationary equilibrium

We close the model by assuming that aggregate labour supply is fixed. Without loss of generality, we normalize it to $\overline{L}=1$. The total mass of firms is determined so that the demand for labour equals its supply. This pins down the mass of firms that enter the market.

We consider the stationary equilibrium where the distribution of firms remains constant over time. Let us define a measure μ such that for all $(a,z)\in A\times Z$, μ(a,z) denotes the mass of firms in state (a,z). The stationary equilibrium consists of the distribution $\mu(a,z)$, wage rate w, a value function $V(a,z;w)$, policy functions $r(a,z;w)$ and $l(a,z;w)$, such that:

i) The value and the policy functions solve the firm problem in (10)
ii) The free-entry condition (12) is satisfied
iii) Labor market clears; i.e.

[19] Notice that the initial level of knowledge capital must be strictly positive. Otherwise the firm could never start growing.

$$\int l(a,z;w)\mu(da,dz)=\overline{L}.$$

iv) The firm distribution is time invariant; i.e. for all $\mathbf{a}\times\mathbf{z}\subseteq\mathbf{A}\times\mathbf{Z}$.

$$\mu(\mathbf{a},\mathbf{z})=\begin{cases}\int\limits_{A\times Z} T(a,z,\mathbf{a},\mathbf{z})\mu(da,dz) \text{ if } \underline{a}\notin\mathbf{a}\\ \int\limits_{A\times Z} T(a,z,\mathbf{a},\mathbf{z})\mu(da,dz)+BP(\mathbf{z}) \text{ if } \underline{a}\in\mathbf{a}\end{cases}$$

where the transition function $T(a,z,\mathbf{a},\mathbf{z})$ gives the probability that a firm in state (a,z) will next period be in a state belonging to $\mathbf{a}\times\mathbf{z}$, B is the mass of firms that enter the market, and $P(\mathbf{z})$ is the probability that the entrants exogenous productivity state belongs to $\mathbf{z}$ (recall that firms' initial level of knowledge capital is $\underline{a}$).

Function T is defined as:

$$Tr(a,z,\mathbf{a},\mathbf{z})=\int \chi(a(a,z;w)^{\nu}r(a,z;w)^{1-\nu},\mathbf{a})Q(\mathbf{z},z)\mu(da,dz),$$

where $\chi(a',\mathbf{a})$ is an indicator function that equals 1 if next period knowledge capital a' belongs to $\mathbf{a}$ and $Q(\mathbf{z},z)$ is the probability that the exogenous productivity state moves from z to $\mathbf{z}$.

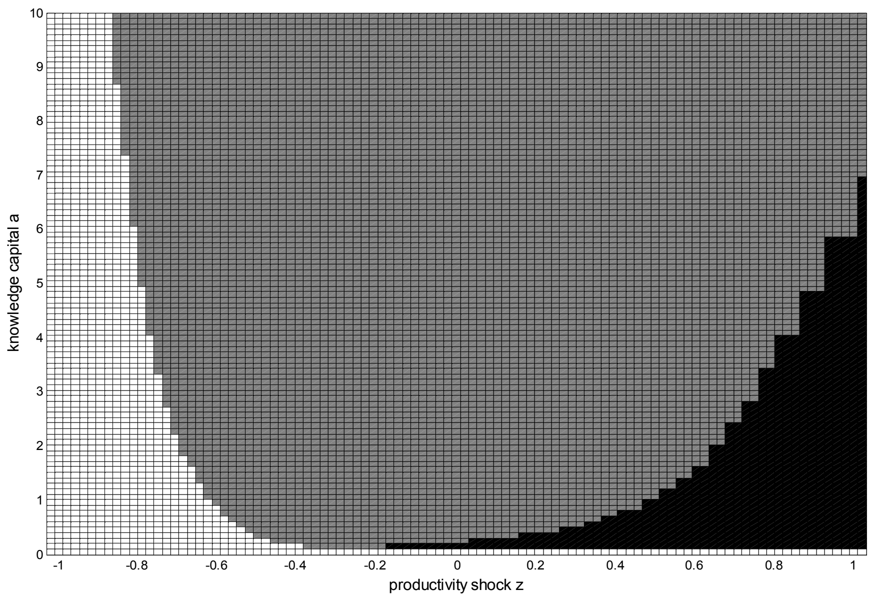
Aggregate consumption, denoted by C, is determined in the stationary equilibrium as

$$C=\int\limits_{A\times Z}\exp(z)a^{\alpha}(l(a,z)-f)^{\gamma-\alpha}d\mu-Dc_e, \tag{13}$$

where D is the mass of firms that pay the entry cost every period.

Figure 3 is helpful in understanding the dynamics of the model. It divides the state space into regions where firms choose to i) increase they knowledge capital (but investing a lot in R&D), ii) decrease they knowledge capital, and iii) exit. Firms with little knowledge capital choose to grow (in terms of knowledge capital) only if they have a very good current productivity shock. On the other hand, firms with low productivity shock exit immediately unless they have lot of knowledge capital.

Figure 3: Firm's exit and R&D policy (white area=exit, grey are=decrease knowledge capital, black area=increase knowledge capital).



3.5 Calibration and the benchmark economy

Before solving the model, we need to specify all parameter values. We first specify a number of technology parameters. We set the parameter γ, which measures the degree of decreasing returns to scale in the production function at $\gamma = 0.95$. This reflects the evidence that returns to scale are close to constant. We interpret the model period as one year and set the discount factor at $\beta = 0.95$ reflecting an annual discount rate of about 5%.

We are left with the following 8 parameters: overhead labour, f, share of current knowledge capital in the accumulation equation, v, autocorrelation parameter, ρ, standard deviations for productivity shocks and initial productivity drawings, σ_ε and σ_z, entry cost, c_e, initial knowledge capital $\underline{a}$, and the share of knowledge capital in the production function, α.

We choose these parameters endogenously trying to match the following statistics in the data: i) the OP covariance component for all firms, ii-iv) the contributions of entrants, exiting firms, and visitors to aggregate productivity, v)-vii) the employment shares of entrants, exiting firms, and visitors, and viii) the employment share of R&D. Except for the last target, the targeted numbers are taken from empirical baseline results for the manufacturing sector. We target an R&D labour force share of 20%. We interpret R&D broadly so that it includes a wide range of innovation activities performed in the firms.

