Labor productivity and reallocation in Finland 2000-2018

Paolo Fornaro, Natalia Kuosmanen, Timo Kuosmanen, Terhi Maczulskij

PUBLICATIONS OF THE GOVERNMENT'S ANALYSIS, ASSESSMENT AND RESEARCH ACTIVITIES 2021:73

tietokayttoon.fi/en

Government's analysis, assessment and research activities

FINNISH GOVERNMENT

Publications of the Government´s analysis, assessment and research activities 2021:73

Labor productivity and reallocation in Finland 2000-2018

Paolo Fornaro, ETLA Economic Research,
Natalia Kuosmanen, ETLA Economic Research,
Timo Kuosmanen, Aalto University School of Business
Terhi Maczulskij, ETLA Economic Resarch

Prime Minister’s Office Helsinki 2021

Publication distribution

Institutional Repository for the Government of Finland Valto

julkaisut.valtioneuvosto.fi

Publication sale

Online bookstore of the Finnish Government

vnjulkaisumyynti.fi

Prime Minister's Office

ISBN pdf: 978-952-383-401-9
ISSN pdf: 2342-6799

Layout: Government Administration Department, Publications

Helsinki 2021 Finland

Description sheet
8 December 2021

Labor productivity and reallocation in Finland in 2000-2018

Publications of the Government's analysis, assessment and research activities 2021:73			
Publisher	Prime Minister's Office		

Author(s)	Paolo Fornaro, Natalia Kuosmanen, Timo Kuosmanen, Terhi Maczulskij		

Language	English	**Pages**	39

Abstract

Labor productivity of the Finnish economy has stuck close to the level of year 2007 for over a decade. Positive productivity development still occurs in many establishments and firms in various industries. This report examines the impacts of resource allocation and structural changes on the labor productivity growth in Finland's manufacturing and service sectors, information and communication technology industry, and the entire business sector during the period 2000-2018. The purpose of this study is to present an empirical comparison of structural change productivity decompositions known in the literature, and based on the results, draw conclusions regarding the productivity impacts of resource allocation and structural changes.

We find that different decomposition methods yield to some extent different empirical results. All methods considered suggest that positive productivity growth mainly occurs in the continuing firms. Most decompositions suggest that the impact of structural change has been generally negative. The role of resource allocation between firms is particularly notable during the recession, however, the allocation has improved to some extent during the last years of the study period. Inefficient allocation of resources between industries contributes to the productivity slowdown of Finland's business sector.

Provision This publication is part of the implementation of the Government Plan for Analysis, Assessment and Research. (tietokayttoon.fi) The content is the responsibility of the producers of the information and does not necessarily represent the view of the Government.

Keywords	labor productivity, structural change, economic growth, research, research activities		
ISBN PDF	978-952-383-401-9	**ISSN PDF**	2342-6799
URN address	https://urn.fi/URN:ISBN:978-952-383-401-9		

Kuvailulehti
8.12.2021

Työn tuottavuus ja allokaatio Suomessa 2000–2018

Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2021:73

Julkaisija	Valtioneuvoston kanslia

Tekijä/t	Paolo Fornaro, Natalia Kuosmanen, Timo Kuosmanen, Terhi Maczulskij		
Kieli	englanti	**Sivumäärä**	39

Tiivistelmä

Työn tuottavuus Suomen kansantaloudessa on juuttunut likimain vuoden 2007 tasolle yli vuosikymmenen ajaksi. Positiivista tuottavuuskehitystä kuitenkin tapahtuu edelleen monissa toimipaikoissa ja yrityksissä useilla toimialoilla. Tässä raportissa tarkastellaan resurssien allokaation ja toimialojen rakennemuutosten vaikutuksia työn tuottavuuden kehitykseen Suomen teollisuus- ja palvelusektoreilla, informaation ja viestinnän toimialalla, sekä koko yrityssektorilla vuosina 2000–2018. Tutkimuksen tarkoituksena on vertailla empiirisesti kirjallisuudessa esitettyjen rakennemuutosta kuvaavien tuottavuushajotelmien tuottamia tuloksia, sekä muodostaa niiden pohjalta yhteenveto panosten kohdentumisen ja rakennemuutosten tuottavuusvaikutuksista.

Vertailussa huomioidut menetelmät tuottavat jossakin määrin toisistaan poikkeavia tuloksia. Kaikkien tutkimuksessa sovellettujen menetelmien mukaan tuottavuuskasvua esiintyy pääasiassa toimintaa jatkavissa yrityksissä. Rakennemuutoksen vaikutus on useimpien tarkasteltujen menetelmien mukaan pääasiassa negatiivinen. Panosten kohdentumisen merkitys yritysten ja toimipaikkojen välillä korostuu erityisesti talouden laskusuhdanteissa, mutta kohdentuminen on hieman parantunut tarkastelujakson loppupuolella. Panosten tehoton allokaatio toimialojen välillä myös osaltaan heikentää tuottavuuskasvua koko yrityssektorin tasolla.

Klausuuli	Tämä julkaisu on toteutettu osana valtioneuvoston selvitys- ja tutkimussuunnitelman toimeenpanoa. (tietokayttoon.fi) Julkaisun sisällöstä vastaavat tiedon tuottajat, eikä tekstisisältö välttämättä edusta valtioneuvoston näkemystä.
Asiasanat	työn tuottavuus, rakennemuutos, talouskasvu, tutkimus, tutkimustoiminta

ISBN PDF	978-952-383-401-9	**ISSN PDF**	2342-6799
Julkaisun osoite	https://urn.fi/URN:ISBN:978-952-383-401-9		

Presentationsblad
8.12.2021

Arbetskraftens produktivitet och omfördelning i Finland 2000-2018

Publikationsserie för statsrådets utrednings- och forskningsverksamhet 2021:73			
Utgivare	Statrådets kansli		
Författare	Paolo Fornaro, Natalia Kuosmanen, Timo Kuosmanen, Terhi Maczulskij		
Språk	engelska	**Sidantal**	39

Referat

Arbetsproduktiviteten i Finlands ekonomi har stannat kvar på 2007 års nivå över ett decennium. Positiv produktivitetsutveckling sker fortfarande i många anläggningar, företag och industrier. Denna rapport undersöker hur resursallokering och strukturförändringar effekt arbetsproduktivitetens tillväxt i Finlands tillverknings- och tjänstesektor, informations- och kommunikationsteknikindustrin och hela näringslivet under perioden 2000-2018. Syftet med denna studie är att presentera en empirisk jämförelse av strukturella nedbrytningar av produktivitet som är kända i litteraturen, och dra slutsatser om produktivitetseffekterna av resursallokering och strukturella förändringar.

Olika nedbrytningsmetoder ger i viss utsträckning olika empiriska resultat. Alla övervägda metoder tyder på att positiv produktivitetstillväxt sker främst i de fortlöpande företagen. De flesta metoder tyder på att effekterna av strukturförändringar har varit negativa. Rollen av resursallokering mellan företag är särskilt anmärkningsvärd under lågkonjunktur, dock har allokeringen förbättrats under de sista åren av studieperioden. Ineffektiv resursfördelning mellan industrier bidrar till att produktiviteten avtar i Finlands näringsliv.

