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UNIVERSITY OF TURKU

ESSAYS ON FIRM DYNAMICS

Eero Mäkynen

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ABSTRACT

In this doctoral dissertation, I explore the determinants of aggregate productivity. The essays in the field of macroeconomics examine how the business environment and firms' actions shape aggregate outcomes such as output, employment, and productivity.

In the first essay, I examine the connection between worker reallocation and economic growth. First, I provide empirical evidence that establishments hiring from their more productive counterparts tend to experience productivity gains in the following years. Then, to explore the aggregate significance of the finding, I set up a quantitative framework where establishments can increase their productivity through hiring. The calibrated model suggests that worker transmitted knowledge increases annual productivity growth by 0.14 percentage points and welfare by 2.5% compared to an economy without knowledge spillovers. Additionally, I find that the mechanism amplifies the adverse effects of firing costs by a factor of 1.2-3.

In the second essay, we explore the implications of early life-cycle uncertainty of firms for aggregate productivity. First, we develop a static measure of misallocation that separates uncertainty from misallocation generated by tax-like distortions. Using the measure, a key empirical finding is that uncertainty accounts for most of the ex-post misallocation in the Finnish firm-level data. Second, to understand the aggregate significance of the uncertainty, we set up a life-cycle model of firm growth where new firms slowly learn their true productivity. Our calibrated model suggests that the uncertainty alone has a 38% negative effect on output, and the corresponding effect for the misallocation is 26%.

The third essay examines why firm sizes and revenues display considerable differences even when producing relatively similar goods. To answer the question, I utilize a flexible static model of firm heterogeneity, which decomposes the differences between firms into differences in productivity, demand, markups, revenue wedges, and capital wedges. Applying the decomposition to the data reveals that differences in sizes and revenues almost entirely stem from differences in demand shifter. In contrast to earlier findings, I also show a significant role for the markups in explaining the differences between firms.

KEYWORDS: firm heterogeneity, worker reallocation, aggregate productivity, economic growth, misallocation

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TIIVISTELMÄ

Tässä väitöskirjassa tarkastelen kansantalouden tuottavuuteen vaikuttavia tekijöitä. Esseet käsittelevät sitä, miten yritystoiminta ja yritysten toimintaympäristö vaikuttavat aggregaattitason tulemiin, kuten tuotantoon, työllisyyteen ja tuottavuuteen.

Ensimmäisessä esseessä tutkin työntekijöiden liikkuvuuden ja talouskasvun välistä yhteyttä. Toimipaikat, jotka palkkaavat työntekijöitä tuottavammista toimipaikoista, näyttävät kasvattavan tuottavuuttaan tulevina vuosina. Tarkastelen havainnon kokonaistaloudellista merkitystä kehittämällä mallin, jossa yritykset voivat kasvattaa tuottavuuttaan palkkaamalla työntekijöitä itseään tuottavammista yrityksistä. Aineistoon sovitetun mallin perusteella työntekijöiden siirtämä tietotaito kasvattaa vuosittaista talouskasvua 0.14 prosenttiyksiköllä ja sosiaalista hyvinvointia kahdella ja puolella prosentilla. Lisäksi kyseinen mekanismi voimistaa irtisanomiskustannusten negatiivisia vaikutuksia jopa kolminkertaisiksi.

Toisessa esseessä arvioimme yritysten alkuvaiheeseen liittyvän epävarmuuden kokonaistaloudellisia tuottavuusvaikutuksia. Kehitämme staattisen mittarin, jolla pystymme erottelemaan veronkaltaisten kitkojen aiheuttaman resurssien huonon sijoittumisen ja epävarmuuden toisistaan. Keskeinen tulos on, että se mikä lopulta näyttää kitkojen aiheuttamalta resurssien huonolta allokaatiolta, on suurimmaksi osaksi yritysten epävarmuutta suomalaisessa aineistossa. Ymmärtääksemme epävarmuuden aiheuttamia aggregaattivaikutuksia, rakennamme yritysten elinkaarimallin, jossa yritykset oppivat hiljalleen todellisen tuottavuutensa. Aineistoon sovitetun mallin mukaan epävarmuus alentaa tuottavuutta jopa 38 %, kun taas kitkojen aiheuttama resurssien huonon sijoittumisen negatiivinen vaikutus tuottavuuteen on 26 %.

Kolmannessa esseessä tarkastelen, miksi yritysten koot ja liikevaihto eroavat toisistaan merkittävästi jopa silloin kun ne tuottavat lähes samanlaisia hyödykkeitä. Hyödynnän tutkimuksessa joustavaa staattista yritysheterogeenisuutta kuvaavaa mallia, joka mahdollistaa yritysten välisten erojen purkamisen eroihin tuottavuudessa, kysynnässä, voittomarginaaleissa, liikevaihto- ja pääomakitkoissa. Empiirinen tarkastelu paljastaa, että erot selittyvät lähes kokonaan kysyntäeroilla. Lisäksi, toisin kuin aikaisemmassa kirjallisuudessa, voittomarginaalierot näyttävät selittävän yritysten välisiä eroja.

ASIASANAT: yritysheterogeenisuus, työntekijöiden liikkuvuus, tuottavuus, talouskasvu, resurssiallokaatio

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April 2022
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List of Essays

This dissertation is based on the following essays, which are referred to in the text by their Roman numerals:

I Eero Mäkynen. Economic Growth through Worker Reallocation: The Role of Knowledge Spillovers.

II Eero Mäkynen & Oskari Vähämaa. Uncertainty, Misallocation and the Life-cycle Growth of Firms.

III Eero Mäkynen. Unraveling the Sources of Firm Heterogeneity.

1 Introduction

This compilation thesis studies how firm dynamics and economic policies affect aggregate productivity, economic growth, and other aggregate outcomes. In this chapter, I lay out the basics of the theoretical frameworks used in the essays and provide an overview of recent firm dynamics literature to give a background for the essays in this dissertation.

1.1 Background

The question of why some countries are wealthier than others has motivated a significant part of past and current macroeconomic research. Providing a decisive answer to the question is challenging as we can think of several interlinked factors determining a nation's income level. Despite its challenges, studying the determinants of cross-country income differences is important. It helps us to single out economic policy tools that foster growth and assist development.

Hsieh & Klenow (2010) and many others argue that in development accounting, three distinct factors: physical capital, human capital, and total factor productivity, explain the income differences between countries. According to their study, differences in the total factor productivity explain roughly 50-70 percent of the differences between countries, and the physical and human capital differences explain the remaining 30-50 percent. Therefore, it seems likely that understanding the determinants of productivity would bring us closer to the reasons behind the wealth and income differences.

Compared to total factor productivity, physical and human capital are easier to relate to measurable factors. For example, the value of machinery in production is a proxy for physical capital, and education is informative about human capital. On the other hand, productivity is more challenging to measure as we do not have a direct empirical proxy for it. Therefore, it is common to determine productivity as a residual of the production function. The resulting measure will contain everything that we cannot attribute to the physical or human capital differences. Therefore, the residual is not an ideal measure for productivity as it may contain several other factors that affect the income differences between countries.