Formally, we minimize the sum of squared errors for these targets. The resulting parameter values are:

$$f = 0.2, v = 0.58, \rho = 0.64, \sigma_{\varepsilon} = 0.23, \sigma_{z} = 0.20, c_{e} = 0.042, \underline{a} = 0.020, \alpha = 0.20$$

Table 5 compares the calibrated model with the empirical targets. The model matches the calibration targets reasonably well. The main mismatch between the model and the data is related to the employment share of visitors which is about 45% lower in the model compared to the data. The problem appears be that we cannot move the employment share of visitors independently of the employment share of entrants. If we were to match the employment share of visitors, the employment share of entrants becomes would be far too high.

Table 5. Calibration targets

Target (%)	Model	Target
covariance term	35.6	33.9
PROD GAPS RELATIVE TO STAYERS		
entrants	-32.7	-30.8
exiting firms	-35.8	-33.2
visitors	-65.2	-53.0
EMPLOYMENT SHARES		
entrants	6.8	5.3
exiting firms	5.6	5.8
visitors	1.1	2.3
R&D employment share	17.8	20.0

Note: Data refer to the empirical results concerning the manufacturing sector

Table 6 presents the covariance decomposition (Equation (7)). The covariance component is 35.6 percentage points among all firms and 22.8 percentage points among stayers. The effect of the non-stayers is thus about 12.8 percentage points.

This effect comes almost entirely via the between groups effect leaving only a modest positive role for the within groups effect. The further breakdown of the within and between groups effects by firm groups are shown in the lower panel of Table 6. The numbers indicate that exiting firms contribute the most to the between groups effect (4.1 percentage points).

Table 6. Decomposition the covariance component, model economy (%-points)

			Contibution of non-stayers	
	OP(All) (1)= (2)+(3)+(4)	OP(Stayers) (2)	Within groups (3)	Between groups (4)
Total	35.6	22.8	1.3	11.5
Contributions				
Entrants			*0.5*	*3.4*
Exits			*0.7*	*4.1*
Visitors			*0.1*	*4.0*

The corresponding empirical results for the manufacturing sector are shown in Panel A of Table 4. In our view, the model replicates the results of our augmented OP decomposition reasonably well. One difference is that in the model the within groups effect of non-stayer firms is positive while it is negative in the data. In other words, the covariance between size and productivity among non-stayer firms is too high in the model relative to the data. The model also exaggerates the covariance contribution of exiting firms.

4 Distortions and productivity

In this section, we use the model to analyze distortions to the allocation of resources across firms. We consider three different distortions. The first distortion is an output tax and subsidy scheme where firms with relatively high technology are taxed while those with a relatively low technology are subsidized. Specifically, we modify the firm problem so that firm revenue is determined as follows:

$$(1-\tau(z,a))\exp(z)a^{\alpha}(l-f)^{\gamma-\alpha},$$

where

$$\tau(z,a)=\chi-\frac{\chi\overline{\exp(z)a^{\alpha}}}{\exp(z)a^{\alpha}}$$

and $\overline{\exp(z)a^{\alpha}}$ is the unweighted average of $\exp(z)a^{\alpha}$ in the benchmark economy and the parameter $0 \le \chi \le 1$ measures the tax and subsidy rate. When $\chi > 0$, firms that have a relatively high technology face a positive output tax while firms with a relatively low technology face a negative output tax. The absolute value of the tax or subsidy rate increases with χ.

The second distortion we consider is an increase in the entry cost c_e. As discussed by Rogerson and Restuccia (2008) and others, there are large differences in entry costs across countries and at least part of this variation can be attributed to policies that create barriers to entry. The entry cost parameter can be interpreted as a proxy for such policies.

The third distortion is an exit cost. We modify the firm problem by assuming that if the firm decides to exit, it needs to pay a one time cost c_{ex}. Exit costs can be related to e.g. layoff costs or contract contingencies with buyers and suppliers.

Table 7 shows how the distortions affect aggregate productivity, wage level, the OP covariance component, the standard deviation of productivity, and the population and employment shares of different firm groups. We vary the tax and subsidy scheme by setting $\chi = 0.2$, 0.4 and 0.8. Recall that higher χ means higher tax and subsidy rates. We also consider entry cost of $c_e = 0.20$ (compared to 0.042 in the benchmark calibration) and introduce an exit cost of $c_{ex} = 0.30$. Aggregate productivity and the wage rate are reported as changes relative to the benchmark model since their absolute levels are not informative. These changes are expressed as log differences (multiplied by 100).

Table 7. Productivity, covariance and firm turnover: the effect of distortion (%-points)

	Benchmark		Output tax		Entry cost	Exit cost
		Khi=0.2	Khi=0.4	Khi=0.8	0.2	0.2
Change in aggregate productivity (%)	0.0	-1.9	-11.9	-50.4	-1.1	-0.9
Change in wage level (%)	0.0	-5.7	-6.7	6.5	-1.0	-0.3
Covariance component (%)	35.6	26.2	16.8	3.1	40.3	40.8
Std of log productivity (%)	36.1	27.5	25.4	27.4	45.6	46.3
Population shares (%):						
Stayers	58.4	56.6	48.2	40.9	91.2	90.4
Entrants	17.2	17.8	20.5	23.0	4.2	4.7
Exits	17.2	17.8	20.5	23.0	4.2	4.7
Visitors	7.3	7.8	10.8	13.1	0.3	0.2
Employment shares (%):						
Stayers	86.4	78.5	62.0	42.5	98.2	97.4
Entrants	6.8	10.4	17.3	23.4	1.1	1.7
Exits	5.6	8.7	14.5	21.7	0.7	0.8
Visitors	1.1	2.4	6.2	12.4	0.0	0.0

Clearly, the output tax has the potential to lower aggregate productivity drastically. The aggregate productivity falls by up to 50.4% as we increase the tax and subsidy scheme. The decrease in aggregate productivity is associated with a large drop in the OP covariance component. It decreases from 35.6% to just 3.1%. In other words, the OP covariance component captures very well this distortion.