Klausul Den här publikation är en del i genomförandet av statsrådets utrednings- och forskningsplan. (tietokayttoon.fi) De som producerar informationen ansvarar för innehållet i publikationen. Textinnehållet återspeglar inte nödvändigtvis statsrådets ståndpunkt

Nyckelord arbetsproduktivitet, strukturella förändringar, ekonomisk tillväxt, forskning, forskningsverksamhet

ISBN PDF	978-952-383-401-9	**ISSN PDF**	2342-6799
URN-adress	https://urn.fi/URN:ISBN:978-952-383-401-9		

Contents

FOREWORD

Aggregate labor productivity in Finland exhibited steady growth since the World War II. During the Great Recession and the European debt crisis, originating from the 2007-2008 subprime mortgage crisis in the USA, Finland's productivity growth ground to a halt. The decline of the Finland's ICT sector during the first two decades of the 21st century further contributed to the productivity slowdown. Recently, the Covid-19 pandemic has presented new unexpected challenges for the firms, industries, and the national economy as a whole.

To shed new light on the productivity slowdown in Finland, in February 2021, the Prime Minister's Office commissioned Aalto University School of Business and ETLA Economic Research to analyze allocative efficiency in Finland and the impacts of policy measures on structural change and resource allocation in the project titled ”Allocation of labor and capital at the establishment, firm, and industry levels: Creative destruction, smart planning and effective regulation”. The research team includes Timo Kuosmanen (PI, Aalto), Juuso Liesiö (Aalto), Eeva Vilkkumaa (Aalto), Sheng Dai (Aalto), Terhi Maczulskij (co-PI, ETLA), Paolo Fornaro (ETLA), Natalia Kuosmanen (ETLA), Tero Kuusi (ETLA), and Heli Koski (ETLA). This interim report presents the first empirical results of this project.

While productivity analysis is a long-standing theme in economics, in recent decades, there has been growing interest in the possible misallocation of labor and capital resources (e.g., Restuccia & Rogerson, 2008; Hsieh & Klenow, 2009). Misallocation of resources can occur between different establishments of the same firm, between the firms of the same industry, and across different industries. It is important to note that misallocation of resources at a lower level of aggregation manifests itself as technical inefficiency at the higher levels of aggregation. Therefore, to design effective policy measures, it is important to gain better understanding of how labor and capital are allocated at different levels of aggregation, including the establishments, firms, industries, as well as the national economy as a whole. These are also the levels considered in this report.

At the lowest level of establishments, efficient allocation of resources largely depends on the managerial decisions, or smart planning. Modern information systems, machine learning and artificial intelligence tools provide means for better planning and coordination, not only within firms, but also between firms within the same supply chain or innovation ecosystem. While better coordination can improve allocation at the lower levels, it could also lead to concentration of the market power. At the higher levels of aggregation, competition and free entry and exit remain important drivers of allocation. Improving allocation at the lower levels can call for different types of policy measures than improving allocation at the level of the national economy. Consider, for example, the textbook case of a monopoly: central planning could be a highly efficient way to allocate resources between different establishments to maximize profit of the industry consisting of a single monopoly firm, but at the same time, a monopoly can be inefficient from the societal point of view.

A natural first step towards understanding the productivity impacts of resource allocation is to apply modern decomposition methods to break down the aggregate productivity to sub-components, which capture productivity impacts of structural changes that occur at the establishment, firm, and industry levels. This interim report briefly reviews the alternative decompositions of structural change known in the literature, and systematically applies them to empirical data of firms and establishments using the register data of Statistics Finland.

The empirical results presented in this report provide a necessary background, paving a way for further study of misallocation of labor and capital in the other work-packages of this project. In the subsequent work-packages, we will use different methods to investigate the optimal allocation of labor and capital, possible sources of misallocation, and their impacts on productivity. Based on the empirical results, practical policy measures to improve efficiency of allocation will be suggested.

The authors of the report would like to express their sincere thanks to the steering group of the project, Markku Stenborg (chair), Seppo Kangaspunta, Fransiska Pukander, Jukka Mattila, Timopekka Hakola, and the external experts Mika Maliranta and Peter Elmgren, for their helpful comments and constrictive feedback. As always, the authors assume sole responsibility for any errors in the report.

Timo Kuosmanen
December 2021

1 Introduction

Favorable development of productivity is the main driver of long-term economic growth. In the light of its importance, a long-lasting economic literature has investigated the sources of productivity growth. Since the early work of Baily et al. (1992)[1], economists have identified a large dispersion of productivity levels among businesses within narrowly defined industries, indicating high firm-level heterogeneity, which contrasts the representative firm assumption. This observation has spurred extensive research on micro-level productivity dynamics and how it relates to aggregate productivity. In particular, a large number of works focused on decomposing aggregate productivity growth into multiple components, using data on enterprises and establishments.

Numerous decomposition techniques have been proposed, but they usually share the tendency to separate productivity growth into two main factors: the effects of within-firm productivity dynamics and the role of the reallocation of resources toward more efficient units. In addition, most techniques also consider the role of entry and exit of firms, which can be seen as a form of resource reallocation (e.g., exiting firms free up resources, which can be used by more productive firms). The resource reallocation among continuing firms, as well as the role of entries and exits, can be interpreted as a manifestation of the creative destruction process formulated in Schumpeter (1947).

In this report, we are particularly interested in the role of labor reallocation effects as a source of aggregate productivity growth for the Finnish economy. Using firm-level data for the period 2000-2018, we decompose industry-level and aggregate productivity growth using multiple techniques, which we describe in the methodological section of this report. The analysis is conducted for three timespans (lasting five and six years), which cover periods of sustained economic growth, as well as years of poor economic conditions (including the Great Recession and the European debt crisis, as well as the decline of Nokia as mobile phone manufacturer). The various decompositions we use allow us to gauge the importance of reallocation in driving productivity growth (or decline), both for continuing firms, and entering and exiting enterprises. We compare the results obtained from the different techniques

[1] The importance of taking into account large plant-level performance variation into models of aggregate productivity growth was also highlighted in earlier works, such as Nelson and Winter (1978).

and link them to the previous literature. Moreover, we conduct a shorter analysis based on establishment-level data, where we consider only aggregate productivity growth.

The results of the empirical analysis resonate with the findings of preceding studies (see, e.g., Böckerman and Maliranta, 2007, or Melitz and Polanec, 2015). In particular, we find that the largest share of productivity growth is due to within-firm trends, while reallocation plays a secondary role. However, reallocation of inputs across continuing firms becomes more important in periods of economic decline, indicating a more pronounced role of creative destruction during periods of economic downturn. In terms of long-term patterns, i.e., comparing the contribution of reallocation to aggregate productivity growth during the first and last period of the analysis, we find a moderate increase at the aggregate level for most decompositions, while the industry-level results are contingent on the industry considered. To summarize, the evidence we gather in our analysis points to an inefficient (in the sense of not productivity enhancing) allocation of resources, which has slightly improved over time and peaks during periods of lower productivity and GDP growth.

The analysis based on establishment-level data mostly confirms the results of the firm-level analysis, i.e., we observe a minor role of reallocation in driving aggregate productivity growth. However, the findings based on the plant-level analysis do not indicate an improvement over time of labor reallocation in driving productivity, instead they display a mostly stable contribution. Among the industry-level results, we find that input reallocation has contributed negatively to the productivity growth of the ICT industry, especially during the latest period of the analysis. One possible interpretation of this result is that the ICT industry has experienced growth of temporarily unproductive firms, which are investing and hiring while expecting to become more productive in the future.

The rest of this report is structured as follows. Section 2 provides a brief overview of the relevant literature. Section 3 contains a description of the decomposition techniques we use to gauge the degree of efficient allocation (and its change over time) in the Finnish economy, while in Section 4 we describe the data. The results of the analysis are reported in Section 5, and we draw some conclusions in Section 6.