A study of firm dynamics is essentially a study of aggregate productivity. Under a single total factor productivity figure, thousands of individual firms operate with varying productivities and conditions. The firm dynamics is mainly a sum of three factors. The first component is the evolution of productivity of each firm. The second one consists of firms' entry and exit. The third factor that forms firm dynamics is allocative efficiency; in other words, how efficiently the economy places resources in the hands of those who know how to utilize them best.

The evolution of firm-level productivities is one of the central elements of an economy's total factor productivity. Most basic models of firm dynamics assume that the evolution of firms' productivities is independent of their actions. More recently, literature has considered theories where a firm's productivity depends on how the firm invests on R&D or how it allocates managerial time to search for new ideas. These investments in the form of money or time depend on the overall business environment and economic policies.

Firm selection, the process of firms exiting and entering the market, is another important determinant of aggregate productivity. It affects what type of firms compete in the market and relates to the notion of creative destruction where new ideas, products, or producers enter the market and old ones eventually die out. As new firms make a large share of innovations, studying the entry of firms is essential in understanding aggregate productivity. Equally important is to understand why firms exit and what is its impact on the aggregate productivity.

The third factor that impacts the total factor productivity is the allocation of resources. This channel is interlinked with the earlier two in the following way: if there are significant barriers for reallocating resources, firms are likely to change the innovation effort or reconsider entering the market. The first objective of the misallocation literature has been to quantify the extent of misallocation. Studying the extent of misallocation gives us an idea of how beneficial redistribution of input resources could be. More recently, the focus has also shifted towards understanding how different factors that generate misallocation contribute to aggregate productivity through the individual firms' productivity process and selection.

1.2 The Role of Job Creation and Destruction for the Aggregate Productivity

How important is entry and exit of firms for aggregate productivity? Can differences in market conditions explain the differences in aggregate productivity? These questions have been widely studied in the literature. A workhorse model of studying such questions is Hopenhayn (1992), and in this section, I provide a simplified version of the model, which makes it explicit how market conditions shape the aggregate productivity through selection, i.e., the entry and exit of firms. The entry and exit choices will be endogenous decisions made by the firms and potential entrants.

In the economy, there exists an endogenously defined number of firms. Each firm draws its productivity $z \in \mathbb{R}$ when entering the market from the distribution G. All firms produce a homogeneous good that firms can sell at a price p and wages w are set as numeraire in the model. Each firm uses decreasing returns to scale to produce the output $f(n) = n^{\alpha}$, where $0 < \alpha < 1$. Firms maximize profits by choosing the number of employees and have to pay fixed costs, c_f, for operating in each period. We can write the firm's static problem as

$$\pi(z,p) = \max_{n} pzn^{\alpha} - n - c_f, \tag{1}$$

which yields labor demand $n(z,p) = (\alpha zp)^{\frac{1}{1-\alpha}}$. Using the labor demand, the maximized profits can be written as a function of productivity and the price of the final good $\pi(z,p) = (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}(pz)^{\frac{1}{1-\alpha}} - c_f$. Each firm has the option to exit the market after the productivity, z, is drawn from G. The value of not operating in the market is equal to zero. Hence, condition $\pi(z^*,p) = 0$ determines the level of productivity z^* at which firm is indifferent between operating and exiting the market. The productivity level z^* is the lowest profitable level of productivity.

The economy has an infinite amount of potential firms that consider entering the market. The value of operating in the market can be described with the value function

$$v(z,p) = \max\{0, \pi(z,p)\}. \tag{2}$$

When deciding whether to enter the market entrants compare the value of entering to the entry cost c_e, which, for example, represents the time spent on registering the business. The entry costs describes in terms of labor how valuable running a business is in expectation before drawing the productivity level. In the equilibrium, for the last entrant, the cost of entering equals the value from entering. The free entry condition is

$$c_e = \int_{z^*}^{\infty} \pi(z,p)dG(z). \tag{3}$$

Thus, we have two conditions, the free entry condition in (3) and the profitability condition, $\pi(z^*,p) = 0$, and two unknowns: the exit threshold, z^*, and the market clearing price, p. By substituting the profitability condition to the free entry condition, we get a simple expression for the productivity cut-off

$$\frac{c_e}{c_f} = \int_{z^*}^{\infty} \left[\left(\frac{z}{z^*} \right)^{\frac{1}{1-\alpha}} - 1 \right] dG(z). \tag{4}$$

A direct implication of this equation is that an increase in the ratio of costs lowers the exit threshold, z^*. In other words, an increase in the entry cost or a decrease in the fixed costs increases the number of low productivity firms in the economy.

To further analyze the model, we can solve the mass of entrants that is a function of the exit threshold. The labor demand in the model is formed by the labor required in production, paying the fixed and entry costs. By assuming that the economy has

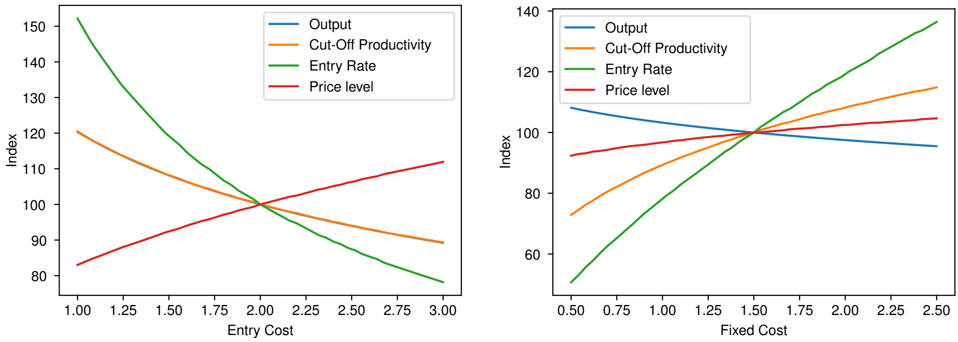

Figure 1. Illustration of the effects of entry and fixed costs in the static model. In left figure the cut-off productivity and output overlap.

fixed labor supply, we arrive at the following expression for the labor market clearing

$$L = \left(\int_{z^*}^{\infty} \frac{\alpha}{1-\alpha} c_f \left(\frac{z}{z^*} \right)^{\frac{1}{1-\alpha}} dG(z) + c_f[1 - G(z^*)] + c_e \right) M^e \tag{5}$$

that defines the endogenous mass of entrants. An immediate implication also is that the mass of incumbents can be defined as $M = [1 - G(z^*)]M^e$.

In Figure 1, I illustrate the effect of entry and fixed costs on output, entry rate, price level, and the exit threshold. I calculated the results by assuming that entrants draw the productivities from Pareto distribution with minimum value of one and scale of two. For the returns to scale parameter, I use the conventional value of 0.64 used, for instance, in Hopenhayn & Rogerson (1993). The baseline value of entry costs is 2, and the fixed cost is 1.5. In the figure, the values are reported as indexes as there is no meaningful interpretation of the absolute values.