The fact that the wage rate first falls and then increases is explained by to the fact in aggregate terms a small tax and subsidy scheme yields positive tax revenue while a larger one implies negative tax revenue. It is also interesting to note that the standard deviation of log productivity – which is also sometimes used as a measure of allocative efficiency - remains roughly constant as we increase the tax and subsidy scheme.

Increasing the tax and subsidy scheme increases firm turnover. For instance, the population share of stayer firms decreases from 58.4% in the benchmark case to 40.9% in the case where χ =0.8. By the same token, the population shares of entrants, exiting firms and visitors increase. The employment shares of non-stayer firms increase more than their population shares. This means that, on average, non-stayer firms become larger and stayer firms smaller.

The entry and exit costs have much more moderate effects on aggregate productivity. The increase in the entry cost considered lowers aggregate productivity by 1.1% and the exit cost by 0.9%. One cannot create much larger declines in productivity by increasing these costs further, because there is already very little firm turnover. Eventually, the same set of firms would stay in the market forever and further increases in entry or exit costs would have no effect.

The effects of entry and exit costs differ in many ways from those of the tax and subsidy scheme. For one thing, the numbers in Table 7 indicate that entry and exit costs decrease the average size of entrants and exiting firms substantially. It is also interesting to note that both the entry and the exit cost increase, rather than decrease, the OP covariance component.

Applying our augmented productivity decompositions to the simulated data gives a much richer account of the mechanism through which the distortions affect aggregate productivity. Table 8 presents the decomposition of the productivity level (cf. Equation (4) and Table 3). Aggregate productivity levels (the first two columns) are expressed as a log difference (multiplied by 100) to the aggregate productivity of all firms in the benchmark economy. For instance, the second entry of the second column tells us that the aggregate productivity level of the stayer firms in the economy with a small tax and subsidy scheme is 3.7 % higher than the aggregate productivity of all firms in the benchmark economy. The contribution of non-stayers refers to the difference between aggregate productivity among all firms and stayer firms. As shown by Equation (4), it is the sum of the contributions that relate to the three different non-stayer groups. In order to facilitate comparison of the different model economies, we also display, in the lower part of the Table, the changes between the benchmark economy and the economies with a distortion. For instance, the third column of the bottom row tells us that relative to the benchmark economy, the contribution of non-stayer firms is 2.8 percentage points higher with the exit cost. By construction, entries in the first column are identical with those in the upper part of the Table.

Table 8. Detailed productivity results (%-points).

	Aggregate prod.		Contribution of	Contribution of		
	All	Stayers	non-stayers	entry	exit	isitors
	(1)	(2)	(3)=(1)-(2)	(4)	(5)	(6)
Benchmark	0.0	3.7	-3.7	-1.7	-1.3	-0.7
Output tax, khi=0.2	-1.9	3.7	-5.7	-2.4	-2.1	-1.1
Output tax, khi=0.4	-11.9	-2.7	-9.2	-3.2	-3.6	-2.4
Output tax, khi=0.8	-50.4	-40.3	-10.0	-1.3	-5.6	-3.2
High entry cost	-1.1	-0.3	-0.8	-0.4	-0.4	0.0
Exit cost	-0.9	0.0	-0.9	-0.4	-0.4	0.0
Change						
Output tax, khi=0.2	-1.9	0.0	-1.9	-0.7	-0.8	-0.5
Output tax, khi=0.4	-11.9	-6.4	-5.5	-1.5	-2.3	-1.7
Output tax, khi=0.8	-50.4	-44.0	-6.3	0.4	-4.3	-2.5
High entry cost	-1.1	-4.0	2.9	1.3	0.9	0.7
Exit cost	-0.9	-3.7	2.8	1.3	0.9	0.7

It is the easiest to discuss the results by considering changes relative to the benchmark economy that are presented in the lower part of the Table. The second column reveals that all three distortions lower the aggregate productivity of stayer firms. Except for a relative small tax and subsidy scheme, most of the decline in aggregate productivity comes from stayer firms. In fact, by drastically reducing firm turnover, entry and exit costs make the negative contribution of non-stayer firms smaller in absolute value.

It is perhaps obvious that the tax and subsidy scheme decreases the aggregate productivity of stayer firms (i.e. firms in the mid-phase of their life-cycle). By favoring low productivity firms over high productivity firms, it clearly makes the resource allocation less efficient within this firm group. It may be less obvious why the entry and exit costs also have qualitatively the same effect. One reason is that they both decrease the equilibrium wage rate. A lower wage rate benefits stayer firms. Some relatively low productivity firms that would exit in the benchmark economy decide to stay in the market when the wage rate is lower. As a result, this firm group includes more firms that have very low productivity.

The tax and subsidy scheme has a negative impact on aggregate productivity also via the contribution of the non-stayer firms. There are at least two reasons for this. First, by providing a subsidy to low productivity firms, the tax and subsidy scheme implies that exiting firms have even lower productivity than in the benchmark economy. Second, as shown in Table 7, the tax and subsidy scheme increases the employment share of non-stayer firms and these firms have relatively low productivity even in the benchmark model.

Entry and exit costs in contrast decrease the negative contribution of non-stayer firms. This is because entry and exit costs drastically reduce the employment share of the non-stayer firms (see Table 7). This mechanism mitigates the adverse impact of entry and exit costs on aggregate productivity.

Table 9A displays the augmented OP decomposition. Again, it is the easiest to discuss the results by considering changes relative to the benchmark economy that presented in the lower part of the Table. The Table tells us that the tax and subsidy scheme lowers the OP covariance component both through stayer and non-stayer firms. The entry and exit costs in turn increase the covariance component among stayer firms.