2 Literature review

The existing literature on the efficient allocation of factors of production has adopted two main approaches to measure the effects of reallocation on productivity. The first approach, which we have already mentioned above and is the one we follow in our analysis, consists in breaking down aggregate and industry-level productivity growth into multiple components, where some of these components represent the effect of reallocation of inputs across production units. In the second approach, resource misallocation is measured through structural models which consider a heterogenous set of firms or plants, while assuming the existence of policies or systemic characteristics which create inefficiencies in the allocation of factors of production. Notice that the works we mention in our short review are not aimed at identifying specific sources of misallocation, but rather at quantifying its net effect on the aggregate economy.

One of the first examples of micro-level productivity growth decompositions is Baily et al. (1992). In this work, the authors examine plant-level data for US manufacturing industries, finding large heterogeneity in productivity levels and growth rates, both within and across industries. While finding a minor role for entry and exit in explaining productivity growth, Baily et al. (1992) observe a pronounced contribution of input reallocation toward more productive plants.

Griliches and Regev (1995) adopt a modified version of the decomposition proposed in Baily et al. (1992), to analyze productivity growth among Israeli firms in mining and manufacturing. As in Baily et al. (1992), the authors find a small contribution of entry and exit. In contrast to the aforementioned paper, Griliches and Regev (1995) observe a dominant role of within-firm productivity growth in driving aggregate developments, while the reallocation of labor has a much lower impact. The decomposition adopted in Griliches and Regev (1995) is one of the techniques we use in our analysis, and it is described in the next section.

The analysis in Olley and Pakes (1996) relies on a different approach compared to Baily et al. (1992) and Griliches and Regev (1995). Instead of decomposing productivity growth, Olley and Pakes (1996) introduce a technique which allows to decompose productivity levels and to disentangle them into an average productivity component and a so-called covariance component. The covariance component indicates the strength of the relation between firm size and productivity, compared to the industry average. Higher covariance components indicate a better allocation of resources. The empirical analysis in Olley and Pakes (1996) looks at the US telecommunication equipment industry, and how deregulation reforms have impacted this industry productivity. They find that while average productivity at the plant level has declined over time, deregulation led to a better reallocation of resources.

An important work which considers multiple techniques to decompose productivity growth of US manufacturing industries is Foster et al. (2007). In their analysis, the authors use a modified version of the Baily et al. (1992) decomposition technique and compare the results against the findings obtained by using the Griliches and Regev (1995) and the Olley and Pakes (1996) decompositions. Importantly, Foster et al. (2007) extend the analysis to a small number of service industries. In our own analysis, we also rely also on the decomposition proposed by Foster et al. (2007). While the authors highlight substantially heterogeneous results, depending on the methodology and on other choices (such as using employment or turnovers as weights, or using labor productivity instead of total factor productivity), Foster et al. (2007) report some consistent findings. For example, they observe that the within component of productivity growth dominates the resource reallocation one, even though the importance of the latter is still substantial and the relative importance of the two components depends on the technique used. Moreover, the authors find that considering longer time spans increases the importance of entry and exit in driving productivity growth.

The literature on the decomposition of aggregate productivity growth has expanded substantially over the years and providing a comprehensive review is unfeasible. Other works that are particularly important in our context are Melitz and Polanec (2015), Böckermän Böckerman and Maliranta (2007) and Holm (2014), because we will rely also on the decompositions formulated in those papers. Böckerman and Maliranta (2007) presents an analysis focused on disentangling the drivers of productivity growth for different Finnish regions, using micro-level data. Among the most interesting results of the paper, the authors find that the reallocation of resources to more productive plants, as well as the shifts in aggregate productivity due to entrants and exiting units, are key drivers of the regional differences in productivity. Melitz and Polanec (2015) provide and extension of the Olley and Pakes (1996) technique, which is capable of handling firm entry and exit, and they apply their decomposition to Slovenian manufacturing data. An important methodological finding gauged in this work is the presence of a substantial measurement bias of entry and exit in more traditional decomposition methods, which leads to an underestimation of the role of reallocation among continuing firms.

The last example we want to mention is Holm (2014). The interesting feature of the analysis provided in this paper is that it considers both within- and between- industry reallocation to explain aggregate productivity growth. This novel decomposition is then applied to Danish data. One important finding of Holm (2014) is that the reallocation component of productivity growth becomes especially strong during periods of economic downturns, which is something we also observe in our own empirical analysis.

Another strand of literature identifies misallocation of resources in an economy using structural models. Given that we do not rely on these techniques in our own analysis, we only summarize few relevant works in a more concise manner than for the first branch of literature examined. Restuccia and Rogerson (2008) use a structural model, calibrated with US data, to examine policy distortions (for example non-competitive banking systems or corruption) which cause heterogenous prices faced by firms, and how the resulting misallocation leads to lower aggregate productivity. An important cross-country analysis is the one in Hsieh and Klenow (2009), where the authors inspect the role of resource misallocation in explaining productivity disparities between manufacturing plants in the US vs. the ones in India and China. Using plant-level data from these economies, Hsieh and Klenow (2009) estimate the marginal return of labor and capital, adopting US establishments as benchmark of optimal allocation. Their findings reveal that equating the resource allocation of Indian and Chinese plants to the one of US establishments would raise total factor productivity substantially. Among the possible main sources of misallocation, the authors point out state ownership and licensing restrictions. Fujii and Nozawa (2013) identify resource misallocation as one of the main drivers of the poor total factor productivity growth for the Japanese economy since the late 1990’s and, interestingly, that the degree of misallocation is correlated with the business cycle. As a source of misallocation, the authors highlight the uncertainty about idiosyncratic productivity shocks and the sluggish adjustments in response to them.

3 Methodology

The empirical exercise conducted in this report is in the essence a comparison of the results obtained from different decomposition techniques, applied to the same data. This approach, similar to the one used in Foster et al. (2007) and Melitz and Polanec (2015), permits us to draw some robust conclusions, and to test whether the different theoretical properties of the techniques we use become evident when applied in an empirical setting.

The decompositions we consider can be split in two families. The first set of techniques we adopt are modifications of the one proposed in Baily et al. (1992). In particular, we use the decomposition presented in Foster et al. (2007), from here onward referred to as FHK, the one in Griliches and Regev (1995), denoted by GR, the one formulated in Böckerman and Maliranta (2007), BM, and finally the technique reported in Holm (2014), denoted as Holm. All these techniques revolve around the idea of decomposing productivity growth into a component representing the productivity developments within the firms, a component tracking the reallocation of resources toward firms with different productivity levels, and a component measuring the effect of the entry and exit of enterprises.

The last decomposition we consider is the one presented in Melitz and Polanec (2015), which we denote as MP. The MP decomposition is also applied to productivity growth, but it is an extension of the Olley and Pakes (1996) technique (OP), which is quite different from the ones we mentioned above. In particular, the OP technique is applied to cross-sections, instead of changes over time, and it is centered around splitting aggregate productivity *levels* into average (unweighted) productivity and a size-productivity covariance moment, representing the degree of efficient allocation of resources. The MP decomposition extends the OP one to allow for entries and exits and it is applied to productivity *growth*, while maintaining the focus on an unweighted mean moment and a covariance component.

Notice that all the decompositions we consider divide the population of enteprises into *continuing* firms (or *stayers*), *entrants* and *exits*. Stayers are defined as firms which are present in the initial and end periods used to compute productivity growth, entrants are companies which appear only in the end period and exiting firms are the ones present only in the initial year. In the rest of this section we describe the techniques discussed above more formally.