An immediate observation from Figure 1 is that the output declines when the entry costs increase. The model's output can also be interpreted as a measure of welfare if we define linear utility over consumption. Moreover, the output can be interpret as the aggregate productivity. This is due the fixed labor supply as the only factor changing in aggregate labor productivity measure Y/N or TFP measure Y/N^{α} is the output. The mechanism through which the entry costs impacts the output operates in the following way. When entering the market is more costly, the number of entrants decreases. It implies looser competition, which causes firms with lower productivities to enter the market. The price level also changes to balance the free entry condition. The price change increases the size of each firm, which means that the labor supply can be exhausted by a smaller mass of firms and thus a lower mass of incumbents.

Next, when looking at the effect of fixed costs, we see that they have the opposite effect on the exit threshold and the entry rate compared to the entry costs. By making it costlier to operate in the market, higher fixed costs increase the exit threshold. However, there is a difference in how the fixed costs affect the price level. The price level depends on the fixed costs in two ways. First, fixed costs directly enter the equation that defines the price level. Second, the exit threshold also depends on the fixed costs, which also enters the price-defining equation. The two distinct channels react in opposite directions when fixed costs increase. When the level of threshold increases, the price adjusts downwards, but at the same time, the direct effect pushes prices upward. The net effect of these two forces determines the price level change. As is visible from Figure 1, the pure effect of fixed costs on the price level appears to dominate as the price level increases. The observation means that firms operate on a larger scale, and thus a smaller mass of firms is enough to use all the supplied labor. It further implies that output decreases. A direct implication of the result is that fixed and entry costs are not flip-sides of the same coin in the sense that what happens with entry cost increase could equally be achieved with fixed cost decrease. The observation highlights that calibrating a quantitative framework is crucial for making any quantitative conclusions about output, productivity, or welfare effects of the two costs.

The simplified example above shows how the selection channel shapes aggregate productivity, output, and welfare. The presented framework follows the basic operating principle of most of the firm dynamics models. For example, the full-fledged model of Hopenhayn (1992) would include the first-order autoregressive process for the idiosyncratic productivity of firms instead of just a constant, and a general equilibrium version of the model would specify the consumer behavior in addition to a more realistic productivity process as in Hopenhayn & Rogerson (1993). The more general process for idiosyncratic productivity helps the model to match the data and creates a within-period worker reallocation between firms as they need to adjust their size in response to changes in productivity. Another empirical fact that the autoregressive productivity process helps match is that the probability of exiting the market declines with firm size. In the international trade literature, the workhorse model is Melitz (2003). The above model is very close to this framework if we abstract from the producers' ability to participate simultaneously in domestic and foreign markets. The remaining difference is that firms engage in monopolistic competition in the Melitz (2003) model instead of producing a homogeneous good.

The literature that quantitatively analyzes the importance of selection on productivity is vast. The ideas presented above have been utilized, for example, in cross-country analysis of the impact of entry costs on the productivity. Another active research field analyzes the role of selection - the entry and exit of firms - over the business cycle (e.g. Sedláček & Sterk, 2017). The frameworks used in the analysis are more complex than the above framework. However, it illustrates the basic ideas of these models.

A well-functioning reallocation of resources is an important feature of the market economies. One form of reallocation is the transition of workers and capital from exiting firms to entrants. As we saw from the above conceptual framework, large entry costs can lower the entry and productivity of an economy and make low-productivity firms stick longer in the market. Moscoso Boedo & Mukoyama (2012) analyze whether the differences between countries' TFPs can be explained by differences in the level of entry and firing costs with rich cross-country data. According to their analysis, a TFP prediction of an industry equilibrium framework can explain 27% of the observed TFP variation with variation in the entry and firing costs. Of the two, entry costs have a larger role, and they alone explain 25% of the observed variation in the total factor productivity across countries.

In addition to the cross-country analysis, the framework lends itself to assessing the effects of different policies within a country. The original application of Hopenhayn & Rogerson (1993) was for the firing costs. Such analysis requires a couple of extensions to the above framework. First, to capture the continuous changes in firms' demand or productivity, the productivity or demand variable is assumed to follow the first-order autoregressive process. As mentioned above, this change implies that workers move between incumbents and that some incumbents have to fire workers while operating in the market. Second, after introducing the firing costs, the number of employees becomes a state variable for the firms as the previous level of employment affects the firing costs the firm has to pay.

In general, the aim of the literature that explores the role of firing costs is to show how factors that limit the reallocation of jobs impact the entry and exit of establishments and, thus, the aggregate productivity. Some of the first papers to look at this question are Bentolila & Bertola (1990) and Hopenhayn & Rogerson (1993). These papers are motivated by the observation that European countries and the U.S. differ considerably in the employment protection legislation. Bentolila & Bertola (1990) discuss the effect of firing costs in the partial equilibrium context and calibrate their model to match aggregate figures. They find that dismissal costs increase employment. Hopenhayn & Rogerson (1993) analyze the effect of the dismissal costs in a general equilibrium context and calibrate the model to the firm-level data. They find the opposite: the dismissal cost corresponding to one year's wage decreases employment by 2.5 percent. The framework they use lends itself also for welfare calculations, and they show that the same dismissal cost decreases welfare by two percent.

Moscoso Boedo & Mukoyama (2012) also analyze the role of firing costs in the cross-country context. However, they find that the firing costs cannot explain the differences between countries' total factor productivity. More specifically, the firing costs alone can only account for 8% of the variation in total factor productivity.

The theoretical setting that predicts a strong connection between productivity and employment protection has motivated empirical research. For example, Autor, Kerr & Kugler (2007) have analyzed the role of wrongful discharge protection in the U.S. They find that the regulation reduces employment flows, firm entry rates, and total factor productivity. However, the regulation also appears to increase the total employment; hence the authors conclude that the overall effect in terms of welfare might not be negative. Another empirical paper by Haltiwanger, Scarpetta & Schweiger (2014) studies the connection between labor market regulation and job reallocation. They motivate their study with the inconclusive prior research on the connection between the two. By making improvements in data and estimation strategy, they show evidence of a negative connection between labor market regulation and job reallocation. Their results support the predictions of the industry equilibrium models, e.g., Hopenhayn & Rogerson (1993).

Ultimately, the literature exploring the connection between the reallocation of jobs and productivity is related to all three essays in this thesis. In the first essay, I set up a quantitative framework that closely follows the ideas of Hopenhayn & Rogerson (1993) and has a random growth mechanism of Poschke (2009). Then, with the help of the quantitative framework, I explore the effects of firing costs. The crucial distinction between the earlier literature and my first essay is that I explore the role of knowledge spillovers generated by worker reallocation. To do so, I expand the former quantitative frameworks with a knowledge diffusion mechanism and use microdata to calibrate the mechanism. A central finding from the calibrated model is that knowledge diffusion increases the impact of firing costs on productivity and welfare even by a factor of three. Furthermore, the result suggests that previously discovered aggregate effects of firing costs could be lower-bound estimates as they do not consider the knowledge diffusion through worker reallocation.