Table 9.a Distortions and augemented OP decomposition (%-points)

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)= (2)+(3)+(4)	(2)	(3)	(4)
Benchmark	35.6	22.8	1.3	11.5
Output tax, khi=0.2	26.2	19.7	0.0	6.5
Output tax, khi=0.4	16.8	14.1	-0.9	3.5
Output tax, khi=0.8	3.1	2.9	-0.3	0.5
High entry cost	40.3	35.4	0.3	4.6
Exit cost	40.8	36.5	0.2	4.0
Change				
Output tax, khi=0.2	-9.5	-3.2	-1.2	-5.0
Output tax, khi=0.4	-18.8	-8.7	-2.1	-8.0
Output tax, khi=0.8	-32.5	-19.9	-1.6	-11.0
High entry cost	4.7	12.6	-1.0	-6.9
Exit cost	5.2	13.7	-1.0	-7.5

Table 9.b. Distortions and augemented OP decomposition: detailed results (%-points).

	Within groups (1)= (2)+(3)+(4)	Contribution of entrants (2)	exits (3)	visitors (4)	Between groups (5)= (6)+(7)+(8)	Contribution of entrants (6)	exits (7)	visitors (8)
Benchmark	1.3	0.5	0.7	0.1	11.5	3.4	4.1	4.0
Output tax, khi=0.2	0.0	-0.1	0.3	-0.1	6.5	1.6	2.5	2.4
Output tax, khi=0.4	-0.9	-0.5	0.0	-0.3	3.5	0.5	1.4	1.6
Output tax, khi=0.8	-0.3	-0.2	0.0	-0.1	0.5	0.0	0.3	0.2
High entry cost	0.3	0.1	0.2	0.0	4.6	1.5	2.7	0.3
Exit cost	0.2	0.0	0.2	0.0	4.0	0.8	3.0	0.2
Change								
Output tax, khi=0.2	-1.2	-0.6	-0.5	-0.2	-5.0	-1.8	-1.6	-1.6
Output tax, khi=0.4	-2.1	-1.0	-0.8	-0.4	-8.0	-2.9	-2.7	-2.4
Output tax, khi=0.8	-1.6	-0.7	-0.8	-0.1	-11.0	-3.4	-3.8	-3.8
High entry cost	-1.0	-0.4	-0.5	-0.1	-6.9	-1.9	-1.4	-3.7
Exit cost	-1.0	-0.5	-0.5	0.0	-7.5	-2.6	-1.1	-3.8

The reason why entry and exit costs increase the covariance component among stayer firms is that by reducing firm turnover they also extend firms' life-cycles. As a result, the group of stayer firms includes more firms that are both small and have a low labor productivity. As a result, the covariance between firm size and productivity increase.

For completeness, the lower panel of Table 9 presents the contributions of different non-stayer groups to the within and between group mechanisms. Perhaps the most noteworthy result from this panel is that changes in the different contributions are at least qualitatively similar with all three distortions. In particular, all distortions make especially the between groups effect smaller.

5 Discussion and conclusions

We have studied the role of firm dynamics for resource allocation and industry productivity. For that purpose we classify firms at a given point in time into four mutually exclusive groups, namely visitors, entrants, exiting firms, and stayers. By visitors we mean firms that have recently entered the market and that will shortly exit the market. By entrants we mean firms that have recently entered the market and will stay in the market at least for some time. By exiting firms we mean firms that will exit the market soon. By stayers we refer to firms that have been in the market for some time and will also remain there for some time.

We have used two types of productivity decomposition methods that together allow examining the different mechanisms through which these firm groups contribute to industry productivity. The first one measures the contribution of different firm groups to the industry productivity level. The second one, which we refer to as augmented Olley-Pakes (1996) productivity decomposition method, is developed here to examine the role of entrants and exits for *resource allocation* in greater detail. It allows studying how the different firm groups contribute to the covariance component of industry productivity. As the covariance component has been commonly used as a measure of allocative efficiency (how productively resources are allocated between less and more productive firms) in the literature, our method makes an important extension by incorporating the role of firm turnover in a way that is easy to interpret.

Application of these methods to comprehensive firm- and plant-level data sets that cover basically the whole business sector of Finland provides us with a rich description on the micro-level mechanisms underlying industry productivity. Our empirical results reveal some important and systematic patterns that are robust across different industries. In particular, visitors, entrants, and exiting firms all contribute negatively to aggregate productivity level. At the same time, they have a positive contribution to the covariance component of all firms. This latter effect is totally due to the fact relative to stayer firms, non-stayer firms are typically small and have a low productivity. In the augmented OP decomposition this effect is capture by the *between groups component*. On the other hand, resource allocation is less efficient among the non-stayer firm groups (i.e. entrants, visitors and exiting firms) than among the stayers, which is indicated by the negative *within group component* of the non-stayer firms in our decomposition.

To obtain a fuller understanding of the mechanisms and long-run effects of policies affecting entries and exits we built a model of firm dynamics that is roughly consistent with the main patterns revealed by our productivity decompositions. One question we are interested in is whether the standard OP covariance component can be used to trace allocation distortions even when firm turnover changes.

We experimented with three different policy distortions, namely 1) an output tax that favours low productivity firms over high productivity firms, 2) an increase in the entry cost, and 3) an exit cost. In line with the previous related literature, we found that the output tax has the potential to lower aggregate productivity substantially. It distorts resource allocation by systematically shifting labour from high productivity firms to low productivity firms. This also shows up as a fall in the covariance component.

In our set-up, entry and exit costs can have only a modest negative effect on aggregate productivity. Their effect on aggregate productivity is mitigated by the fact that by reducing firm turnover, they also reduce the employment share of entrants and visitors that tend to have relatively low productivity. However, we also find that both these distortions work to increase the OP covariance component. The reason is that these distortions make low productivity firms less likely to exit. As the firms enjoying extended life-cycles are typically small and have a low productivity, this results in an increase in the covariance component.

As we discussed in the Introduction, our results suggest some caution in interpreting empirical OP decompositions. More generally, our results stress the need to use structural models that can account for changes in firm dynamics when assessing the effects of various allocation distortions. An interesting avenue for future research would be to apply our augmented productivity decompositions to a set of different countries and then use a structural model to try and understand what kind of country specific distortions can explain the differences.