3.1 FHK decomposition

The FHK decomposition considers the growth rate of aggregate productivity (adapted here for the case of labor productivity) between periods *t* and *s*, where *t* indicates the end year and *s* is the base year. The aggregate productivity formula used in the FHK technique is given by $P_{it} = \sum_k sh_{kit} p_{kit}$, where *i* denotes industry and *k* indicates firms. The elements in the sum are the industry-level employment share for each firm and year, denoted as *sh*, and the firm-level (log) productivity, *p*. Given that productivity is computed in logs, the growth rate of productivity at the industry level is $\Delta P_{it} = P_{it} - P_{is}$.[2]

Denoting by *C* the set of continuing firms in a given industry, *En* the entrants and *Ex* the exiting firms, the FHK decomposition of ΔP_{it} is given by:

$$\Delta P_{it} = \sum_{k \epsilon C} sh_{kis} \Delta p_{kit} + \sum_{k \epsilon C} (p_{kis} - P_{is}) \Delta sh_{kit} + \sum_{k \epsilon C} \Delta sh_{kis} \Delta p_{kit} + \sum_{k \epsilon En} (p_{kit} - P_{is}) sh_{kit} - \sum_{k \epsilon Ex} (p_{kis} - P_{is}) sh_{kis}. \quad (1)$$

The first term on the right hand-side of (1) is the *within* component, which is the weighted sum (weighted by employment share out of all industry-level employment) of firm-level productivity growth between *t* and *s* for continuing firms. Notice that the employment shares are kept fixed at the base year. The second term, which is the one we are most interested in, is the *between* component. It indicates the contribution to productivity growth stemmed from the reallocation of resources (in our case labor), between year *s* and *t,* across productive units, while keeping productivity levels fixed. The component is positive if firms which have higher than (weighted) average productivity, grow over time. The third term in (1) is the *cross/covariance* component, which allows to appropriately disentangle the between and within effects. The last two terms represent the effect of entries and exits, where the firm-level contribution is

[2] Törnqvist et al. (1985) advocate the use of the log change, proving that it is the only symmetric, additive, and normed indicator of relative change, and introducing the term ”log percentage” (L%) as a measure of relative change.

positive if the entrant (exiting firm) has higher (lower) productivity than the industry-level aggregate.

3.2 GR decomposition

The technique described in GR has the similar aim of decomposing aggregate or industry-level log productivity growth ΔP_{it}, as in the FHK method. The decomposition is given by:

$$\Delta P_{it} = \sum_{k \epsilon C} \overline{sh_{ki}} \Delta p_{kit} + \sum_{k \epsilon C} (\overline{p_{ki}} - \overline{P_i}) \Delta sh_{kit} + \sum_{k \epsilon En} (p_{kit} - \overline{P_i}) sh_{kit} - \sum_{k \epsilon Ex} (p_{kis} - \overline{P_i}) sh_{kis}, (2)$$

where the terms with a bar indicate averages between periods *t* and *s*. The use of the average between the start and end year, instead of using only the base year, and the absence of a covariance term distinguish the GR decomposition from the FHK one. While the absence of the covariance term can lead the decomposition to confound the between and within contributions, the use of the average between two years can be beneficial in the presence of measurement errors. The first term in (2) represents the within component, the second term is the between component, and the last two terms are the entry and exit contributions.

3.3 Holm decomposition

Holm (2014) introduces a multilevel decomposition which can be applied to aggregate productivity growth. The interesting feature of this technique is that it includes both a within- and between- industry reallocation components, indicating whether aggregate productivity growth has been enhanced by a transfer of resources toward more productive industries. While this approach could be applied to an industry-level setting, for example by looking at 3-digit and 2-digit industry levels, we use it only for aggregate productivity growth, ΔP_{it}. The Holm decomposition follows:

$$\begin{aligned}\Delta P_t = & \sum_i \Delta sh_{it}(P_{is} - P_s) + \sum_i sh_{it} \sum_{k\epsilon C} sh_{kit}\Delta p_{kit} + \sum_i sh_{it} \sum_{k\epsilon C} (p_{kis} - P_{is})\Delta sh_{kit} \\ & + \sum_i sh_{it} \sum_{k\epsilon C} \Delta sh_{kit}\Delta p_{kt} + \sum_i sh_{it} \sum_{k\epsilon En} (p_{kit} - P_{is}) sh_{kit} \\ & - \sum_i sh_{it} \sum_{k\epsilon Ex} (p_{kis} - P_{is}) sh_{kit} \qquad (3)\end{aligned}$$

The main difference between (3) and the FHK decomposition (1) lies in the first term in (3), which is positive if the reallocation of resources (employment) goes in favor of relatively more productive industries. The double sums in (3) indicate sum of firms within a given industry, which are then aggregated across the industries considered in the exercise. A more subtle difference between (1) and (3) is that in the latter the employment weights use end-year values (*t*) instead of base-year (*s*) ones. The main benefit of the Holm decomposition is that it offers a unified framework to study the contribution of reallocation both between firms and between industries, where the latter component is usually disregarded in traditional decompositions.

3.4 BM decomposition

The BM decomposition, which was originally formulated in Maliranta (1997), presents quite a few differences from the techniques presented so far. First of all, the aggregate productivity considered in this case is given by $P_{it} = \sum y_{kit} / \sum e_{kit}$, where *e* is employment and *y* is value added, and the growth formula used is $\frac{\Delta P_{it}}{\overline{P_{it}}} = (P_{it} - P_{is})/(0.5P_{it} + 0.5P_{is})$ (compare with Törnqvist et al., 1985). The main benefit obtained by using this approach is that it offers a closer approximation to the standard aggregate productivity growth indicators, compared to the GR, FHK and Holm formulas (this is shown in Maliranta, 2003, p.122). The decomposition equation is given by:

$$\frac{\Delta P_{it}}{\overline{P_{it}}} = \sum_{k\epsilon C} \frac{\overline{sh_{ki}}\Delta p_{kit}}{\overline{p_{ki}}} + \sum_{k\epsilon C} \left(\frac{\overline{p_{ki}}}{\overline{P_i^C}}\right) \Delta sh_{kit} + \sum_{k\epsilon C} \overline{sh_{ki}} \frac{\left(\frac{\overline{p_{ki}}}{\overline{P_i^C}} - 1\right)\Delta p_{kit}}{\overline{p_{ki}}} + \log\left(1 + sh_{it}^{En}\left(\frac{P_{it}^{En}}{P_{it}^C} - 1\right)\right) - \log\left(1 + sh_{is}^{Ex}\left(\frac{P_{is}^{Ex}}{P_{is}^C} - 1\right)\right) \qquad (4)$$

There are multiple differences between (4) and other decompositions presented so far. Firstly, the productivity levels and growth are not in logs, and are given by a different formula. This ensures consistent aggregation of firm-level productivity measures to the aggregregate levels. Secondly, the employment shares for continuing firms (in the first three terms of the decomposition) are computed relative to the industry-level employment of continuing firms, meaning that the shares in those terms sum up to one, contrary to the FHK, GR and Holm decomposition. Another distinguishing feature of this decomposition is the presence of a *convergence* component, the third term in (4), which represents within-industry beta-convergence. In other words, this term indicates whether lower productivity firms (in levels) tend to experience higher productivity growth, converging to the other firms in the industry. This kind of trend would result in a negative convergence term. The last two components in (4) are similar to the ones in (1)-(3) and represents entry and exit contributions.

