

Allocation and industry productivity: understanding the role of firm dynamics^{*}

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Abstract

We study the link between resource allocation and industry productivity paying special attention to the role of firm churning. 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 data. 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 policy distortions influence aggregate productivity. Changes in firms' entry and exit behaviour turn out to be important for understanding changes in aggregate productivity. We also explain why policy distortions that lower aggregate productivity may actually increase the standard Olley-Pakes covariance component.

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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 It has also been argued that differences in resource allocation between firms explain a large part of cross-country variation in aggregate productivity levels. There is evidence that in poor countries a large proportion of labour and other resources is employed by low productivity firms, although high productivity firms may be as productive as in the developed countries (Comin & Hobijn, 2004; Banerjee & Duflo, 2005; Hsieh & Klenow, 2009).

One explanation for the inefficient allocation of resources in poor countries is policies that distort allocation of resources between firms. Consistently with this view, some empirical evidence points to the importance of product market regulations or entry costs in explaining cross-country differences in productivity levels (Nicoletti & Scarpetta, 2003; Barseghyan, 2008). Further, the model-based analyses in Restuccia and Rogerson (2008), and Bartelsman, Haltiwanger and Scarpetta (2009b) show that certain type of policy distortions may indeed lower aggregate productivity substantially by making resource allocation between firms less efficient.

An important practical question is how to empirically measure the impact of productivity-deteriorating allocation distortions on the industry productivity level. Bartelsman et al. (2009a) advocate the use of the Olley-Pakes (1996) decomposition (hereafter OP decomposition). The OP decomposition splits the industry level productivity into an unweighted firm-level average and the covariance between firm size and productivity. The covariance component has been used as a measure of allocative efficiency.

The OP covariance term is an appealing measure of resource allocation 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

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

the low productivity firms move to high productivity firms. At the same time, both aggregate productivity and the covariance between firm size and productivity increase. Furthermore, it seems to do a good job in explaining development in transition countries or the effects of certain types of policy distortions (Bartelsman et al., 2009b).

However, two aspects suggest some limitations of the OP decomposition in productivity analysis. The first is an empirical one. Computations with harmonized firm-level data across countries indicate that the *level* of the covariance component is 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). These findings do not seem to give support to the conjecture that differences in resource allocation explain a large part of cross-country variation in aggregate productivity.

The second concern with the OP method is a theoretical one. 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 that productivity increasing changes in resource allocation always increase the OP covariance component. For instance, if a low productivity firm exits and its workers move to higher productivity firms, the covariance between firm size and productivity may well decrease.

In this paper we examine the effect of resource allocation on the industry productivity level paying special attention to the role of firm churning via entries and exits. To this end, we first consider how entrants and exiting firms contribute to aggregate productivity and the OP covariance term. 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 experimenters² and long-lived entrants as just entrants.

We present a decomposition of the industry productivity level which allows gauging the contributions of the experimenters, entrants and exiting firms to the industry productivity level. Further, we develop an augmented OP productivity decomposition method, which allows examining how experimenters, entrants and exiting firms contribute to the covariance component of the industry productivity level through a direct and an indirect channel. The direct effect of the entrants, for instance, depends on how much the covariance component among the entrants differs from that among the stayers. The indirect effect in turn depends on the size and productivity of the entrants relative to the size and productivity of the stayers.

We apply these productivity decompositions to Finnish data that cover basically all firms (and plants) in the business sector. The results show that experimenters and entrants have a *negative* effect on the industry productivity level. This is simply because their aggregate productivity level is lower than that of the stayers. However, our augmented OP decomposition method shows that the entrants have a *positive* contribution to the overall covariance component. This is because of the indirect effect: entrants and especially experimenters are, on average, relatively small firms with low productivity. The exiting firms have also an important role to play. They have a negative contribution to the aggregate industry productivity level. That is to say that if these firms had made their exit already, the current industry productivity level would be higher. On the other hand, they have a positive impact on the overall covariance component. 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.

Our empirical results with accounting methods illustrate the immediate contributions of entry and exit to aggregate productivity and the covariance component. To obtain a fuller understanding of the mechanisms and long-run effects of policies affecting entry and exit, we build a model of firm dynamics and use it to ana-

² Experimenters could also be described as immediate exits.

lyze how certain policy distortions affect firm dynamics and aggregate productivity.

Our model features richer dynamics than the models used in the previous literature on resource allocation, distortions, and aggregate productivity. In our model, both entry and exit decisions are endogenous. Previous related papers have used models with exogenous exit decisions.³

In addition, our model is consistent with the main patterns revealed by our empirical decompositions. In this respect, our model has three key features. First, we follow Hall and Hayashi (1989) and Jones (1995), among others, and assume that in order to grow, firms need to build ‘knowledge capital’ with R&D investments. Increasing knowledge capital requires both R&D investments and existing knowledge capital. As a result, firms can grow only gradually. This allows the model to replicate the fact that young firms are, on average, relative small. In a more standard model with a neoclassical production function, firms can typically scale their production up or down very rapidly.

Second, following Bartelsmann et al. (2009b), we assume that production requires overhead labour. This implies that even absent distortions, labour productivity varies across firms. This allows us to replicate the observed covariance component even without policy distortions. A standard production function with a competitive labour market would imply that all firms have the same labour productivity. Third, both firm entry and exit are determined endogenously (following Gomes, 2001). This allows us to take into account how different distortions affect aggregate productivity through changes in firm dynamics.

We use the model to experiment with three stylized distortions: an additional entry cost, an exit cost and an output tax that favours low productivity firms over high productivity firms. All these distortions lower the industry productivity level. However, both the entry and exit cost distortions actually increase the OP covari-

³ Rogerson and Restuccia (2008) use a model which is static in the sense that firm’s productivity does not change over time. Related to this, there is no churning. Bartelsmann et al. (2009) use a model with entry and exit but the exit decision is not modelled. Instead, firms face a constant exogenous probability that they exit.

ance component. This shows that the standard OP covariance component is not always a robust indicator of the efficiency of resource allocation.

Our augmented productivity decomposition method allows examining in more detail the mechanisms behind these changes in aggregate measures of productivity and allocation. They reveal that the decrease in aggregate productivity results solely from a decrease in the aggregate productivity of the stayer firms. The negative contribution of the entrants and the exiting firms to industry productivity is reduced in absolute terms. This latter effect mitigates the fall in industry productivity.

Even though it is the fall in the aggregate productivity of stayer firm that explains the decrease in aggregate productivity of all firms, we find that the OP covariance component among stayer firms actually increases with entry and exit distortions. At the same time, the contributions of non-stayer firms to the OP covariance component decrease.

As we will explain, all these observations relate to the fact that entry and exit distortions make low productivity firms less likely to exit. As a result, the productivity dispersion among stayer firms increases. Moreover, these low productivity firms enjoying an “extended life-cycle” are relatively small. Consequently, an increase in entry or exit cost leads to a higher covariance between productivity and firm size among the stayer firms. At the same time, extended life-cycles of some low productivity of stayer firms also lead to a lower aggregate productivity. This mechanism explains why the OP covariance may increase following the introduction of a policy distortion that lowers aggregate productivity of all firms.

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 analyze 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:

$$\Phi_t = \sum_{i \in \Omega} s_{it} \varphi_{it} \quad (1)$$

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

$$s_{it} = \frac{L_{it}}{\sum_{i \in \Omega} L_{it}} \quad (2)$$

$$\varphi_{it} = \ln \frac{Y_{it}}{L_{it}} \quad (3)$$

with L_{it} and Y_{it} denoting labor 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, Ilmakunnas, & Maliranta, 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 “experimenters” (Ω_E). The groups are thus mutually exclusive and it holds that $\Omega_S \cup \Omega_N \cup \Omega_X \cup \Omega_E = \Omega$.