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Appendix 1. Derivation of decomposition formulas

Derivation of Equation (4):

By definition, the industry productivity level is a weighted average of the aggregate productivity levels of the firm groups:

$$\Phi_t = \frac{L_t^S}{L_t}\Phi_t^S + \sum_j \frac{L_t^j}{L_t}\Phi_t^j,\ j = N, X, V \tag{A.1}$$

Inserting $\frac{L_t^S}{L_{t\ t}} = 1 - \sum_j \frac{L_t^j}{L_t}\Phi_t^j$ into (A.1) gives

$$\Phi_t - \Phi_t^S = \sum_j \frac{L_t^j}{L_t}\left(\Phi_t^j - \Phi_t^S\right) \tag{A.2}$$

Derivation of Equation (7):

By use of the Olley-Pakes productivity decomposition the difference of aggregate productivity level between all firms and the stayers can be presented as

$$\Phi_t - \Phi_t^S = \overline{\varphi}_t + \mathrm{cov}_t - \overline{\varphi}_t^S - \mathrm{cov}_t^S \tag{A.3}$$

and thus the corresponding difference in the covariance component can written as

$$\mathrm{cov}_t - \mathrm{cov}_t^S = \Phi_t - \Phi_t^S - \left(\overline{\varphi}_t - \overline{\varphi}_t^S\right) \tag{A.4}$$

We then have

$$\begin{aligned} \mathrm{cov}_t - \mathrm{cov}_t^S &= \left(\frac{L_t^S}{L_t}\Phi_t^S + \sum_{j=N,X,V}\frac{L_t^j}{L_t}\Phi_t^j - \Phi_t^S\right) - \left(\frac{N_t^S}{N_t}\overline{\varphi}_t^S + \sum_{j=N,X,V}\frac{N_t^j}{N_t}\overline{\varphi}_t^j - \overline{\varphi}_t^S\right) \\ \Leftrightarrow \mathrm{cov}_t - \mathrm{cov}_t^S &= \sum_{j=N,X,V}\frac{L_t^j}{L_t}\left(\Phi_t^j - \Phi_t^S\right) - \sum_{j=N,X,V}\frac{N_t^j}{N_t}\left(\overline{\varphi}_t^j - \overline{\varphi}_t^S\right) \end{aligned} \tag{A.5}$$

By inserting the average employment we have

$$\mathrm{cov}_t - \mathrm{cov}_t^S = \sum_{j=N,X,V}\frac{N_t^j\overline{L}_t^j}{N_t\overline{L}_t}\left(\Phi_t^j - \Phi_t^S\right) - \sum_{j=N,X,V}\frac{N_t^j}{N_t}\left(\overline{\varphi}_t^j - \overline{\varphi}_t^S\right) \tag{A.6}$$

Rearranging the terms and using the Olley-Pakes decomposition of aggregate productivity yields

$$\mathrm{cov}_t - \mathrm{cov}_t^S = \sum_{j=N,X,V}\frac{N_t^j}{N_t}\left(\frac{\overline{L}_t^j}{\overline{L}_t}\left(\overline{\varphi}_t^j - \overline{\varphi}_t^S + \mathrm{cov}_t^j - \mathrm{cov}_t^S\right) - \left(\overline{\varphi}_t^j - \overline{\varphi}_t^S\right)\right) \tag{A.7}$$

which finally gives us the following equation

$$\text{cov}_t = \text{cov}_t^S + \sum_{j=N,X,V} \frac{L_t^j}{L_t}\left(\text{cov}_t^j - \text{cov}_t^S\right) + \sum_{j=N,X,V} \frac{N_t^j}{N_t}\left(\frac{\bar{L}_t^j}{\bar{L}_t} - 1\right)\left(\bar{\varphi}_t^j - \bar{\varphi}_t^S\right) \quad \text{(A.8)}$$

Appendix 2. Additional tables

Table A.1. Descriptive statistics, averages over the period 2000-2003, firms

	Number of firms	Number of persons	Share of firms (%) Stayers	Entrants	Exits	Visitors	Share of emp. (%) Stayers	Entrants	Exits	Visitors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Manufacturing	14 993	350 301	53.5	21.6	12.7	12.2	86.6	5.3	5.8	2.3
Construction	17 413	108 656	35.2	34.8	9	20.9	67	15.6	9.1	8.2
Services	74 677	554 204	33.1	35.1	10.5	21.4	69.9	15	7.8	7.3
TOTAL	107 082	1 013 161								
MANUFACTURING										
Food (15-16)	1 263	33 664	45.8	25.7	13.6	14.8	86.4	5.1	6.3	2.1
Textiles (17-19)	1 058	13 059	41.6	22.5	16.4	19.5	77.7	6.7	11.8	3.8
Wood (20)	1 376	19 112	46.8	24.7	11.7	16.8	78.9	9.1	7.2	4.7
Paper (21),	150	38 045	72.9	10.6	9.9	6.7	98.5	0.7	0.6	0.2
Printing (22)	1 642	28 087	52.8	18.9	17.0	11.3	83.5	5.4	8.8	2.3
Chemicals (24)	201	12 625	60.9	18.9	11.9	8.3	92.7	3.7	3.0	0.6
Rubber (25)	504	14 707	58.7	17.9	14.2	9.2	87.0	4.8	6.4	1.7
Non-met. minerals (26)	551	13 736	55.2	20.9	12.8	11.1	87.3	5.1	5.7	1.9
Basic metals (27)	111	15 043	59.9	16.6	16.8	6.7	94.8	2.0	2.8	0.5
Metal products (28)	3 008	35 383	51.5	23.8	11.9	12.8	75.3	10.2	10.4	4.0
Machinery (29)	2 089	46 438	49.3	24.9	12.1	13.7	85.1	6.0	6.1	2.7
Electr. mach.(30-31)	384	12 014	57.1	19.0	14.4	9.6	83.2	6.9	7.2	2.8
Telec. eq.&instr. (32-33)	752	37 200	51.8	25.0	11.8	11.4	93.2	2.8	2.9	1.1
Vehicles (34-35)	524	18 061	49.3	25.0	9.4	16.3	91.0	4.1	3.1	1.8
Other manuf. (36-37)	1 384	13 129	45.5	25.7	12.0	16.8	75.0	9.9	9.8	5.4
CONSTRUCTION										
Construction (45)	17 413	108 656	35.2	34.8	9.0	20.9	67.0	15.6	9.1	8.2
SERVICES										
Trade (50-52)	27 266	213 348	38.4	30.5	11.9	19.2	70.7	14.0	8.6	6.7
Hotels and rest. (55)	7 381	50 281	25.2	32.8	11.5	30.5	62.0	17.1	9.1	11.8
Transport (60-63)	17 673	91 343	22.3	52.9	4.7	20.2	68.8	19.5	4.9	6.9
Post and telecomm. (64)	332	37 757	41.2	27.6	10.2	21.0	95.0	2.0	1.4	1.7
Real estate activities (70	3 703	18 138	36.8	31.8	12.8	18.6	53.1	24.4	12.8	9.7
Renting (71)	462	3 282	32.9	31.7	11.0	24.4	64.7	16.6	8.4	10.3
Computer activities (72)	2 130	29 533	27.3	35.1	12.4	25.2	68.4	13.8	8.6	9.3
R&D (73)	154	1 983	28.9	36.6	10.1	24.3	68.5	19.2	5.6	6.7
Legal services (741)	5 811	26 970	37.5	30.7	12.4	19.4	62.5	17.1	10.2	10.1
Engineering serv. (742-7	3 893	26 438	42.3	30.6	12.2	15.0	67.7	14.4	12.5	5.3
Other bus. Serv. (744-74	5 872	55 130	27.2	36.5	10.4	25.9	69.3	15.6	7.4	7.7