3.5 MP decomposition

The last decomposition we adopt is the MP technique, an extension of the OP decomposition. This approach starts from a cross-sectional decomposition which splits productivity levels in an unweighted average component and a size-productivity covariance component. The efficiency of resource allocation in the economy is then measured by the latter. To allow for entries and exits, the MP technique is applied to productivity growth, making it comparable to methods such as the FHK one. The aggregate productivity formula used is again the FHK, GR and Holm one, i.e., $P_{it} = \sum_k sh_{kit} p_{kit}$, where *p* is in logs. Productivity growth is then simply given by the difference. The MP decomposition is given by:

$$\Delta P_{it} = \Delta\overline{P_{it,C}} + \Delta Cov_{it,C} + sh_{it,En}\left(P_{it,En} - P_{it,C}\right) + sh_{it,Ex}\left(P_{is,C} - P_{is,Ex}\right) \qquad (5)$$

where the bar in (5) indicates an unweighted, industry-level, productivity growth. The *Cov* component is given by $\sum_k (sh_{kit} - \overline{sh_{it}})(p_{kit} - \overline{p_{it}})$, and represents how much relatively more productive continuing firms are also larger. The entry and exit components are quite similar as in (1)-(3), even though in (5) the relative productivity of entering and exiting companies is computed against the one of continuing firms only. Moreover, the comparison years are different for entrants and exiting firms, while in the FHK case the base year is used for both groups, as comparison. Another subtle difference is that the employment shares for continuing firms are computed relative to the total employment for stayers, meaning that the shares sum up to one. The decomposition (5) can be extended by splitting the entry and exit components in an average productivity term (in the case of entrants, $sh_{it,En}(\overline{P_{it,En}} - \overline{P_{it,C}})$) and a covariance term ($sh_{it,En}(cov_{it,En} - cov_{it,C})$). Melitz and Polanec (2015) show that traditional decomposition such as the ones in (1)-(2) can generate a bias in the entry and exit components, even though the significance of the bias depends on growth patterns.

4 Data

The data we use in the empirical analysis is obtained from the Financial statement data panel of Statistics Finland. This dataset includes firm-level information on indicators such as value added, turnover and employment, as well as detailed industry information. Our measure of productivity is labor productivity, i.e., the ratio between value added and employment. In our data, employment is measured in full time equivalents (FTE). The nominal variables are deflated using the consumer price index (using 2000 as base year).[3]

Our analysis is conducted on three subperiods: 2000–2005, 2006–2012 and 2013–2018. The choice of these time intervals is dictated mostly by data issues. In particular, due to methodological changes adopted by Statistics Finland in terms of data collection, there are structural breaks in the data between 2005 and 2006, and between 2012 and 2013. We make sure that we have comparable data, by separating the subperiods based on the years when these breaks occur.

Before proceeding with the analysis, we make multiple adjustments to the data. First, we remove 2-digit industries which are viewed as problematic, such as financial and insurance services.[4] Moreover, in order to comply with confidentiality requirements, we remove industries (either at the 2- or 1-digit level) which have too few observations, considering separately the groups of entering and exiting firms. Another adjustment we make is the removal of firms with less than one employee (the possibility to have less than one employee is due to the use of FTEs)[5], the ones with

[3] The adoption of a common price index for all the firms in the analysis is based on the suggestion by Holm (2014), who argues that relative prices carry important information regarding structural reallocation, which would be lost by using industry-level deflators. However, as a robustness check, we have conducted the analysis also using 2-digit level price deflators. While the aggregate productivity of certain industries changes substantially, the main results regarding the relative importance of reallocation in driving aggregate productivity remain intact, compared to what found in the main analysis.
[4] These industries do not belong to the description area of the statistics on financial statements, and therefore the correctness of the data of the enterprises in these industries is not checked by Statistics Finland. For details see https://taika.stat.fi/en/aineistokuvaus.html#!?dataid=YA211_19862016_jua_tppaneeli_001.xml.
[5] To avoid the issue of spurious entries and exits, due to firms going below and above the one employee threshold, we have also tried removing only firms which have less than one employee at most during their lifetime. The results remain very similar with this adjustment.

zero or negative value added, and the ones with missing information. Finally, we remove outlier firms, which have log labor productivity above 4.4 standard deviations from the weighted average, in absolute terms (this definition of outlier is proposed by Mairesse and Kremp, 1993).

After these adjustments, our sample includes 116,692 firms for the 2000–2005 period, 138,111 companies for the years 2006–2012, and 135,832 for the period 2013–2018. The industry classification is based on the Standard Industrial Classification of Statistics Finland (TOL 2008). The TOL 2008 classification complies with NACE Rev. 2 for the digit levels we use. When conducting the 1-digit analysis, we refer to the character level classification provided by Statistics Finland (even though we exclude some industries from the information and communication industry, such as publishing activities, to focus on ICT).

5 Results

Before presenting the findings, it is useful to briefly discuss the aggregation process of the 2-digit industry results. Firstly, we average the components obtained from the decompositions, as well as the productivity growths, across 2-digit industries, using the average of the end and base year industry employment share as weight. A similar procedure is done to obtain 1-digit industry results, using the employment share of the 2-digit industry of interest, relative to the 1-digit industry employment. For the Holm decomposition, we rely on the original formula to aggregate industry level results. A consequence of this choice is that the aggregate productivity growth given by the Holm components is different from the one of FHK and GR decompositions, because the former adds an industry allocation component, which is excluded from the rest of the techniques. The difference in the productivity growths obtained by summing up the components of the FHK, GR and MP decompositions, and the ones of the Holm decomposition is indeed given by the industry reallocation component of the Holm technique.

We start by reporting the productivity growth rates for the three sub-periods of the analysis, obtained from the micro data described in the previous section. We compare the figures calculated using $P_{it} = \sum_k s_{kit} p_{kit}$, the formula at the basis of most of the decompositions we consider, and the ones using $P_{it} = \sum y_{kit} / \sum e_{kit}$, which is adopted in the BM decomposition. We show productivity growth rates for the aggregate economy, for manufacturing (industries 10–33 in the TOL 2008 classification), professional services (69–75) and ICT (61–63), in Table 1. For the rest of the analysis, we report results for the aforementioned industries, but results for 2-digit and the rest of 1-digit industries are available upon request. The growth rates reported represent changes between the end and base year, divided by the number of years in the period considered (we do this because the 2006-2012 period is longer than the others, so we take the average to make periods comparable).

Table 1. Aggregate and 1-digit level labor productivity growth rates (obtained from the weighted average of 2-digit industry-level results) for the periods 2000-2005, 2006-2012 and 2013-2018. All values are in log percentages.

	$\mathrm{d}\sum_k s_{kit} p_{kit}$	$\mathrm{d}\sum y_{kit} / \sum e_{kit}$
Aggregate		
2000–2005	1.68	1.66
2006–2012	-0.55	-0.56
2013–2018	2.24	2.09
Manufacturing		
2000–2005	0.28	0.16
2006–2012	-1.41	-1.27
2013–2018	2.67	2.93
Services		
2000–2005	2.15	2.08
2006–2012	-0.19	-0.31
2013–2018	1.76	1.52
ICT		
2000–2005	2.34	1.23
2006–2012	-0.59	-1.06
2013–2018	1.41	1.29

The first column of Table 1 measures productivity change using the weighted sum of log productivity measures. The second column reports the aggregate productivity according to the BM formulation, which avoids the use of logs in the aggregation. The latter approach is a consistent way to aggregate the firm-level productivity measures to the industry- or aggregate levels when employment shares $\frac{e_{kit}}{E_{kt}}$ are used as share weights because $P_{it} = \frac{\sum y_{kit}}{\sum e_{kit}} = \sum \frac{y_{kit}}{e_{kit}} \cdot \frac{e_{kit}}{E_{kt}} = \sum s_{kit} p_{kit}$.