< FIGURE 1 ABOUT HERE >

We assess the contribution of the non-stayers (i.e. the entrants, exits and experimenters) to industry productivity using two decompositions that are closely inter-related 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.⁴ 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 . Accordingly, the effect can be expressed as follows⁵:

$$\Phi_t - \Phi_t^S = \sum_Z \frac{L_t^Z}{L_t} (\Phi_t^Z - \Phi_t^S), \quad Z \in \{N, X, E\} \quad (4)$$

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

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

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_Z , $Z \in \{N, X, E\}$, and the stayers, i.e. $\Phi_t^Z - \Phi_t^S$, as well as the employment shares of the non-stayer firm groups, i.e. L_t^Z / L_t , $Z \in \{N, X, E\}$.

In what follows, we propose an augmented Olley-Pakes productivity decomposition method. It examines how the different non-stayer firm groups contribute to

⁴ 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). Hyytinen, Ilmakunnas and Maliranta (2010) considers statistical inference of this sort of productivity decompositions.

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;

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

Obviously, the same decomposition can be defined separately for each non-stayer firm group. Hence we have $\Phi_t^Z = \bar{\varphi}_t^Z + \text{cov}_t^Z$, $Z \in \{N, X, E, S\}$.

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

$$\Phi - \Phi^S = \bar{\varphi} - \bar{\varphi}^S + \text{cov} - \text{cov}^S \quad (6)$$

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 experimenters⁶;

$$\begin{aligned}\text{cov}_t - \text{cov}_t^S &= \\ &\left[\frac{L_t^N}{L_t} (\text{cov}_t^N - \text{cov}_t^S) \right] + \left[\frac{N_t^N}{N_t} \left(\frac{\bar{L}_t^N}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^N - \bar{\varphi}_t^S) \right] + \\ &\left[\frac{L_t^X}{L_t} (\text{cov}_t^X - \text{cov}_t^S) \right] + \left[\frac{N_t^X}{N_t} \left(\frac{\bar{L}_t^X}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^X - \bar{\varphi}_t^S) \right] + \\ &\left[\frac{L_t^E}{L_t} (\text{cov}_t^E - \text{cov}_t^S) \right] + \left[\frac{N_t^E}{N_t} \left(\frac{\bar{L}_t^E}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^E - \bar{\varphi}_t^S) \right] \\ &\quad \text{direct effects} \qquad \qquad \qquad \text{indirect effects}\end{aligned}\quad (7)$$

where N_t is the total number of firms active in year t and $\bar{L}_t = \frac{L_t}{N_t}$. N_t^Z denotes

the number of firms in the firm group Ω_Z , $\bar{L}_t^Z = \frac{L_t^Z}{N_t^Z}$ and $\bar{\varphi}_t^Z = \frac{\sum_{i \in \Omega_Z} \varphi_{it}}{N_t^Z}$,

$Z \in \{N, X, E\}$

⁵ For derivation of this equation, see Appendix.

Equation (7) shows that each of the non-stayer firm groups contributes to the covariance component by a direct effect, whose sign depends on the term

$(\text{cov}^Z - \text{cov}^S)$, and by an indirect effect, whose sign depends on the product

$\left(\frac{\bar{L}_t^Z}{\bar{L}_t} - 1\right)(\bar{\varphi}^Z - \bar{\varphi}^S)$. The latter effect is positive, for example, if the average firm

size is relatively small, $\frac{\bar{L}_t^Z}{\bar{L}_t} < 1$, and the average productivity is low, $\bar{\varphi}^Z < \bar{\varphi}^S$. The

magnitude of the direct effect depends on the employment share of the firm group,

i.e. $L_t^Z / L_t, Z \in \{N, X, E\}$, and the magnitude of the indirect effect depends on the

share of the firms, i.e. $N_t^Z / N_t, Z \in \{N, X, E\}$.

2.2 A numerical illustration

Figure 2 provides a graphical description of hypothetical data that can be examined by use of the decomposition formulas (4) and (7). The figure displays 11 firms of which 6 are stayers and 5 are non-stayers. The vertical axis represents employment and the horizontal axis the log of the productivity level. The figure contains three important aspects. First, firms are heterogeneous both in terms of size and productivity level. Second, both the average size and productivity level of the stayers are larger than those of the non-stayer firms. Third, the entrants have a larger productivity dispersion but a smaller size dispersion than the stayers (e.g. Haltiwanger, Jarmin, & Schank, 2003). Fourth, although the average (both un-weighted and weighted) of the non-stayer firms is lower than that of the stayers, the highest productivity level can be found amongst the non-stayer firms.

< FIGURE 2 ABOUT HERE >

Table 1 shows the results for the decomposition of the productivity level with formula (4). The contribution of the the non-stayers to the industry productivity level is -6.0%-points. This is a product of the negative productivity gap (-50.6%) between the aggregate productivity level of the non-stayers and stayers and the

⁶ Derivation of this equation is shown in Appendix.

employment share of the non-stayers (11.9%). In other words, without the non-stayers the industry productivity level would be 6.0% ($= -50.6\% \times 11.9\%$) higher.

Table 2 displays the decomposition of the covariance component with formula (7). The covariance component of all firms is 33.9%-points and the corresponding number of the stayer firms is 18.3%-points So, in the absence of the non-stayer firms the covariance component of the industry would 15.7%-points lower. This effect comes mainly from the indirect effect that is 16.0%-points.

< TABLE 1 ABOUT HERE >

< TABLE 2 ABOUT HERE >

2.3 Data

We use the Structural Business Statistics data that exhaustively cover basically all firms in the Finnish business sector in the period 1995-2008.⁷ 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.⁸ In our baseline analysis we have included 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

⁷ 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), telecommunication 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 telecommunications (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).

⁸ As for more detailed information, see http://www.stat.fi/meta/til/tetipa_en.html

include 107 082 firms and 1 013 161 persons per year (the average of the years 2000-2003).⁹

Table A.1 shows that the non-stayer firms (i.e. the entrants, exits and experimenters) account for a substantial fraction of the total number of firms; 46.5% 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% 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 can also be inferred from these figures that the relative size of the entrants and the experimenters is quite similar.

It should be noted that all sector-level results (i.e. those for the manufacturing, construction¹⁰ 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 and the impact of the industry structures is ignored. On the other hand, the industry-level results indicate a substantial amount of variation between industries within sectors.

2.4 Empirical results

Table A.2 in Appendix describes some important empirical patterns in our data concerning the heterogeneity in productivity. Variation in productivity levels between firms (within industries) is, indeed, remarkable. As indicated in the first column, the standard deviation of log productivity (i.e. log of 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 Manufacturing is -15.1 percent (in

⁹ 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.

¹⁰ However, note that the construction sector consists of a single industry.

log-units), and the corresponding gaps for the exiting firms and the experimenters are -14.3 and -37.2 percent, respectively. Quite 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 Construction and Services. However, the relative sizes of productivity gaps measured with un-weighted and weighted average in Services are other way around when compared to those in Manufacturing.

Table 3 displays 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 found above 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 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 probably reflect some particularly severe measurement problems.

< TABLE 3 ABOUT HERE >

To sum, these decompositions indicate that industries would perform better in terms of the productivity level without new firms (i.e. entrants and experimenters), at least in the short-run.¹¹

The results obtained by the use of the augmented Olley-Pakes decomposition, i.e. Equation (7), for Manufacturing and its industries are reported in Table 4A and the corresponding results for Construction and Services in Table 4B. The tables show that the group of the non-stayers generally has a positive contribution to the covariance component, i.e. the covariance term is larger among all firms than among the stayers. In Manufacturing the total effect is 6.1 percentage points

¹¹ It should be noted that as we use 5-year window in the analysis the entrants and experimenters may include firms that are 5 years old and the average age is around a couple of years.

which is almost one fifth of the total covariance component. More importantly, the indirect effect of the non-stayers is even larger being 7.2 percentage points. As explained above, the sector level results are the employment weighted averages from the industry-level results. However, given 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.

< TABLE 4A ABOUT HERE >

It is found that the experimenters contribute to the overall covariance component via the indirect mechanism by 3.7 percentage points in Manufacturing. This is a consequence the fact that experimenters are usually very small and have a very low productivity level (see also columns (6) and (10) in Table A1 and column (4) in Table A2 in Appendix 2). The indirect effect of the (long-lived) entrants to the overall covariance is also quite significant being 2.5 percentage points so that the indirect effect of the long-lived and short-lived entrants together is as large as 6.2 percentage points in Manufacturing.