Table A.2. Variation in productivity levels, averages over the period 2000-2003, firms

	std of log productivity	Productivity gap to stayers					
		Unweighted average			Weighted average		
		Entr.	Exits	Visit.	Entr.	Exits	Visit.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Manufacturing	57.6	-15.1	-14.3	-37.2	-30.8	-33.2	-53.0
Construction	53.5	-8.0	-9.9	-19.8	-12.7	-11.4	-28.2
Services	68.1	-21.3	-16.2	-40.1	-10.0	-4.3	-26.5
MANUFACTURING							
Food (15-16)	59.0	-17.1	-19.0	-43.7	-32.3	-31.7	-58.5
Textiles (17-19)	63.6	-22.7	-25.8	-42.9	-30.0	-29.1	-44.1
Wood (20)	59.9	-15.4	-15.7	-35.4	-11.1	-15.7	-38.7
Paper (21),	59.0	-22.5	-21.1	-60.8	-51.9	-68.2	-91.5
Printing (22)	58.8	-14.6	-11.6	-32.4	-20.9	-10.3	-45.1
Chemicals (24)	92.3	-36.0	-23.0	-53.3	-29.6	-31.0	-50.0
Rubber (25)	54.3	-17.0	-17.3	-35.5	-8.9	-13.4	-19.4
Non-met. minerals (26)	56.4	-26.6	0.2	-48.4	-43.6	-9.7	-44.1
Basic metals (27)	46.4	-11.6	-1.9	-45.9	-43.5	-33.2	-60.5
Metal products (28)	46.7	-8.8	-10.2	-25.5	-10.8	-15.3	-26.1
Machinery (29)	52.4	-7.7	-12.3	-19.0	-16.0	-24.1	-28.6
Electr. mach.(30-31)	52.1	-12.2	-10.3	-39.9	-16.8	-19.9	-46.6
Telec. equip.&instr. (32-33)	63.4	-8.0	-16.4	-32.7	-74.1	-86.0	-108.0
Vehicles (34-35)	59.2	-11.8	-5.5	-26.6	-11.6	-6.2	-37.9
Other manuf. (36-37)	57.1	-21.9	-15.9	-46.0	-17.0	-14.2	-31.7
CONSTRUCTION							
Construction (45)	53.5	-8.0	-9.9	-19.8	-12.7	-11.4	-28.2
SERVICES							
Trade (50-52)	74.2	-28.7	-22.1	-56.0	-17.0	-11.0	-40.1
Hotels and restaurants (55)	62.5	-21.5	-16.7	-41.3	-11.1	-6.8	-31.1
Transport (60-63)	47.7	-17.5	-14.0	-25.2	-20.7	-21.3	-31.2
Post and telecomm. (64)	76.9	-21.1	-10.4	-34.9	6.1	38.7	-2.0
Real estate activities (70)	94.3	8.4	3.6	-0.6	39.6	-7.6	7.8
Renting (71)	92.3	-35.6	-18.1	-61.8	-39.0	-4.8	-60.1
Computer activities (72)	81.7	-25.6	-18.8	-40.8	-48.4	-26.3	-49.0
R&D (73)	81.4	-7.0	10.0	-22.4	46.0	68.2	28.5
Legal services (741)	69.9	-10.1	-10.6	-24.6	-11.6	-11.8	-22.1
Engineering serv. (742-743)	58.2	-12.6	-13.1	-27.3	-14.7	-3.7	-25.8
Other bus. Serv. (744-748)	63.5	-15.3	-10.5	-31.2	31.7	36.8	19.6

Note: The sector level numbers are employment weighted averages of the industry level numbers.