In contrast, the logarithm of a weighted sum of productivity measures does not equal the weighted sum of the log productivity measures (see Kuosmanen and Kuosmanen, 2021, for further discussion). Table 1 reveals that the aggregation error of the commonly used sum of log productivity (the left column) can be large especially during the times of rapid structural changes affecting the share weights.[6]

Comparing the three sub-periods, Table 1 shows dramatic shifts in productivity growth patterns. For the aggregate economy, we see a period of productivity growth between 2000 and 2005, in tandem with the rise in importance of Nokia on the global markets, followed by a large drop during 2006 and 2012, corresponding to the Great Recession and the European debt crisis, and a strong rebound for the last subperiod. When looking at the industry-level results, the observations regarding productivity patterns remain similar, i.e., we see an initial period of quite strong productivity growth, followed by a large decline and a final rebound. However, there are a couple of interesting differences between manufacturing industries, services and ICTs. Firstly, the former experienced a weaker growth period in 2000–2005, and a substantially worse drop in 2006–2012 (especially compared to services). The second difference is that both services and ICTs display an initial period with stronger productivity growth, while the final subperiod does not have such a strong rebound, compared to manufacturing. In terms of different aggregate productivity measures, we do not see dramatic differences between the log difference used in decompositions such as the FHK one and the formula used in the BM decomposition. However, there is a substantial discrepancy between the productivity growths of the ICT industry, for the first two subperiods, given by the two different formulas, with the growth given by the BM formula lower than the alternative.

5.1 Results of the FHK, GR and Holm decompositions

We start by reporting the results obtained by applying the FHK, GR and Holm decompositions to labor productivity growth, for the time intervals described above. We group the results of these decompositions together because they rely on the same labor productivity formula and because they are all extension of the technique of Baily

[6] Notice that the productivity growth rates reported in Table 1 do not track perfectly the ones provided by Statistics Finland, at least when comparing the two growth periods. In particular, the aggregate estimates provided by Statistics Finland are higher for the 2000–2005 period and quite lower for the last subperiod. These discrepancies are due to multiple factors, such as a more restricted data source, in our case.

et al. (1992). We present, in Table 2, the results of the decomposition of aggregate productivity growth.

Table 2. Results for the FHK, GR and Holm decompositions of aggregate labor productivity growth (obtained from the weighted average of 2-digit industry-level results), for periods 2000–2005, 2006–2012 and 2013–2018. All values are in log percentages. Within and between refer to the within and between components of decompositions (1)-(3), cross represents the cross component of decomposition (1), net entry is defined as the different between the entry and exit components of decompositions (1)-(3) and the industry reall. is the industry reallocation component of decomposition (3).

	Within	Betwen	Cross	Net entry	Industry reall.
FHK					
2000–2005	1.39	0.15	-0.30	0.44	
2006–2012	-0.86	0.75	-0.38	-0.06	
2013–2018	1.60	0.33	-0.34	0.66	
GR					
2000–2005	1.24	0.02		0.42	
2006–2012	-1.05	0.56		-0.07	
2013–2018	1.43	-0.13		0.68	
Holm					
2000–2005	1.12	0.17		0.50	-0.47
2006–2012	-1.15	0.71		-0.07	-0.37
2013–2018	1.26	0.31		0.66	-0.06

Table 2 provides us with interesting results, which can be linked to previous findings. First of all, the within component, meaning the productivity growth at the firm level, is the main driver of aggregate labor productivity changes. This observation was already picked up in previous studies such as Foster et al. (2007). On the other hand, the between component, which measures the impact of reallocation on aggregate productivity component, is fairly small, at least for the periods of growth. This is even more evident for the GR decomposition, where the between component is lower than in the other two decompositions, and even negative for the last sub-period. Interestingly, the between component becomes much larger during the period of productivity decline. A similar finding was reported in Böckerman and Maliranta (2007) and in Holm (2014), and it can be explained by the increased role of creative destruction during recessions. On the other hand, net entry contributes more to aggregate productivity during periods of favorable economic conditions. Finally, the Holm decomposition provides an additional interesting indicator of reallocation effects on productivity growth, through reallocation across industries. In this case, the contribution is always negative, although improving over time, highlighting an inefficient transfer of resources to comparatively less productive industries. Overall, the results contained in Table 2 highlight a relatively minor role of reallocation in driving aggregate productivity growth, for the Finnish economy. However, it is important to point out that the standard growth model with homogeneous firms would imply productivity growth to be solely driven by within-firm productivity developments, thus a small but non-zero between component still indicates an important deviation from the homogenous firm assumption.

We now proceed by showing results regarding the manufacturing, services and ICT industries, which we have defined in more details in the data description. The results are reported in Table 3. Notice that for industry-level analyses, the Holm decompositions is not applied.

Table 3. Results for the FHK and GR decompositions of labor productivity growth for selected 1-digit industries (obtained from the weighted average of 2-digit industry-level results), for periods 2000-2005, 2006-2012 and 2013-2018. All values are in log percentages. Within and between refer to the within and between components of decompositions (1)-(3), cross represents the cross component of decomposition (1), net entry is defined as the different between the entry and exit components of decompositions (1)-(3).

	Within	Betwen	Cross	Net entry
Manufacturing				
FHK				
2000–2005	0.85	-0.03	-0.23	-0.31
2006–2012	-1.71	0.34	-0.02	-0.01
2013–2018	1.89	0.04	0.08	0.67
GR				
2000–2005	0.74	-0.06		-0.40
2006–2012	-1.72	0.29		0.02
2013–2018	1.93	0.08		0.67
Services				
FHK				
2000–2005	0.75	-0.14	0.55	0.99
2006–2012	0.02	0.00	-0.06	-0.16
2013–2018	1.28	0.15	-0.13	0.46
GR				
2000–2005	1.03	0.11		1.02
2006–2012	-0.01	-0.01		-0.17
2013–2018	1.22	0.04		0.50
ICT				
FHK				
2000–2005	0.84	-0.19	0.18	1.51
2006–2012	-0.04	-0.09	0.00	-0.46
2013–2018	1.91	-0.44	-0.16	0.10
GR				

	Within	Betwen	Cross	Net entry
2000–2005	0.93	-0.16		1.56
2006–2012	-0.04	-0.04		-0.52
2013–2018	1.83	-0.52		0.10

The conclusions we can draw from Table 3 are similar to the ones we gathered for the aggregate productivity growth case. The within component is the main driver of productivity growth for the industries we consider, especially during periods of favorable economic conditions. On the other hand, the between component is relatively small, and even substantially negative for the last two periods of the ICT industry. This would imply that, for that industry, relatively more inefficient firms have grown more over time. While this indicates an inefficient allocation of resources, it might also signal strong investments (in terms of scaling up) for small ICT firms which are not yet productive but might become so after growing. For manufacturing, the net entry component is relatively small, while for services and ICTs, especially during the first subperiod of the analysis, the effect on productivity growth of entries and exits is remarkably strong. This can indicate that these industries have faced a more marked period of market restructuring.

5.2 Results of the BM decomposition

We now turn to the results regarding the BM decomposition. We report them separately from the FHK, GR and Holm results because the BM technique relies on a different measure of aggregate productivity. Moreover, this decomposition approach provides an additional component which describes the role of convergence in the development of productivity. The results are reported in Table 4, below.