The direct effect of the experimenters as well as other non-stayer groups is negative indicating that the relationship between the productivity level and the size is somewhat stronger among the stayers than among the non-stayer firm groups. Indeed, while the covariance component is 27.8% among the stayers in Manufacturing, the corresponding numbers for the entrants, exits and the experimenters are 12.2%, 9.0% and 10.0%, respectively (not reported in the table). In other words, the covariance component is one half or less among the new firms. However, the magnitudes of the direct effects are modest because the employment shares of non-stayer firm groups are rather small.

Similar analyses have been performed also for the construction sector and service sector. These results are reported in Table 4B. The results for the construction sector are broadly similar to those of the manufacturing sector except the effect of the non-stayers is somewhat larger mainly due to a slightly larger indirect effect. In the service sector the total effect is 13.7%. Again, the indirect effect dominates and the experimenters constitute the main part of it. Perhaps the main discrepancy

to the manufacturing sector is that now the direct component is positive. However, the industry level results give some indication that the results for the service sector may not be quite reliable. Some results are clearly out of line and highly suspicious, obviously for problems in measuring productivity in the service sector.

< TABLE 4B ABOUT HERE >

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 entries (and exits) that is needed for classifying the firms into the groups of stayers, entrants, exits and experimenters. In the course of our empirical analysis we noticed that the entrants and experimenters, 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. Clearly, it appears 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.¹² Importantly, we perceived that few artificial entrants may be quite consequential. 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 the robustness check we used 250 persons as an alternative criterion and found that the results were quite similar to those of our baseline analysis.¹³ This gives some confirmation to our view that our results are robust when few exceptional new firms are eliminated one way or another.

¹² Bartelsman, Haltiwanger and Scarpetta ¹² Bartelsman, Haltiwanger and Scarpetta (2009a) make a similar observation concerning the Finnish firm-data in their footnote 17.

¹³ 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.

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 experimenters. 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.3 in Appendix 2 and Table 4A (Table 4B) with Table A.4A (Table A.4B). First, the non-stayer firm groups have broadly similar negative contribution to the industry productivity levels. Second, the non-stayers and especially the experimenters have a large positive contribution to the covariance term via the indirect effect. Third, new firms (and exits) have a negative direct effect on the covariance term. This is because the covariance terms among the entrants, exits and experimenters 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 firms is, as in the case of the firm-level data, only one half that of the stayer firms. This means that according to the augmented OP productivity decomposition formula (7) these firms groups have a negative contribution to the overall covariance component via the direct component.

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 A3 (level decomposition) and Table A4 (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. Also the indirect effects go down but are, however, high with all alternative thresholds. As for the direct effects on the covariance term, the impact of excluding smaller firms is quite inconsequential.

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 reported also in Table A.3 and Table A.4. 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 experimenters.

The impacts on the results with the augmented OP decomposition method are not, however, quite clear. This is true especially for the direct 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 direct effect of the entrants on the overall covariance 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 .¹⁴ 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

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

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

¹⁴ 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. Jalava, Aulin-Ahmavaara, & Alanen, 2007; Corrado, Hulten, & Sichel, 2009)

OP covariance component.¹⁵ 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

$$a' = a^\nu r^{1-\nu} \quad (9)$$

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 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.

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:

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

¹⁵ 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.

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

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

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 $\varphi(z)$. After that, they decide whether to enter and start production.

All firms start with an initial knowledge capital level $\underline{a} > 0$.¹⁶ The free-entry condition reads as

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

As long as there is entry, this equation holds with equality. In that case, 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 $\bar{L} = 1$. 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 $(a, z) \in A \times Z$, $\mu(a, z)$ 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.

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

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

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

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:

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

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

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

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

¹⁶ Notice that the initial level of knowledge capital must be strictly positive. Otherwise the firm

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 set the share of knowledge capital in the production function, α , at $\alpha = 0.2$. This implies that roughly 20% of labour force is allocated to R&D. We interpret R&D broadly so that it includes a wide range of innovation activities performed in the firms.

We assume that the initial knowledge capital is very close to zero and set it at $a = 0.01$. We also assume that entrants' initial exogenous productivity state is drawn from a truncated normal distribution over $Z = [-4\sigma_z / \sqrt{1-\rho^2}, 4\sigma_z / \sqrt{1-\rho^2}]$. The standard deviation of the underlying normal distribution is denoted by σ_z .

We are left with the following 6 parameters: overhead labour, f , share of current knowledge capital in the accumulation equation, v , autocorrelation parameter, ρ , standard deviation of productivity shocks, σ_ε , entry cost, c_e , and σ_z .

We choose these parameters endogenously so as to match the OP covariance component, the contributions of different firm groups to the aggregate productivity level, and the employment shares of selected firm groups with our empirical baseline results for the manufacturing sector. In other words, we have the following targets: i) the OP covariance component for all firms, ii-iv) the contributions of entrants, exiting firms, and experimenters to aggregate productivity, v) the employment share of stayer firms, and vi) the employment share of experimenters.

Table 5 displays the targets and the calibrated parameter values. It shows that we roughly match all the targets. The calibration implies that overhead labor accounts for 4.2% of total labor while entry costs account for 0.34% of aggregate output.

< TABLE 5 ABOUT HERE >

could never start growing.

Table 6 presents the covariance decomposition (Equation (7)). The covariance component is 33.5 percentage points among all firms and 21.5 percentage points among stayers. The effect of the non-stayers is thus 11.9 percentage points. This effect comes almost entirely via the indirect mechanism leaving only a modest positive role for the direct mechanism. The further breakdown of the direct and indirect mechanisms by the firm groups shown in the lower panel of Table 6 indicates that the main part of the indirect mechanism can be attributed to exiting firms (4.4 percentage points).

< TABLE 6 ABOUT HERE >

The corresponding empirical results for the manufacturing sector are shown in Table 4A. In our view, the model replicates the results of our augmented OP decomposition quite well. Perhaps the main difference is that in the model the direct 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. However, the direct effect is close to zero both in the data and the model. The model economy also features too little dispersion in labor productivity. The standard deviation of labor productivity is 0.33 in the model and 0.576 in the data (see Table A.2).

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

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

and $\overline{\exp(z) a^\alpha}$ is the unweighted average of $\exp(z) a^\alpha$ in the benchmark economy and the parameter $0 \leq \chi \leq 1$ 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 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, the equilibrium wage rate, the OP covariance component, and the population and employment shares of different firm groups. The tax and subsidy considered corresponds to $\chi = 0.6$, the entry cost is increased from $c_e = 0.045$ to $c_e = 0.18$, and the exit cost is set at $c_{ex} = 0.40$. 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 ABOUT HERE >

Clearly, the output tax has the potential to lower aggregate productivity drastically. In our example, aggregate productivity falls by 27.8%. This decrease in aggregate productivity is associated with a large drop in the OP covariance component which decreases from 33.5% to 13.7%. Hence, the OP covariance component captures this distortion.

The entry and exit costs have much more moderate effects on aggregate productivity. The increase in the entry cost considered lowers aggregate productivity by 1.5% 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

churn. Eventually, the same set of firms would stay in the market forever and further increases in entry or exit costs would have no effect. Interestingly, however, both these distortions increase the OP covariance component substantially. In this sense, the OP covariance component fails to capture these distortions.

The output tax increases the equilibrium wage rate by 10.2%. It makes entry more attractive by subsidizing low technology firms. For the free entry condition to hold, the wage rate must therefore increase. The entry and exit costs in turn both lower the wage rate slightly. Clearly, a higher entry cost must be compensated with a lower wage rate since otherwise the free-entry condition would not hold anymore. The exit cost in turn lowers the expected value of entry which also must be compensated with a lower wage rate.