The second essay explores the role of early life cycle uncertainty for aggregate productivity. In the essay, we define uncertainty as a firms inability to forecast fully their level of fundamentals when choosing their inputs. The job reallocation arises in the model from the firms' need to adjust their size as they slowly learn their productivity and from firms' entry and exit decisions. Additionally, the framework accounts for costs related to adjusting the number of employees, which is one form of potential barrier for reallocation. With a calibrated model, the paper shows that firms' uncertainty about their productivity suppresses the output by 38%. The learning at the beginning of the firm's life-cycle reduces the aggregate productivity by 17%, and adjustment costs reduce the output by 11%. Together the adjustment costs and uncertainty reduce output by 40%, which shows that adjustment costs make firms more careful in initial adjustments of their size and thus might mitigate the negative effect of the uncertainty. Considering the role of uncertainty is not new to the literature. However, in the second essay shows how the data from firm profits can be utilized when exploring the role of uncertainty. More precisely, information about profits allows us to disentangle uncertainty from other factors that might create a bridge between the marginal cost and product of inputs with minimal model structure.

In the third paper, I try to understand the source of variation in the firm sizes and revenues. I decompose these observable characteristics' variation into five different determinants of firm heterogeneity: productivity, demand shifter, markups, revenue wedges, and capital wedges. Although I do not directly explore the impact on aggregate productivity, the results are informative about the firm differences that might impact aggregate productivity. The traditional explanation of firm-level differences relates to the differences in demand or productivity. I confirm this finding by showing that demand shifter is a significant source of between firm variation, which is in line with recent papers of Eslava & Haltiwanger (2020) and Hottman, Redding & Weinstein (2016). However, my analysis also shows that firms' ability to charge different markups on their products might be the reason for the firm-level differences. This finding contrasts the results in recent papers and has policy relevance as markups create a bridge between the market and a planner's solution.

1.3 Evolution of Individual Firms' Productivities and Aggregate Productivity

Recent literature focuses on understanding aggregate productivity and its growth through the evolution of the productivity of individual firms. Research in this area has emerged from the increasing availability of firm-level datasets that provide information on individual firms' behavior. The information makes it possible to compare the critical attributes of firms conditional on profitability and possibly shed light on the path that led the most productive firms to the top.

I roughly classify the growth literature in firm dynamics context into three categories. The first class discusses the role of research and development (R&D) investments and how firms actively develop new products when trying to benefit from a temporary monopoly that new products grant. Conceptually, the growth results from dynamic behavior such as making investments, and there is no role for spontaneous inventions. The second category includes the theories of random growth. In this line of thought, the innovations are random occurrences, and entrants that imitate the incumbents sustain the growth. The third set of literature relates to the random growth theories with a distinction that incumbent imitation generates the growth. This literature strand could be called idea flow models or diffusion-based growth models. In these papers a leading theme is to discuss how the social interaction between individuals or firms diffuses knowledge across the economy and, hence, impacts the rate of aggregate growth.

Klette & Kortum (2004) is one of the seminal contributions that connects firm-level dynamics to endogenous growth theory. Their work provides a simple tractable endogenous growth model which explains several empirical regularities related to the R& D investment, patenting, and firm growth. Their model is considered to be a baseline model for questions related to R&D investment and aggregate growth.

The core mechanism in Klette & Kortum (2004) has a simple operating principle.

In the economy, there exist infinite product lines in the unit line. Each firm occupies n number of the product lines. A firm concurs a product line by innovating after investing in the R&D. The firm that innovates can produce the product more efficiently than its incumbent producer, and the innovator occupies the product line in a Bertrand competition. As the firms do not target the innovation effort to a specific product line, each product line can be captured with equal probability by the firm's competitors. Through this exchange of product lines and improvements, firms define the pace of aggregate growth and thus the economy's productivity level.

The quantitative framework of Klette & Kortum (2004) can reproduce several empirically observable facts related to firm behavior. The model can replicate the positively skewed distribution of firms, an empirical regularity of the modern economies. In the model, the R&D intensity is independent of the firm size, another stylized fact found in the empirical literature. The model also facilities realistic entry and exit dynamics. Firms enter with one product line and increase their portfolio through innovating. Firms exit when they have zero product lines left. Exit is the fate of any firm eventually as it is inevitable to reach a long period without innovations in which the producer only loses product lines.

The model has been used to answer a rich set of policy questions as the model successfully replicates several empirical facts related to R&D investment, patenting, and firm growth. One recent example of this line of work is the paper by Acemoglu et al. (2018). The authors set out to analyze the aggregate consequences of several types of industrial policies. A central result is that subsidies on R&D, operating costs, or entrants are ineffective in fostering growth and improving welfare. However, taxing the continuing operations of firms appears to be effective. The key mechanism that explains the result is that by encouraging the exit of firms, the tax frees resources for the most innovative firms, leading to increased welfare and growth.

Building on the work of Klette & Kortum (2004), later studies have tried to understand the nature of aggregate growth. Two prominent examples of such studies are Lentz & Mortensen (2008) and Akcigit & Kerr (2018). Lentz & Mortensen (2008) extend Klette & Kortum (2004) framework by allowing for heterogeneity in the size of individual firms' improvements on a specific product line. Their results imply that in each cohort of firms over half of the growth stems from the reallocation of labor from less productive firms to more productive ones. Akcigit & Kerr (2018) build on Klette & Kortum (2004) and Lentz & Mortensen (2008) to study the connection between firm heterogeneity and productivity growth through different types of innovations. They consider three types of innovations: innovations by entrants, external innovations by incumbents as they try to occupy other product lines, and internal innovations by incumbents as they innovate at the product lines they already own. According to the most prominent result, over half of the aggregate growth stems from the external innovations made by the incumbents. The remainder is distributed equally among the other two types of innovations.