Table A.3. Decomposition of the productivity levels by industries, firms

	Contr. of non-stayers (1)= (2)+(3)+(4)	Contribution of			Productivity gap		
		Entrants (2)	Exits (3)	Visit. (4)	Entrant (5)	Exits (6)	Visit. (7)
MANUFACTURING							
Food (15-16)	-4.9	-1.6	-2.0	-1.3	-32.3	-31.7	-58.5
Textiles (17-19)	-7.1	-2.0	-3.5	-1.7	-30.0	-29.1	-44.1
Wood (20)	-3.9	-1.0	-1.0	-1.8	-11.1	-15.7	-38.7
Paper (21),	-1.0	-0.4	-0.4	-0.2	-51.9	-68.2	-91.5
Printing (22)	-3.1	-1.1	-0.9	-1.0	-20.9	-10.3	-45.1
Chemicals (24)	-2.1	-1.0	-0.9	-0.2	-29.6	-31.0	-50.0
Rubber (25)	-1.8	-0.5	-0.8	-0.5	-8.9	-13.4	-19.4
Non-met. minerals (26)	-3.6	-2.2	-0.6	-0.8	-43.6	-9.7	-44.1
Basic metals (27)	-2.0	-0.8	-0.9	-0.2	-43.5	-33.2	-60.5
Metal products (28)	-3.7	-1.1	-1.6	-1.0	-10.8	-15.3	-26.1
Machinery (29)	-3.2	-1.0	-1.5	-0.8	-16.0	-24.1	-28.6
Electr. mach.(30-31)	-3.9	-1.2	-1.4	-1.3	-16.8	-19.9	-46.6
Telec. equip.&instr. (32-33)	-5.0	-1.8	-2.1	-1.1	-74.1	-86.0	-108.0
Vehicles (34-35)	-1.5	-0.4	-0.3	-0.8	-11.6	-6.2	-37.9
Other manuf. (36-37)	-4.8	-1.7	-1.4	-1.7	-17.0	-14.2	-31.7
CONSTRUCTION							
Construction (45)	-5.4	-2.0	-1.0	-2.3	-12.7	-11.4	-28.2
SERVICES							
Trade (50-52)	-6.0	-2.4	-0.9	-2.7	-17.0	-11.0	-40.1
Hotels and restaurants (55)	-6.2	-1.9	-0.6	-3.7	-11.1	-6.8	-31.1
Transport (60-63)	-7.3	-4.1	-1.0	-2.1	-20.7	-21.3	-31.2
Post and telecom. (64)	0.6	0.1	0.5	0.0	6.1	38.7	-2.0
Real estate activities (70)	9.5	9.7	-1.0	0.8	39.6	-7.6	7.8
Renting (71)	-13.3	-6.5	-0.6	-6.2	-39.0	-4.8	-60.1
Computer activities (72)	-13.5	-6.7	-2.3	-4.6	-48.4	-26.3	-49.0
R&D (73)	15.5	9.3	4.3	1.9	46.0	68.2	28.5
Legal services (741)	-5.4	-2.0	-1.2	-2.2	-11.6	-11.8	-22.1
Engineering serv. (742-743)	-3.9	-2.1	-0.5	-1.3	-14.7	-3.7	-25.8
Other bus. serv. (744-748)	9.1	5.0	2.6	1.5	31.7	36.8	19.6

Table A.4a. Augmented OP productivity decomposition by industry, %-

	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)=(2)+(3)+(4)	(2)	(3)	(4)
MANUFACTURING				
Food (15-16)	48.6	43.0	-1.1	6.7
Textiles (17-19)	12.8	8.1	-2.4	7.1
Wood (20)	34.5	24.9	0.0	9.6
Paper (21),	55.6	51.7	-2.3	6.3
Printing (22)	25.2	22.0	1.3	2.0
Chemicals (24)	8.7	-3.9	2.8	9.8
Rubber (25)	15.2	11.7	-1.2	4.7
Non-met. minerals (26)	5.8	1.0	-1.2	5.9
Basic metals (27)	41.0	29.2	4.2	7.5
Metal products (28)	17.4	15.6	-1.7	3.4
Machinery (29)	30.2	28.1	-1.1	3.2
Electr. mach.(30-31)	38.2	35.8	-1.3	3.8
Telec. equip.&instr. (32-33)	115.9	124.2	-15.2	6.9
Vehicles (34-35)	8.8	5.7	-2.0	5.1
Other manuf. (36-37)	6.6	4.9	-3.2	4.9
CONSTRUCTION				
Construction (45)	18.3	19.1	-3.8	3.0
SERVICES				
Trade (50-52)	30.0	21.2	2.4	6.5
Hotels and restaurants (55)	0.4	-0.1	-1.3	1.9
Transport (60-63)	29.5	26.0	-2.3	5.8
Post and telecom. (64)	-3.0	8.0	-4.1	-6.9
Real estate activities (70)	-9.7	-8.1	1.2	-2.9
Renting (71)	10.1	-0.4	7.8	2.7
Computer activities (72)	11.7	6.6	-0.8	5.9
R&D (73)	-7.4	-11.1	-4.5	8.2
Legal services (741)	11.0	15.1	-3.4	-0.7
Engineering serv. (742-743)	10.2	8.2	1.2	0.8
Other bus. serv. (744-748)	-27.0	-29.5	-1.7	4.2

Table A.4b. Augmented OP productivity decomposition by industry, contributions by firm groups, %-points