Table 7 also shows that all three distortions have a very large impact on the number of entrants, experimenters, and exits. With the output tax, the population shares of entries and exits (which are identical by construction) drop from 17.5% to 9.3% with the output tax while the share of experimenters drops from 8.8% to 1.0%. As it comes to the employment shares, the impacts are much smaller and even positive for the entrants and exiting firms. Hence the average size of entrants and exiting firms increases.

The effects of entry and exit costs differ significantly from that of the output tax. The decline in the population shares of entrants, experimenters and exiting firms is larger than in the case of the output tax. At the same, the employment shares of these firm groups fall even more. These numbers indicate that entry and exit costs decrease the average size of entrants and exiting firms. The effect of entry and exit costs is particularly dramatic for the employment share of the experimenters that goes almost to zero.

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 the output tax is 27.8 % lower 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 the comparison of the different model economies, we also display, in the last three rows, 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 2.7 percentage points higher with the exit cost.

< TABLE 8 ABOUT HERE >

It is the easiest to discuss the results by considering changes relative to the benchmark economy. The first column shows again the aggregate productivity effects of the distortions. The second column reveals that all three distortions lower the aggregate productivity of stayer firms. Relative to the benchmark economy, aggregate labor productivity among stayer firms is 26.4%, 4.1% and 3.6% lower with the output tax, the higher entry cost, and the exit cost, respectively. Hence, the entry and exit cost decrease the aggregate productivity of stayer firms much more than the aggregate productivity of all firms.

It is perhaps obvious that the output tax 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 taxes also have qualitatively the same effect. One reason is that they both decrease the equilibrium wage rate. A lower wage rate in turn 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 output tax also makes the contribution of the non-stayer firms to aggregate productivity more negative. That is, the output tax has a negative impact on aggregate productivity also via the contribution of the non-stayer firms. This effect

amounts to 1.4 percentage points at it is related to the exiting firms. The reason is twofold. On one hand, by providing a subsidy to low productivity firms, the output tax implies that firms at the end of their life-cycles, i.e. exiting firms, have even lower productivity than in the benchmark economy. On the other hand, as shown in Table 7, the output tax does not decrease the employment share of non-stayer firms.

Entry and exit costs in contrast decrease the negative contribution of non-stayer firms in absolute terms. 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 9 displays the augmented OP decomposition. Again, we also present changes relative to the benchmark economy. The first thing to note from the upper panel of Table 9 is that entry and exit costs increase whereas the output tax decreases the covariance component among stayer firms. The covariance component among stayer firms decreases by 8.6 percentage points with the output tax, but increases by 12.4 and 14.5 percentage points with a higher entry cost and the exit cost, respectively. On the other hand, all three distortions lower the contribution of non-stayer firms.

< TABLE 9 ABOUT HERE >

Again, the decrease in the covariance component among stayer firms following the introduction of the output tax is easy to understand. The output tax directly distorts the allocation of employment between these firms. It is more surprising that the entry and exit costs increase the covariance component among stayer firms. However, the same mechanism that explains why entry and exit costs lower the aggregate productivity of stayer firms, also explains why they increase the covariance term among those firms. By lowering the wage rate, entry and exit costs 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. These firms increase the covariance between firm size and productivity.

As can be seen in the third column of Table 9 the contribution of the non-stayer firms to the covariance component decreases in all three cases. We find that this decline is mainly due to the indirect mechanism. The reason is that the population shares of the non-stayer firms decline as a result of all three policy distortions and the contributions to the indirect component are dependent on the population shares (cf. Equation (7)).

For completeness, the lower panel of Table 9 presents the contributions of different non-stayer groups to the indirect and direct 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. The indirect mechanism falls drastically with all three distortions and it is always the decline in the contribution of experimenter firms that falls the most. Again, this is expected as all three policy distortions had particularly dramatic negative impact on the population share of the experimenters firms (see Table 7). To put it differently, all policy changes that have a large impact on the population share of the short-lived entrants (i.e. experimenter firms) seem to have an important effect on the covariance component of the OP productivity decomposition.

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 experimenters, entrants, exiting firms, and stayers. By experimenters 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 churning 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, experimenters, 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 that non-stayer firms are typically small and have a low productivity, which is captured by the *indirect component* in the augmented OP decomposition. On the other hand, resource allocation is less efficient among the non-stayer firm groups (i.e. entrants, experimenters and exiting firms) than among the stayers, which is indicated by the negative *direct component* of the non-stayer firm groups 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 consistent with the main patterns revealed by our productivity decompositions. We use the model to analyze 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 find 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 standard OP covariance measure.

Both entry and exit costs in turn can have only a modest negative effect on aggregate productivity. Their effect on aggregate productivity is mitigated by the fact that by reducing firm churning, they also reduce the employment share of entrants and experimenters 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, the covariance component increases.

As we discussed in the Introduction, the link between the level of the OP covariance component and aggregate productivity is not very strong in cross-country data. The OP covariance component is quite high in a number of poor countries. Our results show that this should not be interpreted as undermining the hypothesis that differences in resource allocation are important for explaining cross-country variation in aggregate productivity. We have shown why certain distortions – at least entry and exit costs – actually increase the OP covariance component.

More generally, our results stress the need to use structural models that can account for changes in firm dynamics. In particular, our results highlight the importance of taking both entry and exit decisions into account. As we explained, many of our results are closely related to changes in exit behaviour. Models where firm exit is exogenous miss these mechanisms by construction.

Although our model is capable of replicating many essential micro-level patterns revealed by our productivity decompositions in a satisfactory manner, it still leaves scope for improvement. For instance, the model seems to be incapable of producing the negative direct contribution of the entrants to the overall covariance component that we observe in the empirical analysis. An important direction in future research would be to incorporate other frictions into this type of models. Incorporating labour adjustment costs or some other frictions might help to replicate our empirical productivity decompositions even more accurately.

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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:

$$\Phi_t = \frac{L_t^S}{L_t} \Phi_t^S + \frac{L_t^N}{L_t} \Phi_t^N + \frac{L_t^X}{L_t} \Phi_t^X + \frac{L_t^E}{L_t} \Phi_t^E \quad (\text{A.1})$$

Inserting $\frac{L_t^S}{L_t} = 1 - \frac{L_t^N}{L_t} - \frac{L_t^X}{L_t} - \frac{L_t^E}{L_t}$ into (A.1) gives

$$\Phi_t - \Phi_t^S = \frac{L_t^N}{L_t} (\Phi_t^N - \Phi_t^S) + \frac{L_t^X}{L_t} (\Phi_t^X - \Phi_t^S) + \frac{L_t^E}{L_t} (\Phi_t^E - \Phi_t^S) \quad (\text{A.2})$$

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

$$\Phi_t - \Phi_t^S = \bar{\varphi}_t + \text{cov}_t - \bar{\varphi}_t^S - \text{cov}_t^S \quad (\text{A.3})$$

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

$$\text{cov}_t - \text{cov}_t^S = \Phi_t - \Phi_t^S - (\bar{\varphi}_t - \bar{\varphi}_t^S) \quad (\text{A.4})$$

We then have

$$\begin{aligned} \text{cov}_t - \text{cov}_t^S &= \\ &\left(\frac{L_t^S}{L_t} \Phi_t^S + \frac{L_t^N}{L_t} \Phi_t^N + \frac{L_t^X}{L_t} \Phi_t^X + \frac{L_t^E}{L_t} \Phi_t^E - \Phi_t^S \right) - \\ &\left(\frac{N_t^S}{N_t} \bar{\varphi}_t^S + \frac{N_t^N}{N_t} \bar{\varphi}_t^N + \frac{N_t^X}{N_t} \bar{\varphi}_t^X + \frac{N_t^E}{N_t} \bar{\varphi}_t^E - \bar{\varphi}_t^S \right) \\ &\Leftrightarrow \text{cov}_t - \text{cov}_t^S = \\ &\left[\frac{L_t^N}{L_t} (\Phi_t^N - \Phi_t^S) + \frac{L_t^X}{L_t} (\Phi_t^X - \Phi_t^S) + \frac{L_t^E}{L_t} (\Phi_t^E - \Phi_t^S) \right] - \\ &\left[\frac{N_t^N}{N_t} (\bar{\varphi}_t^N - \bar{\varphi}_t^S) + \frac{N_t^X}{N_t} (\bar{\varphi}_t^X - \bar{\varphi}_t^S) + \frac{N_t^E}{N_t} (\bar{\varphi}_t^E - \bar{\varphi}_t^S) \right] \end{aligned} \quad (\text{A.5})$$