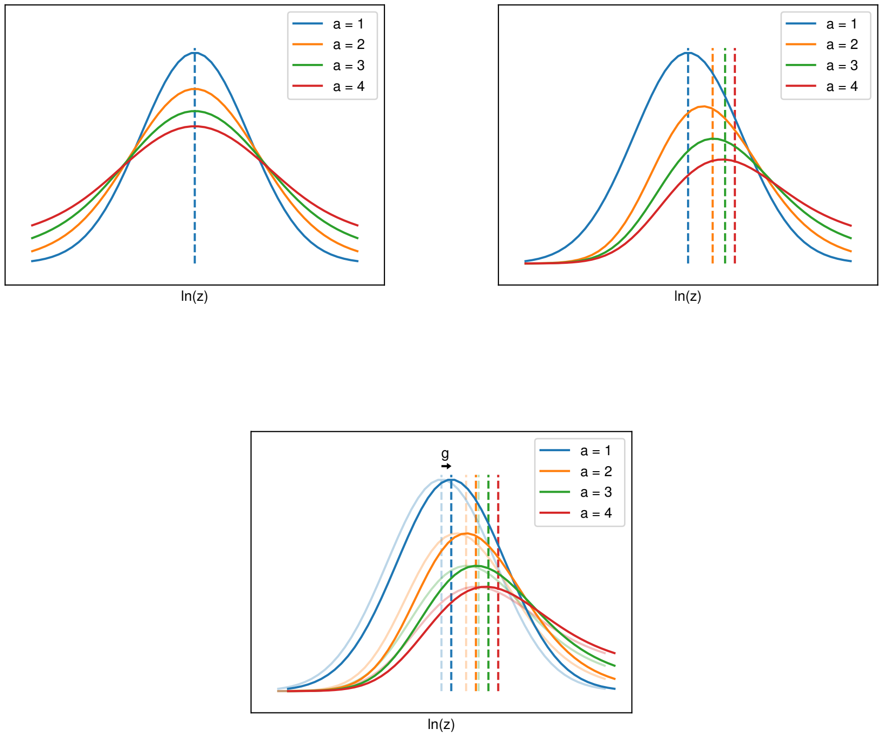

Figure 2. Illustration of the growth mechanism in the random growth models. All solid lines summarize productivity distribution of firms. In each figure, different colors represent the same cohort of firms with different ages, a. The dotted lines are positioned to the mean of the respective distribution of productivity. The top-right figure presents a scenario if no-one would exit. The top-right includes exits if the productivity goes below the exit threshold. The bottom figure represents the new cohort that arrive with higher average productivity.

Another way to view growth, especially innovations, is to think of them as something that firms cannot attain through direct investments to R&D. This literature strand draws from the urban economics literature, where city growth is modeled as a result of random shocks. Contributions in the firm dynamics context include Luttmer (2007) and Poschke (2009). In this theory of aggregate productivity growth, the productivity improvements or ideas occur randomly to a firm. I have illustrated the operation of the simple mechanism in Figure 2. In the most basic version of the theory firm's productivity is assumed to follow a random walk. As productivity shocks hit the firms, the variance of the cross-sectional distribution of firm productivities increases. The increase in the variance is visible in the top-left of the Figure 2, which plots the productivity distribution of the first four years for a single cohort of firms. After the productivity shocks have hit the firms, some are pushed below the profitability limit, defined by fixed operating costs, and decide to exit. The exit of firms leads to truncation of the productivity distribution of firms from the left. The well-known feature of truncation and increase of variance is that it increases the mean of the remaining distribution in many cases. This effect is visible in the top-right figure as the mean productivity of the specific cohort increases[1]. Thus, the average level of productivity within a cohort grows, and further, when multiple cohorts experiencing the same increase in productivity populate the economy, its aggregate productivity grows. If such a mechanism would operate a long time without any new firms entering the market, the distribution of firm productivities would be very flat. The force that prevents the flattening of the productivity distribution is the imitation by entrants. Entrants follow the average level of productivity in the economy and thus can keep up with development. The imitation ensures that new firm mass enters the distribution of productivities, and it also means that old cohorts will eventually exit the market. Such an assumption is quite realistic as we rarely see new businesses being found to manufacture outdated products. In the bottom of Figure 2, I have plotted the first four years of the next cohort, which enters the market more productive than the previous cohorts. To be precise, the increase in the cohort's productivity corresponds to the economy's growth rate.

As the first essay of the dissertation utilizes the random growth mechanism, I give a more formal description of the model in the spirit of Poschke (2009). Some parts of the model are close to the Hopenhayn (1992) type of model described earlier. However, the model requires few dynamic considerations contrary to the above, even in its most reduced form.

Firms use similar technology and operate in similar fashion as in the previous section. Simple static choice of employment for operating firms yields the same employment and profit equations as before

$$n(z,p,w) = \left(\alpha \exp(z)\frac{p}{w}\right)^{\frac{1}{1-\alpha}} \tag{6}$$

$$\pi(z,p,w) = (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\left(\frac{p}{w}\exp(z)\right)^{\frac{1}{1-\alpha}} - wc_f. \tag{7}$$

Now, as the mechanism operates through random shocks, I slightly change the productivity process specification. As mentioned earlier, the productivity follows a random walk, and I can formally write it as $z' = z + \epsilon$, where $\epsilon \sim N(0, \sigma_\epsilon^2)$ is a random innovation to the firm's productivity and dot represent the next periods value. The specification of the productivity process makes the firm's exit decision dynamic, which leads to a slightly more complex expression of the value of running a firm

$$V(z,p,w) = \pi(z,p,w) + \beta \max\{\mathrm{E}_z[V(z',p,w)], 0\}, \tag{8}$$

[1] In the figure, two-fifths of the least productive firms decide to exit.

where the $0 < \beta < 1$ is the discount rate. The solution to the problem is a policy function $\varphi(z, p, w)$ that describes the optimal exit strategy. Another modification I make to the equations is keeping the wage in the equations for clearer exposition.

As before, the model features entrants that draw productivity after entering the market. The only difference is that the productivity of entrants follows the endogenously determined mean of the incumbent productivities, which grows with a constant rate, $\bar{z}$ from a distance κ. The expression for the free entry condition is

$$wc_e = \int \pi(z, p, w) dG(z). \tag{9}$$

The variance of the entrants productivities is fixed to σ_z. Moreover, the distribution G is assumed to be normal. Next, we need to determine the mean of incumbent productivities. For that purpose, I set up a distribution operator T that describes the evolution of the productivities for incumbent firms

$$\Psi'(z') = T(\Psi(z)) = \int \left(Q(z'|z)\Psi(dz) + G(dz)M \right), \tag{10}$$

where Q gives the fraction firm with productivity z that move tomorrow to productivity level z', and M is the mass of entrants. Using the operator T, we can solve the distribution of incumbent firms in each point in time given the initial distribution $\Psi_0(z)$. By using the measure of incumbents, I can calculate the endogenously determined mean productivity $\bar{z}$ that feeds into the free entry condition.

To complete the model, the number of entrants has to be determined. As in the previous section, I specify similar the labor market clearing condition

$$L = \int n(z, p, w)\Psi(dz) + c_f \int \Psi(dz) + c_e M. \tag{11}$$

Convenient features of the firm measure (see Hopenhayn, 1992), such as homogeneity in M, allow solving the number of entrants directly from the labor market clearing condition.

The competitive equilibrium of the model consists of sequences of policy functions, distributions, a mass of entrants, and prices. Four conditions hold in the competitive equilibrium. First, the policy function is the solution to the incumbent's problem. Second, the mass of entrants is such that the labor market clearing condition holds. Third, the prices adjust such that the free entry condition holds. Fourth, the distribution is defined recursively according to the law of motion specified in (10).