	Within groups (1)= (2)+(3)+(4)	Contribution of			Between groups (5)= (6)+(7)+(8)	Contribution of		
		entrants (2)	exits (3)	visitors (4)		entran (6)	exits (7)	visitors (8)
MANUFACTURING								
Food (15-16)	-1.1	-1.1	0.4	-0.4	6.7	2.5	1.1	3.1
Textiles (17-19)	-2.4	-0.5	-1.5	-0.4	7.1	0.7	1.6	4.8
Wood (20)	0.0	0.8	-0.4	-0.3	9.6	2.0	1.9	5.7
Paper (21),	-2.3	-2.0	0.0	-0.3	6.3	2.0	1.4	2.9
Printing (22)	1.3	1.8	-0.2	-0.3	2.0	0.0	0.4	1.6
Chemicals (24)	2.8	2.1	0.4	0.2	9.8	2.0	1.9	5.8
Rubber (25)	-1.2	-0.3	-0.6	-0.3	4.7	0.8	1.2	2.7
Non-met. minerals (26)	-1.2	-1.4	0.1	0.2	5.9	0.4	2.2	3.3
Basic metals (27)	4.2	-0.2	0.0	4.5	7.5	2.3	3.2	2.1
Metal products (28)	-1.7	-1.1	-0.2	-0.4	3.4	1.0	0.7	1.7
Machinery (29)	-1.1	-0.9	0.2	-0.4	3.2	0.8	0.7	1.7
Electr. mach.(30-31)	-1.3	0.2	-1.2	-0.3	3.8	1.3	0.4	2.0
Telec. equip.&instr. (32-33)	-15.2	-5.7	-8.1	-1.5	6.9	2.6	0.6	3.7
Vehicles (34-35)	-2.0	-3.1	1.0	0.1	5.1	1.5	0.4	3.2
Other manuf. (36-37)	-3.2	0.6	-3.7	-0.1	4.9	0.9	0.9	3.1
CONSTRUCTION								
Construction (45)	-3.8	-1.6	-0.7	-1.4	3.0	1.0	0.1	1.9
SERVICES								
Trade (50-52)	2.4	1.3	0.8	0.2	6.5	1.4	1.0	4.0
Hotels and restaurants (55)	-1.3	-0.1	-0.7	-0.6	1.9	0.2	0.4	1.3
Transport (60-63)	-2.3	-1.0	-0.6	-0.6	5.8	3.9	0.1	1.8
Post and telecom. (64)	-4.1	0.4	-3.7	-0.8	-6.9	-1.2	3.5	-9.2
Real estate activities (70)	1.2	1.3	-0.9	0.7	-2.9	-0.6	-0.4	-1.9
Renting (71)	7.8	5.1	1.1	1.7	2.7	1.3	-0.1	1.4
Computer activities (72)	-0.8	1.4	-1.2	-1.0	5.9	1.7	0.0	4.3
R&D (73)	-4.5	-1.4	-2.4	-0.7	8.2	1.7	-0.3	6.8
Legal services (741)	-3.4	-1.3	-1.3	-0.8	-0.7	-0.2	-0.2	-0.3
Engineering serv. (742-743)	1.2	0.7	0.4	0.2	0.8	0.1	0.0	0.7
Other bus. serv. (744-748)	-1.7	0.2	-2.9	1.1	4.2	1.6	-0.5	3.1

Table A.5. Decomposition of the contribution to the aggregate productivity level by plant groups

	Contribution of non-stayers	Contribution of			Productivity gap		
		entrants	exits	visit.	entrants	exits	visit.
	(1)= (2)+(3)+(4)	(2)	(3)	(4)	(5)	(6)	(7)
Manufacturing	-5.2	-1.9	-2.4	-1.0	-31.5	-27.4	-59.0
Construction	-8.3	-3.2	-1.8	-3.3	-19.7	-15.5	-36.3
Services	-5.2	-2.2	-1.3	-1.7	-13.9	-10.9	-27.8

Table A.6. Augmented Olley-Pakes productivity decomposition, plant data, %-points

Panel A: Manufacturing

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)=(2)+(3)+(4)	(2)	(3)	(4)
Total	36.9	33.5	-2.2	5.5
<u>*Contributions*</u>				
Entrants			*-1.0*	*1.4*
Exits			*-1.0*	*1.1*
Visitors			*-0.2*	*3.0*

Panel B: Construction

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)=(2)+(3)+(4)	(2)	(3)	(4)
Total	18.3	19.1	-3.8	3.0
<u>*Contributions*</u>				
Entrants			*-1.6*	*1.0*
Exits			*-0.7*	*0.1*
Visitors			*-1.4*	*1.9*

Panel C: Services

			Contibution of non-stayers	
	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)=(2)+(3)+(4)	(2)	(3)	(4)
Total	15.4	11.3	0.0	4.2
<u>*Contributions*</u>				
Entrants			*0.5*	*1.4*
Exits			*-0.4*	*0.5*
Visitors			*-0.1*	*2.2*

Notes: The numbers refer to the weighted average of industries within sector (weighted by the employment share of the industry) and the average of years 2000-2003, calculated by plant data. Components may not add up due to rounding.

Table A.7. Decomposition of the aggregate productivity level, manufacturing, sensitivity checks, %-points

	Contribution of	Contribution of			Productivity gap		
	non-stayers	entrants	exits	visit.	entrants	exits	visit.
	(1)= (2)+(3)+(4)	(2)	(3)	(4)	(5)	(6)	(7)
Cut-off threshold (*)							
more than 0	-3.4	-1.2	-1.3	-0.9	-30.6	-33.4	-51.4
at least 1	**-3.4**	**-1.2**	**-1.3**	**-0.9**	**-30.8**	**-33.2**	**-53.0**
more than 1	-3.3	-1.0	-1.4	-0.9	-29.4	-33.6	-51.9
at least 5	-3.2	-1.1	-1.3	-0.8	-30.2	-33.7	-48.4
at least 10	-3.2	-1.1	-1.3	-0.9	-28.3	-34.1	-48.6
at least 20	-3.5	-1.1	-1.4	-0.9	-29.4	-38.3	-48.4
Year (**)							
2000	-3.1	-1.2	-1.1	-0.8	-25.9	-27.9	-46.8
2001	-3.7	-1.2	-1.6	-0.9	-34.3	-37.6	-52.6
2002	-3.2	-0.9	-1.4	-0.9	-29.4	-33.7	-50.2
2003	-3.8	-1.3	-1.4	-1.1	-33.6	-33.7	-62.5
Average	**-3.4**	**-1.2**	**-1.3**	**-0.9**	**-30.8**	**-33.2**	**-53.0**

Note: Computations are made with firm data
(*) the average of years 2000-2003
(**) firms employing at least one person

Table A.8a. Augmented OP productivity decomposition, manufacturing sector, sensitivity checks, %-points

	OP(All)	OP(Stayers)	Within groups	Between groups
	(1)=(2)+(3)+(4)	(2)	(3)	(4)
Cut-off threshold (*)				
more than 0	33.8	30.0	-1.6	5.4
at least 1	**33.9**	**27.8**	**-1.1**	**7.2**
more than 1	31.7	27.3	-1.3	5.7
at least 5	27.2	24.2	-1.5	4.5
at least 10	25.6	23.5	-1.8	4.0
at least 20	25.2	22.3	-1.6	4.4
Year (**)				
2000	28.4	23.3	-1.0	6.1
2001	35.0	30.7	-1.6	5.9
2002	33.1	28.9	-1.2	5.4
2003	39.0	28.4	-0.6	11.2
Average	**33.9**	**27.8**	**-1.1**	**7.2**

Note: Computations are made with firm data

(*) the average of years 2000-2003

(**) firms employing at least one person