By inserting the average employment we have

$$\begin{aligned} \text{cov}_t - \text{cov}_t^S = & \\ & \left[\frac{N_t^N \bar{L}_t^N}{N_t \bar{L}_t} (\Phi_t^N - \Phi_t^S) + \frac{N_t^X \bar{L}_t^X}{N_t \bar{L}_t} (\Phi_t^X - \Phi_t^S) + \frac{N_t^E \bar{L}_t^E}{N_t \bar{L}_t} (\Phi_t^E - \Phi_t^S) \right] - \\ & \left[\frac{N_t^N}{N_t} (\bar{\varphi}_t^N - \bar{\varphi}_t^S) + \frac{N_t^X}{N_t} (\bar{\varphi}_t^X - \bar{\varphi}_t^S) + \frac{N_t^E}{N_t} (\bar{\varphi}_t^E - \bar{\varphi}_t^S) \right] \end{aligned} \quad (\text{A.6})$$

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

$$\begin{aligned} \text{cov}_t - \text{cov}_t^S = & \\ & \left[\frac{N_t^N}{N_t} \left(\frac{\bar{L}_t^N}{\bar{L}_t} (\bar{\varphi}_t^N - \bar{\varphi}_t^S + \text{cov}_t^N - \text{cov}_t^S) - (\bar{\varphi}_t^N - \bar{\varphi}_t^S) \right) \right] + \\ & \left[\frac{N_t^X}{N_t} \left(\frac{\bar{L}_t^X}{\bar{L}_t} (\bar{\varphi}_t^X - \bar{\varphi}_t^S + \text{cov}_t^X - \text{cov}_t^S) - (\bar{\varphi}_t^X - \bar{\varphi}_t^S) \right) \right] + \\ & \left[\frac{N_t^E}{N_t} \left(\frac{\bar{L}_t^E}{\bar{L}_t} (\bar{\varphi}_t^E - \bar{\varphi}_t^S + \text{cov}_t^E - \text{cov}_t^S) - (\bar{\varphi}_t^E - \bar{\varphi}_t^S) \right) \right] \end{aligned} \quad (\text{A.7})$$

which finally gives us the following equation

$$\begin{aligned} \text{cov}_t - \text{cov}_t^S = & \\ & \left[\frac{L_t^N}{L_t} (\text{cov}_t^N - \text{cov}_t^S) \right] + \left[\frac{N_t^N}{N_t} \left(\frac{\bar{L}_t^N}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^N - \bar{\varphi}_t^S) \right] + \\ & \left[\frac{L_t^X}{L_t} (\text{cov}_t^X - \text{cov}_t^S) \right] + \left[\frac{N_t^X}{N_t} \left(\frac{\bar{L}_t^X}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^X - \bar{\varphi}_t^S) \right] + \\ & \left[\frac{L_t^E}{L_t} (\text{cov}_t^E - \text{cov}_t^S) \right] + \left[\frac{N_t^E}{N_t} \left(\frac{\bar{L}_t^E}{\bar{L}_t} - 1 \right) (\bar{\varphi}_t^E - \bar{\varphi}_t^S) \right] \end{aligned} \quad (\text{A.8})$$

Appendix 2. Additional tables

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

	Number of firms (1)	Number of persons (2)	Share of the firms (%)				Employment share (%)			
			Stayers (3)	Entrants (4)	Exits (5)	Exp. (6)	Stayers (7)	Entrants (8)	Exits (9)	Exp. (10)
By sectors										
<i>Manufacturing</i>	14 993	350 301	53.5	21.6	12.7	12.2	86.6	5.3	5.8	2.3
<i>Construction</i>	17 413	108 656	35.2	34.8	9.0	20.9	67.0	15.6	9.1	8.2
<i>Services</i>	74 677	554 204	33.1	35.1	10.5	21.4	69.9	15.0	7.8	7.3
TOTAL	107 082	1 013 161								
By industries										
<i>MANUFACTURING</i>										
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), Printing (22)	150	38 045	72.9	10.6	9.9	6.7	98.5	0.7	0.6	0.2
Chemicals (24)	1 642	28 087	52.8	18.9	17.0	11.3	83.5	5.4	8.8	2.3
Rubber (25)	201	12 625	60.9	18.9	11.9	8.3	92.7	3.7	3.0	0.6
Non-met. minerals (26)	504	14 707	58.7	17.9	14.2	9.2	87.0	4.8	6.4	1.7
Basic metals (27)	551	13 736	55.2	20.9	12.8	11.1	87.3	5.1	5.7	1.9
Metal products (28)	111	15 043	59.9	16.6	16.8	6.7	94.8	2.0	2.8	0.5
Machinery (29)	3 008	35 383	51.5	23.8	11.9	12.8	75.3	10.2	10.4	4.0
Electr. mach.(30-31)	2 089	46 438	49.3	24.9	12.1	13.7	85.1	6.0	6.1	2.7
Telec. equip.&instr. (32-33)	384	12 014	57.1	19.0	14.4	9.6	83.2	6.9	7.2	2.8
Vehicles (34-35)	752	37 200	51.8	25.0	11.8	11.4	93.2	2.8	2.9	1.1
Other manuf. (36-37)	524	18 061	49.3	25.0	9.4	16.3	91.0	4.1	3.1	1.8
<i>CONSTRUCTION</i>	1 384	13 129	45.5	25.7	12.0	16.8	75.0	9.9	9.8	5.4
Construction (45)	17 413	108 656	35.2	34.8	9.0	20.9	67.0	15.6	9.1	8.2
<i>SERVICES</i>										
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 restaurants (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 telecommunica- tions (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 services (742- 743)	3 893	26 438	42.3	30.6	12.2	15.0	67.7	14.4	12.5	5.3
Other business services (744-748)	5 872	55 130	27.2	36.5	10.4	25.9	69.3	15.6	7.4	7.7

Note: The sector level numbers for the shares of the number of the firms and employment are employment weighted averages of the industry level numbers.

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

	std of log productivity (%) (1)	Productivity gaps to the stayers (%)					
		Unweighed average			Weighted average		
		Entrants (2)	Exits (3)	Exp. (4)	Entrants (5)	Exits (6)	Exp. (7)
By sectors							
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
By industries							
<i>MANUFACTURING</i>							
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), Printing (22)	59.0	-22.5	-21.1	-60.8	-51.9	-68.2	-91.5
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
<i>CONSTRUCTION</i>							
Construction (45)	53.5	-8.0	-9.9	-19.8	-12.7	-11.4	-28.2
<i>SERVICES</i>							
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 telecommunications (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 services (742-743)	58.2	-12.6	-13.1	-27.3	-14.7	-3.7	-25.8
Other business services (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 level, plants