Next, I define the balanced growth equilibrium, which is more useful to understand the connection between firm dynamics and aggregate growth. At the balanced growth path, equilibrium quantities (such as output), wages, the average productivity grow at the constant rate g, and the shape of the firm distribution remains invariant. To analyze the balanced growth path, I need to apply variable transformations. For variables that grow in the balanced growth path, I use transformation $\hat{x} = x\exp(-gt)$. For constant variables, I do not apply a transformation, and for firm-level productivity, I use $\hat{x} = x - gt$ as the productivity enters to firms production function in exponential form. To fix the relative price, I normalize the initial wage level to one. With the suitable transformations in place, I can solve the balanced growth path.

The numerical algorithm follows a similar algorithm used to solve Hopenhayn & Rogerson (1993) model. However, finding the equilibrium growth rate requires an additional loop to find the economy's growth rate. The algorithm can be described in the following steps:

1. Guess g and p
2. Solve incumbent's problem to attain the firms optimal policy $\varphi(\hat{z}, p; g)$
3. Check the free entry condition. If satisfied, continue. Otherwise, update p and return to 2.
4. Solve the productivity distribution of incumbents and check whether $\bar{\hat{z}} - \kappa$ is equal to the entrant's stationarized mean productivity. If satisfied, continue. Otherwise, update g and return to 2.
5. Using the productivity distribution, solve the labor market clearing condition and attain equilibrium amount of entrants.

The solution will also require suitable numerical methods to discretize the continuous variables.

To illustrate the central connection between growth rate and firm selection, I report numerical results in Figure 3. For the calculations, I use selected parameter values and solve the model by changing the fixed and entry costs with respect to the baseline[2]. The blue line shows how the increase in the fixed costs increases the aggregate growth. The reason for the increase is that higher fixed costs mean stricter selection. Stricter selection implies that incumbent firms get replaced with more productive entrants faster, increasing the growth rate. With this explanation in mind, it is easy to understand why the increase in entry costs has the opposite effect. In random growth models, strict selection means higher aggregate growth rates.

In a random growth model, there is not much of a role for policies guided directly towards increasing the innovation rate as firms cannot affect the evolution of their productivities. However, a policy that affects the entry and exit of firms can

[2]The used parameter values are $L = 1$, $\sigma_\epsilon = 0.05$, $\sigma_z = 0.3$, $c_f = 1.1$, $c_e = 2$, $\alpha = 0.64$, $\beta = 0.95$ and $\kappa = 0.2$

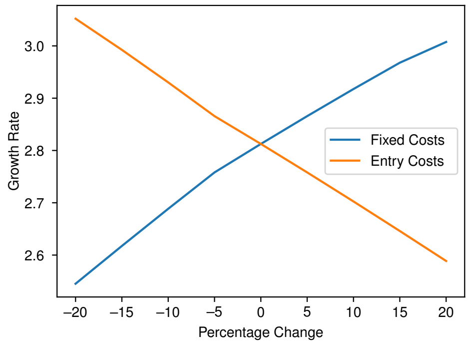

Figure 3. Aggregate growth rate with different levels of fixed and entry costs.

be effective. This is because the increases in firms' average productivity largely depend on where the profitability cut-off lies and how easy it is to enter the market. An example of an analysis of economic policy that affects these margins is Poschke (2009). He analyzes how employment protection legislation affects the rate of aggregate growth when it alters the incentives to enter and operate in the market. His main findings are that moving towards a European level of employment protection in the U.S. would reduce aggregate growth by 0.1 percentage points and that it matters for the growth effect whether exiting firms are required to pay the firing costs similarly as incumbents.

In this dissertation's first essay, I use a similar growth mechanism as Poschke (2009) and Luttmer (2007). Thus, even if the paper's focus differs from the earlier literature that studies this particular type of growth, the basic operating principle of the core mechanism is similar. The essay contains a similar policy experiment as done in Poschke (2009) with a distinction that I consider the role of knowledge diffusion in such an experiment. By running a similar exercise as Poschke (2009) does, I find that knowledge diffusion amplifies the effect of firing costs with a factor of 1.2-3. This result means that the earlier mentioned 0.1 percentage point growth impact could have been 0.12-0.3 if the model had included a similar level of knowledge flows. Of course, this is a coarse generalization as there is no sufficient information to calibrate my model to the U.S. data.

The third class of growth models containing firm heterogeneity is the idea flow models, where growth stems from social interactions between individuals. One of the first contributions in this theory strand is Jovanovic & Rob (1989). Later, a similar theoretical approach has been proposed by Lucas (2009), Lucas & Moll (2014), and Perla & Tonetti (2014).

In the idea flow models, the diffusion of knowledge acts as a sole engine of growth. The theories have some resemblance to random growth models as new ideas are generated randomly, or all technology already exists in the economy[3]. However, the way the ideas get transmitted from one individual to another is different. In the idea flow models, technology transmits through bilateral meetings between individuals. In more detail, each individual determines a search effort or has pre-set meeting probability with others. When a meeting occurs, the productivity of the more knowledgeable individual transmits to the less knowledgeable one. As knowledge can only improve through this process, it implies that the average productivity of the economy grows.

One of the most explored questions with the idea flow models is related to international trade. The leading idea in this strand of literature is that ideas diffuse across countries when they trade goods. Selling a particular good abroad allows the receiver country to learn from it and potentially infer some details of the manufacturing process of that good. Alvarez, Buera & Lucas (2008, 2013) have laid out the most basic description of the mechanism. More recently, Buera & Oberfield (2020) test the model with data to understand how much larger are the effects of bilateral trade costs with and without the knowledge flows. A main result from their study is that knowledge diffusion through trade doubles the benefits of relaxing the bilateral trade costs in comparison to standard reallocation gains. The result implies that earlier analysis of the gains from trade liberalization might have underestimated its benefits. The related approach of Perla, Tonetti & Waugh (2021) reaches a similar conclusion with a different set of assumptions. In their framework, the gains from trade are more indirect as firms can only learn from the domestic markets.

Even if I have tried to classify the growth models with firm heterogeneity in three classes, there exists an overlap between classes. One example of such overlap is the Benhabib, Perla & Tonetti (2021). The authors combine the diffusion models with a frontier that expands as a result of R&D investments. They demonstrate the interaction between innovation and adoption and show that low adoption costs might disincentivize innovation. This is because if the adoption of technologies is easy, firms might choose to relax R&D investments and prefer to fall back as an industry follower that only has to invest in adoption.

In the first essay, I evaluate the aggregate significance of knowledge transmitted by workers. The quantitative framework bases on the random growth models. However, the model contains an additional mechanism that lets firms control their productivity by hiring workers from more productive firms. In this sense, the article comes close to the knowledge diffusion models. One challenge of the knowledge diffusion models is that the calibration of the central mechanism sets high requirements for data. The data must contain information about the event that transmitted knowledge and the levels of knowledge before and after. If we, for instance, would be interested in knowledge flows across entrepreneurs, we would need data on meet-

[3]Romer (2015) has criticized this particular feature of the model as, when taken literally, nothing new is generated in the model.

ings between them. However, such data would be hard to attain. In the case of hiring, the data requirements are easier to meet as employer-employee data contains sufficient information about producers' productivities, and worker flows between them. In the first essay, I use such data to calibrate a particular type of knowledge diffusion mechanism.