Table 4. Results for the BM decomposition, for aggregate and selected 1-digit industries productivity growth, for periods 2000-2005 (obtained from the weighted average of 2-digit industry-level results), 2006-2012 and 2013-2018. All values are in percentages. Within and between refer to the within and between components of decompositions (4), convergence represents the convergence component of decomposition (4), net entry is defined as the different between the entry and exit components of decompositions (4).

	Within	Betwen	Convergence	Net entry
Aggregate				
2000–2005	1.60	-0.09	0.25	-0.11
2006–2012	-1.20	0.69	-0.40	-0.09
2013–2018	1.69	-0.31	0.29	0.43
Manufacturing				
2000–2005	0.96	-0.05	0.11	-0.87
2006–2012	-1.94	0.31	0.04	0.31
2013–2018	2.15	0.06	0.28	0.45
Services				
2000–2005	1.62	-0.09	0.09	0.46
2006–2012	0.00	-0.02	-0.13	-0.15
2013–2018	1.46	-0.11	0.03	0.14
ICT				
2000–2005	1.20	-0.08	-0.18	0.31
2006–2012	-0.18	-0.10	-0.07	-0.70
2013–2018	1.96	-0.94	0.33	-0.05

Considering the results obtained from the BM decomposition, in Table 4, we find again a relative dominance of the within component, especially during periods of economic expansions. Moreover, we still observe a rise in importance of the between component during recessions, at least for aggregate productivity growth. However, we see a substantial discrepancy for the between component during the last period. In particular, the BM decomposition produces a markedly negative between component, while the rest of the decompositions show a positive or slightly negative component. Also, the net entry component of the BM decomposition, for the first subperiod, is negative, in contrast to the one obtained from the rest of the decompositions. The additional component provided by the BM decomposition, the convergence component, shows a divergent behavior during periods of positive economic conditions, while during recessions it displays a convergent trend (lower productivity firms become more productive at a faster pace). Going to the industry-level results, we do not see substantial differences between decompositions. Again, the within component is the dominant one, even though we find exceptions, such as the large negative between component for the ICT industry during 2013-2018.

Overall, the decomposition techniques based on longitudinal data highlight a dominant role of within-firm developments in explaining productivity growth, while reallocation of resources among continuing firms is less relevant. The latter, however, becomes significantly more important during recessions. The reallocation of resources between industries has had a substantial negative effect on productivity, even though it became less negative in recent years. Looking at selected industries, the most remarkable finding is a strong negative between component for the ICT industry during the last period of the analysis, possibly indicating strong investments in firms which are not yet profitable (and productive). To sum up, it seems that the Finnish business sector has room for improvement, in terms of the allocation of resources for productivity gains.

5.3 Results of the MP decomposition

Finally, we report the results for the MP decomposition. The decision to report the results in a separate section is due to the radical difference between the MP approach and the ones we have looked so far. In particular, the MP decomposition is an extension of the cross-sectional technique developed in Olley and Pakes (1996). Instead of separating aggregate productivity growth in within and between components (as well as entry and exit ones), the MP decomposition splits aggregate productivity in a moment reflecting the unweighted average, at the firm level, and a covariance component representing how much firm size and productivity are correlated. A larger covariance term, and its growth, indicates a better and improving reallocation of resources. We report the results in Table 5.

Table 5. Results for the MP decomposition, for aggregate and selected 1-digit industries productivity growth (obtained from the weighted average of 2-digit industry-level results), for periods 2000–2005, 2006–2012 and 2013–2018. All values are in log percentages. Average indicates the unweighted average moment in decomposition (5), while covariance indicates the covariances component in (5). Net entry is given by the sum of the entry and exit components in (5).

	Average	Covariance	Net entry
Aggregate			
2000–2005	2.28	-0.58	-0.02
2006–2012	-0.41	-0.17	-0.03
2013–2018	1.72	0.10	0.42
Manufacturing			
2000–2005	2.07	-1.02	-0.76
2006–2012	-1.11	-0.74	0.43
2013–2018	1.74	0.48	0.45
Services			
2000–2005	1.99	-0.35	0.51
2006–2012	0.24	-0.27	-0.15
2013–2018	1.43	0.07	0.26
ICT			
2000–2005	3.12	-2.15	1.37
2006–2012	0.50	-0.70	-0.40
2013–2018	3.12	-1.61	-0.11

While the relative dominance of within-firms productivity developments is again underlined, the results contained in Table 5 lead us to slightly different conclusions, relative to the other decompositions we have adopted so far. First of all, the effectiveness of the allocation of resources in driving productivity improved during the recession years but remains negative. Moreover, contrary to most of the previous decompositions, reallocation seems to have had a strong negative effect for aggregate productivity growth during the first period of the analysis. For the final subperiod we again see the familiar pattern of positive small contribution stemmed by a better allocation of resources. The role of net entry is quite similar for the MP and the rest of the decompositions. At the industry level, we see again the remarkable negative effect of the covariance term on the ICT industry productivity growth, reflecting the results we gathered in previous subsections. Interestingly, the poor allocation of resources for ICTs is also present for the first period of the analysis, contrary to what found in previous decompositions. Substantially negative covariance components also for the manufacturing and service industries (for the first subperiod) stand in contrast with the small (sometime positive) between components obtained from the other decompositions.

The general picture we gather from the results of the MP decomposition is in line with what we have found so far, i.e., that the allocation of resources toward more productive firms has not been a driver of productivity growth for the Finnish economy. Instead, we see a reallocation toward relatively inefficient enterprises, which drags down aggregate productivity. While for certain industries, such as ICTs, this could be a sign of small young, initially unproductive, firms trying to scale up, this phenomenon is replicated for the aggregate economy, and other industries where we expect larger firms to be more productive and attract more resources.

5.4 Results of establishment-level decompositions

Our main analysis is focused on firm-level data. This is mostly due to better data availability, in particular the possibility of using value added data in calculating labor productivity. However, the use of data at the firm level has a number of drawbacks. First of all, actual production and economic activity takes place in establishments, rather than firms, where the latter can have multiple plants. There might be a lot of variation, in terms of labor productivity, within the same firm, due to specific characteristics of different establishments. Moreover, multi-establishment firms might encompass multiple industries, even at quite rough industry classifications, and the use of plant-level data allows us to make a more accurate breakdown of the industry structure of the economy. Finally, data on plants offers an organic view of entries and exits, which might be distorted by changes in legal IDs of firm-level data (such as in the case of mergers and acquisitions). The downside of using establishment-level data, as we mentioned above, is that we need to use turnovers to measure labor productivity, which is an inferior alternative to value added.

To keep the length of this report compact, we conduct our decomposition exercise using plant-level data only for the aggregate economy. We follow the same data cleaning process as in the main analysis, i.e., we remove establishments with less than one FTE, the ones with negative turnovers and outliers. In case an establishment changes industry of operation between the end and base year of a period, we use the base year industry to classify the establishment. As in the firm-level exercise, we divide the period of analysis in three sub-periods: from 2000 to 2005, from 2006 and 2012, and from 2013-2018. The results, in tables 6-8, are presented in log percentages, and the growth rates computed between two periods are averaged over the length of the subperiods.

Table 6. Results for the FHK, GR and Holm decompositions of aggregate labor productivity growth, for periods 2000-2005 (obtained from the weighted average of 2-digit industry-level results), 2006-2012 and 2013-2018, using establishment-level data. All values are in log percentages. Within and between refer to the within and between components of decompositions (1)-(3), cross represents the cross component of decomposition (1), net entry is defined as the different between the entry and exit components of decompositions (1)-(3) and the industry reall. is the industry reallocation component of decomposition (3).