	Effect of the non-stayers (%) (1)	Contribution of		
		entrants (2)	exits (3)	exp. (4)
By sectors				
Manufacturing	-5.2	-1.9	-2.4	-1.0
Construction	-8.3	-3.2	-1.8	-3.3
Services	-5.2	-2.2	-1.3	-1.7
By industries				
<i>MANUFACTURING</i>				
Mining (15-16)	-4.6	-1.9	-1.8	-0.9
Textiles (17-19)	-6.5	-0.8	-4.2	-1.5
Wood (20)	-4.6	-0.4	-2.5	-1.7
Paper (21), Printing (22)	-5.0	-3.4	-1.1	-0.5
Chemicals (24)	-2.6	0.6	-2.4	-0.7
Rubber (25)	-4.3	-0.8	-2.3	-1.2
Non-met. minerals (26)	-2.8	-1.8	-0.6	-0.4
Basic metals (27)	3.2	-0.7	-0.4	4.3
Metal products (28)	-5.3	-2.2	-1.6	-1.5
Machinery (29)	-3.2	-1.5	-0.6	-1.1
Electr. mach.(30-31)	-4.4	-1.4	-2.3	-0.8
Telec. equip.&instr. (32-33)	-19.5	-7.0	-9.9	-2.6
Vehicles (34-35)	-3.5	-3.7	0.8	-0.6
Other manuf. (36-37)	-7.0	0.0	-5.4	-1.5
<i>CONSTRUCTION</i>				
Construction (45)	-7.1	-2.8	-1.5	-2.7
<i>SERVICES</i>				
Trade (50-52)	-7.9	-4.6	-1.2	-2.1
Hotels and restaurants (55)	22.7	4.4	4.4	13.9
Transport (60-63)	8.8	5.2	0.7	2.9
Post and telecommunications (64)	0.4	0.9	0.8	-1.4
Real estate activities (70)	-14.2	-4.3	-1.5	-8.5
Renting (71)	-15.2	-6.8	-1.6	-6.8
Computer activities (72)	-1.0	-0.6	-0.5	0.1
R&D (73)	0.3	0.5	0.3	-0.5
Legal services (741)	-9.5	-3.0	-4.5	-2.0
Engineering services (742-743)	-6.2	-2.8	-1.5	-1.9
Other business services (744-748)	-4.3	-2.1	-1.5	-0.8

Notes: The numbers are the average over the period 2000-2003. Computations are performed with data including all plants employing at least one person.

TABLE A.4A. Decomposition of allocation component of labor productivity by industries, the manufacturing sector, plants

	All	Stayers	Difference	Components of direct effect					Components of indirect effect			
				Total effect (3)=(1)- (2)=(4)+(8)	Direct effect (4)=(5)+(6)+(7)	Entrants (5)	Exits (6)	Exp. (7)	Indirect effect (8)=(9)+(10)+(11)	Entrants (9)	Exits (10)	Exp. (11)
	(1)	(2)										
MANUFACTURING SECTOR	36.8	33.5	3.3	-2.2	-1.0	-1.0	-0.2	5.5	1.4	1.1	3.0	
Manufacturing industries												
Food (15-16)	48.6	43.0	5.6	-1.1	-1.1	0.4	-0.4	6.7	2.5	1.1	3.1	
Textiles (17-19)	12.8	8.1	4.7	-2.4	-0.5	-1.5	-0.4	7.1	0.7	1.6	4.8	
Wood (20)	34.5	24.9	9.6	0.0	0.8	-0.4	-0.3	9.6	2.0	1.9	5.7	
Paper (21), Printing (22)	55.6	51.7	4.0	-2.3	-2.0	0.0	-0.3	6.3	2.0	1.4	2.9	
Chemicals (24)	25.2	22.0	3.2	1.3	1.8	-0.2	-0.3	2.0	0.0	0.4	1.6	
Rubber (25)	8.7	-3.9	12.6	2.8	2.1	0.4	0.2	9.8	2.0	1.9	5.8	
Non-met. minerals (26)	15.2	11.7	3.5	-1.2	-0.3	-0.6	-0.3	4.7	0.8	1.2	2.7	
Basic metals (27)	5.8	1.0	4.8	-1.2	-1.4	0.1	0.2	5.9	0.4	2.2	3.3	
Metal products (28)	41.0	29.2	11.8	4.2	-0.2	0.0	4.5	7.5	2.3	3.2	2.1	
Machinery (29)	17.4	15.6	1.7	-1.7	-1.1	-0.2	-0.4	3.4	1.0	0.7	1.7	
Electr. mach.(30-31)	30.2	28.1	2.1	-1.1	-0.9	0.2	-0.4	3.2	0.8	0.7	1.7	
Telec. equip.&instr. (32-33)	38.2	35.8	2.5	-1.3	0.2	-1.2	-0.3	3.8	1.3	0.4	2.0	
Vehicles (34-35)	115.9	124.2	-8.3	-15.2	-5.7	-8.1	-1.5	6.9	2.6	0.6	3.7	
Other manuf. (36-37)	8.8	5.7	3.1	-2.0	-3.1	1.0	0.1	5.1	1.5	0.4	3.2	
	6.6	4.9	1.7	-3.2	0.6	-3.7	-0.1	4.9	0.9	0.9	3.1	

Notes: The numbers are the average over the period 2000-2003. Computations are performed with data including all plants including at least one person.

TABLE A.4B. Decomposition of allocation component of labor productivity by industries, the construction and service sector, plants

	All	Stayers	Difference		Components of direct effect			Indirect effect	Components of indirect effect		
			Total effect (3)=(1)-(2) =(4)+(8)	Direct effect (4)=(5)+(6)+(7)	Entrants (5)	Exits (6)	Exp. (7)		Entrants (9)	Exits (10)	Exp. (11)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONSTRUCTION SECTOR	18.3	19.1	-0.8	-3.8	-1.6	-0.7	-1.4	3.0	1.0	0.1	1.9
SERVICE SECTOR	15.4	11.3	4.1	-0.0	0.5	-0.4	-0.1	4.2	1.4	0.5	2.2
Service industries											
Trade (50-52)	30.0	21.2	8.8	2.4	1.3	0.8	0.2	6.5	1.4	1.0	4.0
Hotels and restaurants (55)	0.4	-0.1	0.5	-1.3	-0.1	-0.7	-0.6	1.9	0.2	0.4	1.3
Transport (60-63)	29.5	26.0	3.5	-2.3	-1.0	-0.6	-0.6	5.8	3.9	0.1	1.8
Post and telecommunications (64)	-3.0	8.0	-11.0	-4.1	0.4	-3.7	-0.8	-6.9	-1.2	3.5	-9.2
Real estate activities (70)	-9.7	-8.1	-1.7	1.2	1.3	-0.9	0.7	-2.9	-0.6	-0.4	-1.9
Renting (71)	10.1	-0.4	10.5	7.8	5.1	1.1	1.7	2.7	1.3	-0.1	1.4
Computer activities (72)	11.7	6.6	5.2	-0.8	1.4	-1.2	-1.0	5.9	1.7	0.0	4.3
R&D (73)	-7.4	-11.1	3.7	-4.5	-1.4	-2.4	-0.7	8.2	1.7	-0.3	6.8
Legal services (741)	11.0	15.1	-4.1	-3.4	-1.3	-1.3	-0.8	-0.7	-0.2	-0.2	-0.3
Engineering services (742-743)	10.2	8.2	2.0	1.2	0.7	0.4	0.2	0.8	0.1	0.0	0.7
Other business services (744-748)	-27.0	-29.5	2.6	-1.7	0.2	-2.9	1.1	4.2	1.6	-0.5	3.1

Notes: The numbers are the average over the period 2000-2003. Computations are performed with data including all plant employing at least one person.

Table A.5 Decomposition of the productivity level, sensitivity checks

	Effect of the non-stayers (%) (1)	Contribution of		
		entrants (2)	exits (3)	exp. (4)
<u>Cut-off threshold (*)</u>				
more than 0	-3.4	-1.2	-1.3	-0.9
at least 1	-3.4	-1.2	-1.3	-0.9
more than 1	-3.3	-1.0	-1.4	-0.9
at least 5	-3.2	-1.1	-1.3	-0.8
at least 10	-3.2	-1.1	-1.3	-0.9
at least 20	-3.5	-1.1	-1.4	-0.9
<u>Year (**)</u>				
2000	-3.1	-1.2	-1.1	-0.8
2001	-3.7	-1.2	-1.6	-0.9
2002	-3.2	-0.9	-1.4	-0.9
2003	-3.8	-1.3	-1.4	-1.1
Average	-3.4	-1.2	-1.3	-0.9

Notes: The computations for the manufacturing sector. The baseline results are bolded.