1.4 Misallocation of Production Resources and Aggregate Productivity

Are the resources in the hands of those that have the best means to utilize them? Restuccia & Rogerson (2008) were the first to point out that in standard firm dynamics framework, such as Hopenhayn (1992), a tax-like distortion, which generates gap between the marginal cost and product, can cause significant harm for the measured total factor productivity. Moreover, the losses are substantial if the distortion correlates with a firm's productivity such that high-productivity firms are "taxed" more. Hsieh & Klenow (2009) test this idea with the data and set up a simple quantitative framework to carry out an accounting exercise. The exercise's main results revealed that India and China could significantly improve their output and productivity by redistributing resources compared to the U.S., which they considered as the benchmark of an undistorted economy.

In this section, I illustrate, with the help of a structural model, how the misallocation of resources can lead to losses in measured total factor productivity and output. The purpose is to go over the basic idea of Restuccia & Rogerson (2008) with a modified version of the model in Hsieh & Klenow (2009). The topic covered is closely linked to the second essay of this thesis.

The economy is populated by a fixed mass of firms with productivity, $z \in \mathbb{R}^+$, drawn from log-normal distribution distribution G, with mean, μ, and variance ,σ_z^2. Each firm produces homogenous goods that they can sell at a constant price, p, which I normalize to one. Firms can produce using technology $y = f(n) = n^\alpha$, where the $0 < \alpha < 1$. Similarly, as in the previous section, labor, n, is the only input in production. Introducing capital would be an unnecessary complication, as I can illustrate the point with this simplified input structure. I also abstract from any selection effects, i.e., entry and exit of firms. Even if the interaction between selection and misallocation is an important channel, the core idea can be illustrated without it. Firms have to pay wage, w, for using labor. Additionally, to illustrate the effect of tax-like wedges, $(1-\tau) \in \mathbb{R}^+$, firms are subject to a distortion $(1-\tau) = \epsilon/z^\theta$, where $\epsilon \sim$ Log-N$(0, \sigma_\epsilon^2)$ and $\theta \in [0, 1)$ sets the degree of correlation between the productivity, z, and effective distortion, $(1-\tau)$. The static profit maximization of a firm can be expressed as

$$\max_n (1-\tau) z n^\alpha - wn, \tag{12}$$

which yields optimal firm size of $n = (\alpha z(1-\tau)/w)^{\frac{1}{1-\alpha}}$. From an alternative representation of the optimality condition $w = (1-\tau)\alpha z n^{\alpha-1}$, we can see that the distortion generates a wedge between the marginal product and cost of the labor input. This is the precise source of inefficiency in the economy as equating marginal product with cost would be optimal.

To illustrate the impact of σ_ϵ^2 and θ on the output and observed productivity of the economy, it is useful note that firms output resulting from the optimization is

$$y(z,(1-\tau)) = ((1-\tau)z)^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}}. \tag{13}$$

Then the total output of the economy can be written as

$$\sum_{i=1}^{M} y_i(z,(1-\tau)), \tag{14}$$

where M is the number of firms in the economy.

To understand what is meant by the misallocation of resources, we have to do the following thought exercise. First, suppose that the observed number of employees and outputs are chosen under the above environment where the $(1-\tau)$ is present. Then, a social planner would essentially want to equate the marginal cost with the marginal products. To see this, let's consider the social planner's problem of maximizing the economy's output by choosing the level of employment for each firm in a world without the friction $(1-\tau)$.

$$\max_{\{n_i\}} \sum_{i=1}^{M} y_i(z_i, 1) \tag{15}$$

$$\text{s.t.} \quad N = \sum_{i=1}^{M} n_i, \tag{16}$$

where N is the number of employees in the economy and social planner knows every firm's productivity. The first order condition to the planner's problem yields the following conditions

$$n_j = \left(\frac{z_j}{z_i}\right)^{\frac{1}{1-\alpha}} n_i, \quad \forall i \neq j. \tag{17}$$

By substituting these conditions to the planner's constraint, we can solve the level of employment planner would choose for each firm i,

$$n_i = \frac{z_i^{\frac{1}{1-\alpha}}}{Z} N, \tag{18}$$

where $Z = \sum_{i=1}^{M} z_i^{\frac{1}{1-\alpha}}$. It is straightforward to show that firm's choice of n_i would lead to the same allocation if $(1-\tau_i) = 1\, \forall\, i = 1, \ldots, M$. Thus, it is clear that if

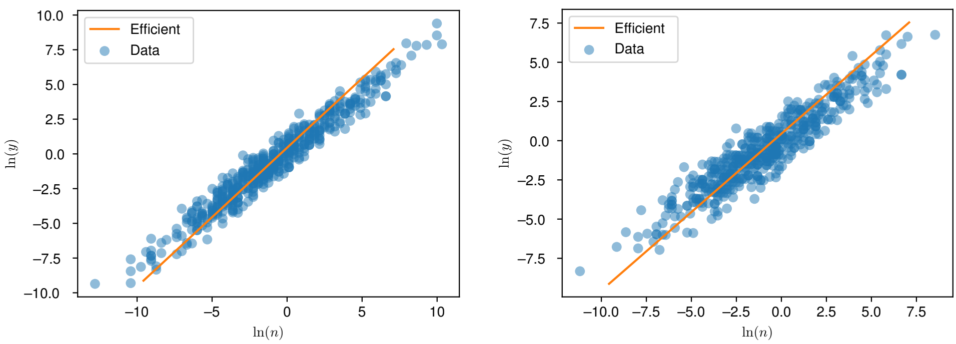

Figure 4. Illustration of the effects of uncorrelated (left) and correlated tax-like wedges. In the case of uncorrelated tax-like wedges $\theta = 0$ and in the correlated case $\theta = 0.5$

the firms face tax-like wedges, the observed employment might not coincide with the social planner's solution.

If the economy's underlying structure follows the above specification, we can have a rough idea about the extent of misallocation by drawing a scatter plot of output and number of employees. For illustrative purposes, I draw this graph with simulated data. I parametrize the mean of productivities and frictions to zero, standard deviations to one, wage to one, and returns-to-scale parameter, α, to 0.64. This parametrization results in Figure 4, where on the left-hand side $\theta = 0$ and on the right $\theta = 0.5$.

In Figure 4 the orange line represents the optimal allocation. We can interpret misallocation's extent by looking at the size of orthogonal deviations from the orange line. For instance, we immediately see that increasing θ, the correlation between wedges and productivity, increases the misallocation in the economy, as clearly the amount of orthogonal deviations increases. A similar figure could be drawn from any microdata that contains the information about output and the number of employees. The empirical scatterplot would then tell us something about the extent of misallocation. Of course, interpreting the figure literally through the simple framework might overstate the magnitude of misallocation as there are potentially several factors unrelated to misallocation that cause deviations from the linear connection between output and employment. However, the graphs presented here illustrate the concept.