	Within	Between	Cross	Net entry	Industry reall.	Aggregate prod. growth
FHK						
2000–2005	2.06	0.39	-0.78	0.42		2.09
2006–2012	0.53	0.37	-0.68	0.04		0.27
2013–2018	2.00	0.37	-0.87	0.31		1.80
GR						
2000–2005	1.67	0.00		0.42		2.09
2006–2012	0.19	0.04		0.03		0.27
2013–2018	1.56	-0.06		0.30		1.80
Holm						
2000–2005	1.27	0.38		0.44	-0.76	1.33
2006–2012	-0.14	0.38		0.03	-1.34	-1.07
2013–2018	1.12	0.36		0.30	-0.81	0.96

Table 7. Results for the BM decomposition, for aggregate productivity growth (obtained from the weighted average of 2-digit industry-level results), for periods 2000-2005, 2006-2012 and 2013-2018, using establishment-level data. All values are in percentages. Within and between refer to the within and between components of decompositions (4), convergence represents the convergence component of decomposition (4), net entry is defined as the different between the entry and exit components of decompositions (4).

	Within	Between	Convergence	Net entry	Aggregate prod. growth
Aggregate					
2000–2005	1.77	-0.07	0.40	0.18	2.28
2006–2012	0.23	-0.10	0.35	-0.03	0.58
2013–2018	1.72	-0.22	0.38	0.00	1.89

Table 8. Results for the MP decomposition, for aggregate productivity growth (obtained from the weighted average of 2-digit industry-level results), for periods 2000-2005, 2006-2012 and 2013-2018, using establishment-level data. All values are in percentages. Average indicates the unweighted average moment in decomposition (5), while covariance indicates the covariances component in (5). Net entry is given by the sum of the entry and exit components in (5).

	Average	Covariance	Net entry	Aggregate prod. growth
Aggregate				
2000–2005	1.92	0.05	0.12	2.09
2006–2012	0.11	0.18	-0.03	0.27
2013–2018	2.01	-0.25	0.04	1.80

The results in Table 6-8 mostly confirm the broader findings of the main analysis. The aggregate productivity growth calculated from plant-level data mostly follows the one obtained from firm-level data, even though the productivity growth during the recession period is substantially higher when considering plant-level data, once removing the effect of industry reallocation. In particular, it is interesting to see that the reallocation of resources to different industries has had a markedly negative effect on productivity growth, especially during the 2006-2012 years, and that this pattern is confirmed by both firm and plant-level data. Regarding the decompositions, we again find the within component to be the main driver of labor productivity growth, meaning that productivity improvements inside continuing plants are the most important contributors to aggregate dynamics. On the other hand, we do not find a pronounced increase the importance of the between component during the recession period, for most decomposition techniques. We do see a larger covariance component for the MP decomposition during the 2006-2012 period, indicating a more positive contribution of reallocation to productivity. Finally, the role of net entry is similar to what found in the firm-level analysis, i.e., the entry and exit of plants is productivity enhancing during times of economic growth and much less so during recessions, where net entry provides often a negative contribution to aggregate productivity. Overall, the decompositions based on establishment-level data indicate that the efficient allocation of inputs is not a driving force on aggregate productivity growth for the Finnish economy, and that is a substantial degree of misallocation.

6 Conclusions

In this study, we have used multiple decomposition techniques to gauge the role of the allocation of labor resources in driving aggregate productivity growth. Using firm-level data covering both manufacturing and service industries, for three subperiods between the years 2000 and 2018, we decompose productivity growth in within-firm components, between components (which reflect the role of reallocation) and the effect of entries and exits of firms. We complement the analysis by applying the same decompositions to the population of establishments in Finland.

While the results vary between different industries and decomposition techniques, we observe a number of persistent findings. Firstly, as observed in multiple previous studies, developments within individual firms are the main drivers of aggregate productivity, especially during periods of positive economic trends. Regarding the role of input reallocation, we find a minor contribution which becomes more relevant during periods of economic crisis (indicating the heightened role of creative destruction in recessions). Even though the contribution of reallocation to productivity has slightly increased over time, its role is still minor and there is still room for improvement. This observation is reinforced when looking at establishment-level data, where the components related to inputs reallocation tend to be negative. Finally, we observe a substantially negative contribution of reallocation to the productivity growth of the ICT industry, especially during the last period of the analysis. This finding can be explained by ICT firms which are heavily investing and growing in size before they become more productive. The results drawn from the decomposition of plant-level data does not completely replicate the ones obtained from the firm-level data, but the main message of the analysis, i.e., that reallocation has not played a major role in driving productivity growth, remains intact.

References

Baily, M. N., Hulten, C., Campbell, D., Bresnahan, T., & Caves, R. E. (1992). Productivity dynamics in manufacturing plants. *Brookings papers on economic activity. Microeconomics*, *1992*, 187-267.

Böckerman, P., & Maliranta, M. (2007). The micro-level dynamics of regional productivity growth: the source of divergence in Finland. *Regional Science and Urban Economics*, *37*(2), 165-182.

Foster, L., Haltiwanger, J., & Krizan, C. J. (2007). *8. Aggregate Productivity Growth: Lessons from Microeconomic Evidence* (pp. 303-372). University of Chicago Press.

Fujii, D., & Nozawa, Y. (2013). Misallocation of Capital during Japan's Lost Two Decades. *Development Bank of Japan Working Paper*, *1304*.

Griliches, Z., & Regev, H. (1995). Firm productivity in Israeli industry 1979-1988. *Journal of econometrics*, *65*(1), 175-203.

Holm, J. R. (2014). The significance of structural transformation to productivity growth. *Journal of Evolutionary Economics*, *24*(5), 1009-1036.

Hsieh, C. T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India. *The Quarterly journal of economics*, *124*(4), 1403-1448.

Kuosmanen, T., & Kuosmanen, N. (2021). Structural change decomposition of produtivity without share weights. *Structural Change and Economic Dynamics*, 59, 120-127.

Mairesse, J., & Kremp, E. (1993). A look at productivity at the firm level in eight French service industries. In *Productivity issues in services at the micro level*. Springer, Dordrecht, pp. 207-230.

Maliranta, M., 1997. Plant level explanations for the catch up process in Finnish manufacturing: a decomposition of aggregate labour productivity growth. In: Laaksonen, S. (Ed.), *The Evolution of Firms and Industries*. Statistics Finland, Helsinki, pp. 352-369.

Maliranta, M. (2003). Micro level dynamics of productivity growth. An empirical analysis of the great leap in finnish manufacturing productivity in 1975-2000. *ETLA A*.

Melitz, M. J., & Polanec, S. (2015). Dynamic Olley-Pakes productivity decomposition with entry and exit. *The Rand journal of economics*, *46*(2), 362-375.

Olley, G., & Pakes, A. (1996). The Dynamics of Productivity in the Telecommunications Equipment Industry. *Econometrica, 64*(6), 1263-1297. doi:10.2307/2171831

Nelson, R. R., & Winter, S. G. (1978). Forces generating and limiting concentration under Schumpeterian competition. *The Bell Journal of Economics*, 524-548.

Restuccia, D., & Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic dynamics*, *11*(4), 707-720.

Schumpeter, J. A. (1947). The creative response in economic history. *The journal of economic history*, *7*(2), 149-159.

Törnqvist, L., Vartia, P. & Vartia, Y.O. (1985) How Should Relative Changes Be Measured? *The American Statistician,* 39(1), 43-46.

tietokayttoon.fi/en

ISBN PDF 978-952-383-401-9
ISSN PDF 2342-6799