(*) the average of years 2000-2003

(**) firms employing at least one person

TABLE A.6. Decomposition of the covariance term, sensitivity checks

			Difference	Components of direct effect			Indirect effect	Components of indirect effect			
	All	Stayers	Total effect (3)=(1)-(2) =(4)+(8)	Direct effect (4)=(5)+(6)+(7)	Entrants	Exits		Exp.	Entrants	Exits	Exp.
	(1)	(2)			(5)	(6)	(7)	(8)=(9)+(10)+(11)	(9)	(10)	(11)
<u>Cut-off threshold (*)</u>											
more than 0	33.8	30.0	3.7	-1.6	-0.7	-0.6	-0.4	5.4	1.7	0.9	2.8
at least 1	33.9	27.8	6.1	-1.1	-0.4	-0.5	-0.2	7.2	2.5	1.0	3.7
more than 1	31.7	27.3	4.4	-1.3	-0.5	-0.6	-0.2	5.7	1.5	1.3	2.9
at least 5	27.2	24.2	3.0	-1.5	-0.6	-0.7	-0.2	4.5	1.4	1.2	1.9
at least 10	25.6	23.5	2.1	-1.8	-0.7	-0.7	-0.3	4.0	0.9	1.0	2.1
at least 20	25.2	22.3	2.8	-1.6	-0.6	-0.5	-0.4	4.4	1.0	1.7	1.7
<u>Year (**)</u>											
2000	28.4	23.3	5.1	-1.0	-0.4	-0.5	-0.2	6.1	3.0	0.7	2.4
2001	35.0	30.7	4.3	-1.6	-0.6	-0.8	-0.3	5.9	1.7	1.0	3.2
2002	33.1	28.9	4.2	-1.2	-0.5	-0.5	-0.2	5.4	1.0	1.3	3.1
2003	39.0	28.4	10.7	-0.6	-0.2	-0.3	0.0	11.2	4.2	0.9	6.1
Average	33.9	27.8	6.1	-1.1	-0.4	-0.5	-0.2	7.2	2.5	1.0	3.7

Notes: The computations for the manufacturing sector. The baseline results are bolded.

(*) the average of years 2000-2003

(**) firms employing at least one person

TABLES

Table 1. Decomposition of the productivity level, hypothetical data (%).

The effect of non-stayers	Productivity gap	Employment share
(1)=(2)x(3)	(2)	(3)
-6.0	-50.6	11.9

Note: Decomposition is made by applying formula (4)

Table 2. Decomposition of the covariance component, hypothetical data (%-points)

Covariance		The effect of	The form of effect	
All	Stayers	the non-stayers	direct	indirect
(1)	(2)	(3)=(1)-(2)=(4)+(5)	(4)	(5)
33.9	18.3	15.7	-0.3	16.0

Note: Decomposition is made by applying formula (7)

Table 3. Decomposition of the productivity level, averages over the period 2000-2003, firms

	Effect of the non-stayers (%) (1)	Contribution of		
		entrants (2)	exits (3)	exp. (4)
By sectors				
Manufacturing	-3.4	-1.2	-1.3	-0.9
Construction	-5.4	-2.0	-1.0	-2.3
Services	-4.0	-1.5	-0.5	-2.0
By industries				
<i>MANUFACTURING</i>				
Food (15-16)	-4.9	-1.6	-2.0	-1.3
Textiles (17-19)	-7.1	-2.0	-3.5	-1.7
Wood (20)	-3.9	-1.0	-1.0	-1.8
Paper (21), Printing (22)	-1.0	-0.4	-0.4	-0.2
Chemicals (24)	-2.1	-1.0	-0.9	-0.2
Rubber (25)	-1.8	-0.5	-0.8	-0.5
Non-met. minerals (26)	-3.6	-2.2	-0.6	-0.8
Basic metals (27)	-2.0	-0.8	-0.9	-0.2
Metal products (28)	-3.7	-1.1	-1.6	-1.0
Machinery (29)	-3.2	-1.0	-1.5	-0.8
Electr. mach.(30-31)	-3.9	-1.2	-1.4	-1.3
Telec. equip.&instr. (32-33)	-5.0	-1.8	-2.1	-1.1
Vehicles (34-35)	-1.5	-0.4	-0.3	-0.8
Other manuf. (36-37)	-4.8	-1.7	-1.4	-1.7
<i>CONSTRUCTION</i>				
Construction (45)	-5.4	-2.0	-1.0	-2.3
<i>SERVICES</i>				
Trade (50-52)	-6.0	-2.4	-0.9	-2.7
Hotels and restaurants (55)	-6.2	-1.9	-0.6	-3.7
Transport (60-63)	-7.3	-4.1	-1.0	-2.1
Post and telecommunications (64)	0.6	0.1	0.5	0.0
Real estate activities (70)	9.5	9.7	-1.0	0.8
Renting (71)	-13.3	-6.5	-0.6	-6.2
Computer activities (72)	-13.5	-6.7	-2.3	-4.6
R&D (73)	15.5	9.3	4.3	1.9
Legal services (741)	-5.4	-2.0	-1.2	-2.2
Engineering services (742-743)	-3.9	-2.1	-0.5	-1.3
Other business services (744-748)	9.1	5.0	2.6	1.5

TABLE 4A. Decomposition of allocation component of labor productivity by industries, the manufacturing sector, firms

	All (1)	Stayers (2)	Difference		Components of direct effect			Indirect effect (8)=(9)+(10)+(11)	Components of indirect effect		
			Total effect (3)=(1)- (2)=(4)+(8)	Direct effect (4)=(5)+(6)+(7)	Entrants (5)	Exits (6)	Exp. (7)		Entrants (9)	Exits (10)	Exp. (11)
MANUFACTURING SECTOR	33.9	27.8	6.1	-1.1	-0.4	-0.5	-0.2	7.2	2.5	1.0	3.7
Manufacturing industries											
Food (15-16)	33.9	25.2	8.7	-1.9	-0.8	-0.8	-0.3	10.7	3.6	1.3	5.7
Textiles (17-19)	26.3	15.7	10.7	-0.9	-0.5	-0.4	-0.1	11.6	3.6	1.2	6.8
Wood (20)	18.5	10.7	7.9	0.4	0.4	0.1	-0.2	7.5	2.5	0.7	4.3
Paper (21), Printing (22)	63.8	55.9	7.9	-0.6	-0.2	-0.3	-0.1	8.4	2.2	2.0	4.2
Chemicals (24)	24.7	19.1	5.5	-0.5	-0.4	0.1	-0.3	6.0	2.1	0.9	3.0
Rubber (25)	44.1	31.5	12.5	0.1	0.3	-0.3	0.2	12.4	5.9	2.0	4.4
Non-met. minerals (26)	19.7	12.6	7.1	0.8	0.3	0.3	0.2	6.3	2.1	1.4	2.7
Basic metals (27)	32.7	25.0	7.8	-1.3	-0.9	-0.5	0.1	9.1	4.4	0.1	4.6
Metal products (28)	40.6	37.6	3.0	-1.5	-0.6	-0.9	0.0	4.5	1.7	0.3	2.5
Machinery (29)	6.1	3.1	3.0	-0.8	-0.2	-0.5	0.0	3.8	1.3	0.2	2.3
Electr. mach.(30-31)	19.4	16.5	2.9	-1.5	-0.5	-0.7	-0.2	4.4	1.6	0.7	2.1
Telec. equip.&instr. (32-33)	16.8	12.8	4.0	-1.2	-0.3	-0.7	-0.2	5.2	1.6	0.8	2.8
Vehicles (34-35)	78.9	76.0	3.0	-4.0	-1.5	-1.7	-0.8	7.0	2.0	1.5	3.5
Other manuf. (36-37)	12.9	6.4	6.5	-0.3	0.0	0.0	-0.3	6.8	2.5	0.3	4.0
	18.3	7.4	10.9	1.5	0.5	0.2	0.8	9.4	3.8	0.3	5.4

Notes: The numbers are the average over the period 2000-2003. Computations are performed with data including all firms employing at least one person.

TABLE 4B. Decomposition of allocation component of labor productivity by industries, the construction and service sector, firms

	All	Stayers	Difference		Components of direct effect			Indirect effect	Components of indirect effect		
			Total effect (3)=(1)- (2)=(4)+(8)	Direct effect (4)=(5)+(6)+(7)	Entrants (5)	Exits (6)	Exp. (7)		Entrants (9)	Exits (10)	Exp. (11)
	(1)	(2)						(8)=(9)+(10)+(11)			
CONSTRUCTION SEC- TOR	6.8	4.2	2.6	-1.6	-0.7	-0.2	-0.7	4.2	1.6	0.0	2.6
SERVICE SECTOR	13.2	-0.4	13.7	3.2	1.5	0.8	0.9	10.5	4.3	0.5	5.7
Service industries											
Trade (50-52)	23.0	6.6	16.3	3.7	1.6	1.0	1.1	12.7	4.9	0.7	7.1
Hotels and restaurants (55)	16.2	0.7	15.5	3.9	1.8	0.9	1.2	11.6	3.4	0.4	7.8
Transport (60-63)	14.9	7.1	7.7	-1.4	-0.7	-0.4	-0.4	9.2	5.9	0.0	3.3
Post and telecommunica- tions (64)	0.7	-14.2	14.9	1.8	0.5	0.7	0.6	13.1	5.4	0.9	6.7
Real estate activities (70)	15.0	8.4	6.6	7.0	7.6	-1.4	0.8	-0.4	-0.6	0.0	0.2
Renting (71)	35.4	20.3	15.1	0.5	-0.6	0.9	0.2	14.6	5.3	0.7	8.6
Computer activities (72)	22.0	13.9	8.1	-4.6	-3.1	-0.7	-0.8	12.7	5.4	0.7	6.6
R&D (73)	-20.8	-43.2	22.5	17.2	10.2	3.6	3.4	5.3	1.4	0.3	3.6
Legal services (741)	11.7	7.7	4.1	0.0	-0.2	-0.1	0.3	4.1	1.4	0.2	2.5
Engineering services (742- 743)	11.2	5.3	5.9	1.0	-0.3	1.2	0.1	4.9	2.1	0.0	2.8
Other business services (744-748)	-24.9	-48.9	24.0	14.6	7.4	3.4	3.9	9.3	3.3	0.3	5.7

Notes: The numbers are the average over the period 2000-2003. Computations are performed with data including all firms employing at least one person.

Table 5. Parameter values and calibrated targets

Parameter values		Targets (%)	Model	Data
f (overhead)	0.31	covariance term	33.5	33.9
v (knowledge capital share in R&D)	0.63	contribution of entrants	-1.4	-1.2
	0.65	contribution of exiting firms	-1.3	-1.3
ρ (autocorrelation term for productivity)	0.31	contribution of experimenters	-0.7	-0.9
σ_e (std. productivity shocks)	0.29	employment share of stayer firms	84.5	86.6
σ_z (std. of initial productivity)	0.04	employment share of experimenters	1.5	2.3
c_e (entry cost)				

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

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

a)

Covariance		Effect of non-stayers	Mechanism	
all	stayers		Direct	Indirect
33.5	21.5	11.9	1.5	10.5

b)

Direct effect	Contribution of			Indirect effect	Contribution of		
	entry	exit	exp.		entry	exit	exp.
1.5	0.5	0.9	0.1	10.5	2.1	4.4	4.0

Table 7. Productivity, covariance, and churning: the effect of distortions (%).

	Benchmark	Output tax	Entry cost	Exit cost
Change in aggregate productivity (%)	0.0	-27.8	-1.5	-0.9
Change in wage level (%)	0.0	10.2	-1.4	-0.3
Covariance component	33.5	13.7	39.4	39.8
Population shares:				
Stayers	56.4	80.4	89.9	91.7
Entrants	17.5	9.3	4.8	4.1
Exits	17.5	9.3	4.8	4.1
Experimenters	8.8	1.0	0.5	0.3
Employment shares:				
Stayers	84.5	83.7	97.8	97.8
Entrants	8.2	8.6	1.3	1.5
Exits	5.9	7.0	0.9	0.7
Experimenters	1.5	0.7	0.1	0.0

Table 8. Decomposition of the productivity level, benchmark vs. distortions (%-points) .

	Aggregate prod.			Contribution of		
	All	Stayers	non-stayers	entry	exit	exp.
Benchmark	0	3.5	-3.5	-1.4	-1.3	-0.8
Output tax	-27.8	-23.0	-4.8	-1.2	-3.3	-0.4
High entry cost	-1.5	-0.6	-0.9	-0.4	-0.4	-0.1
Exit cost	-0.9	-0.1	-0.7	-0.3	-0.4	0.0
Change						
Output tax	-27.8	-26.4	-1.4	0.2	-1.9	0.4
High entry cost	-1.5	-4.1	2.6	1.0	0.9	0.7
Exit cost	-0.9	-3.6	2.7	1.1	0.9	0.7

Table 9. Decomposition of the covariance component, benchmark vs. distortions (%-points).

a) The effect and mechanisms

	Covariance		Effect of non stayers	Mechanism	
	All	Stayers		Direct	Indirect
Benchmark	33.5	21.5	11.9	1.5	10.5
Tax and subsidy	13.7	13.0	0.7	-0.6	1.2
High entry cost	39.4	33.9	5.4	0.4	5.0
Exit cost	39.8	36.0	3.9	0.2	3.6
Change					
Tax and subsidy	-19.8	-8.6	-11.3	-2.0	-9.3
High entry cost	5.9	12.4	-6.5	-1.1	-5.4
Exit cost	6.4	14.5	-8.1	-1.2	-6.9

b) The contribution of the firm groups to the direct and indirect mechanism

	Direct mechanism		Contribution of		Indirect mechanism		Contribution of	
	entry	exit	entry	exit	entry	exit	entry	exit
Benchmark	1.5	0.5	0.9	0.1	10.5	2.1	4.4	4.0
Tax and subsidy	-0.6	-0.3	-0.2	0.0	1.2	0.1	1.0	0.1
High entry cost	0.4	0.1	0.2	0.0	5	1.4	3.1	0.5
Exit cost	0.2	0.0	0.2	0.0	3.6	0.5	2.9	0.2
Change								
Tax and subsidy	-2.0	-0.8	-1.1	-0.1	-9.3	-2.0	-3.4	-3.9
High entry cost	-1.1	-0.3	-0.7	-0.1	-5.4	-0.7	-1.3	-3.4
Exit cost	-1.2	-0.5	-0.7	-0.1	-6.9	-1.6	-1.5	-3.8

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

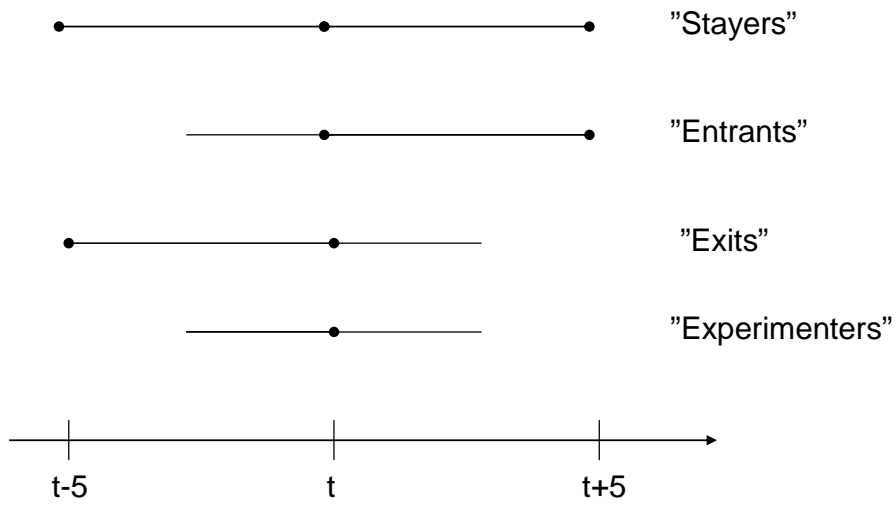


Figure 2. Productivity and employment in firms, an illustrative example