To discuss the aggregate significance of the misallocation, I calculate the increase in output if a social planner redistributes resources in an economy. I alter the size of the standard deviation of the friction and the correlation parameter, and the results are presented in Table 1. We see that both factors, when large, can cause significant misallocation. However, the illustrative calculation's most important message is how the correlation with a firm's productivity changes the potential gains from redistribution with low levels of ϵ variation. This result was one of the main points

Table 1. The effect of redistributing resources under different σ_ϵ and θ. The numbers represent the percentage increase in the output

	θ			
σ_ϵ	0	0.2	0.5	0.9
0.2	2	4	17	63
0.5	11	15	31	78
1	41	55	81	131
1.5	100	117	143	184

in Restuccia & Rogerson (2008), where they show that taxing the high productivity firms and subsidizing the low productive ones might have a significant negative effect on the output.

The literature that evaluates the aggregate significance of the misallocation can be roughly classified into two broad approaches. For example, Restuccia & Rogerson (2017) use a similar classification. The classification labels the approaches as indirect and direct depending on the methodology used. In the indirect approach, the deviations in the revenue productivity are measured using microdata about the inputs and outputs. The direct approach differs from the indirect approach as it specifies the source of the variation in $(1-\tau)$ and, thus, is a more structural way of discussing the extent of misallocation. For example, the indirect approach pools adjustment costs and uncertainty to the misallocation measure as the direct approach can disentangle the individual contributions of these mechanisms on the extent of misallocation.

Hsieh & Klenow (2009) is one of the first contributions to the indirect measurement of the significance of misallocation. They use a quantitative framework similar to the above framework to measure misallocation in India, Mexico, and the U.S. They find a large negative impact of misallocation for the manufacturing sector TFP: 30-50% decrease for TFP in China and 40-60% in India. The result signals that factors reducing misallocation could have a large effect on the measured TFP. However, the caveat of the indirect approach is that it is silent about the sources of misallocation. The reason is that it only measures the deviation from the theoretically stated optimal allocation in a static maximization sense. Thus it is quite likely that dynamic aspects, such as pricing, investment, or hiring choices that expand over multiple periods would be interpreted falsely as misallocation. From the policy maker's perspective, this is problematic as it would be essential to know the cause of misallocation to address it adequately.

One of the limitations of using the simple indirect approach is that it accounts for measurement error as misallocation. For example, when we compare developing countries to the U.S., it is vital to correct the data from the measurement error as its likely that statistical offices make errors when recording the data. Bils, Klenow & Ruane (2020) address this issue by exploiting the fact that revenue growth is less sensitive to input growth when the plant's average product is measured with error. Their correction reduces the potential gains from reallocation by 20% for the manufacturing sector in India and 60% for the U.S.

Restuccia & Rogerson (2017) point out one discrepancy in the literature related to the differences between indirect and direct measurement of misallocation. For instance, as we see from Hsieh & Klenow (2009) and the indirect misallocation measures, the quantitative significance appears to be massive. However, when the literature has looked at the significance of misallocation from a more structural perspective by specifying the sources of misallocation, even the sum of different sources appears not to explain the results of the indirect approach. Even if corrections to the measurement error bring the indirect and direct approaches closer together, there is still a large gap between the two. There appears not to be any single factor that could explain the majority of the observed misallocation. Therefore, it seems possible that indirectly measured misallocation is a sum of several smaller individual components. Such components are, for instance, differences in markups, adjustment costs, production technology, and information frictions. All of which would be classified as misallocation caused by unspecified friction in an indirect approach. Next, I review studies that use a direct approach and are closely related to the second essay of this thesis.

David & Venkateswaran (2019) study how much of the indirectly measured misallocation in capital choice of firms can be explained by adjustment costs, uncertainty, markup heterogeneity, differences in the production technology, and tax-like wedges. By developing a quantitative framework that can isolate the contribution of these margins, they show that roughly 70% of the indirectly measured misallocation can be attributed to other factors than tax-like wedges in the U.S. For China, the corresponding number is somewhat smaller, 33%. Even if their research considers only some of the factors that can show up as "misallocation" in the indirect approach, the results already show the relative strength of the structural approach as it informs us about the nature of the tax-like wedge. In the misallocation discussion, literature is interested in the margins that a social planner wants to address. For instance, if the differences in the marginal products stem from differences in the production technology, there is not much of a role for a social planner to address the misallocation as it is likely that planner is unable to force specific technology to each firm and whether this would be even optimal is an open question. However, the markup heterogeneity could be classified as a misallocation when looked through the planner's perspective as the markups, caused potentially by monopoly power, can be socially suboptimal. Using a more lenient view on David & Venkateswaran's (2019) results, we could conclude that 28 – 56 % of the indirectly measured misallocation is something other than pure misallocation that a planner could address redistributing resources. Taking together Bils et al. (2020) and David & Venkateswaran (2019) both imply that the original results of Hsieh & Klenow (2009) are overstating the extent of misallocation. However, the results also show that a large share of the observed misallocation persists after correcting for measurement error and factors that are not necessarily misallocation but appear as marginal product dispersion.

David & Venkateswaran (2019) is an example of the direct approach of quantifying the significance of several specific channels that cause marginal product dispersion. However, they leave out a large set of other potential candidates that can cause dispersion in the marginal products from the analysis. For example, studies using the direct approach have looked at the role of firing costs, selective industrial policies, financial frictions, and trade restrictions.

In the previous section, I discussed the role of firing costs for aggregate productivity, which are explored, for instance, by Hopenhayn & Rogerson (1993). Later, the results of that literature strand have been more closely linked to the emerged misallocation discussion in Hopenhayn (2014). Hopenhayn (2014) shows that the firing cost of 2 years wage causes 3% TFP losses, firing cost of five years wage causes 8% losses, and if the cost is extended to 25 years wage the losses are 24%. However, the high firing costs seem implausible, and thus it seems more likely that firing costs only explain a small fraction of the observed misallocation.

Financial constraints are another potential source of the indirectly measured misallocation. They operate through a similar channel as firing costs, making it harder for producers to adjust their size. Buera & Shin (2013) and Midrigan & Xu (2014) are two examples of studies examining the effects of financial constraints. In both studies, the authors isolate the contribution of distortions that cause the misallocation of resources from the effects of financial constraints that would show up as a part of indirectly measured misallocation. However, the studies differ considerably, and a direct comparison can only be made at a quite aggregated level. Buera & Shin (2013) study the slow convergence of so-called miracle economies after financial liberation. Their results show that eliminating tax-like wedges increases productivity almost by 50% after 20 years. Moreover, the model displays a roughly 30% increase in productivity after 20 years after relaxing financial constraints. Results imply that the effects of financial constraints are large and can have a substantial impact. Midrigan & Xu (2014) study the effect of financial constraints that affect through two channels. First, the frictions distort the entry and technology adoption decisions. Second, the frictions cause misallocation of resources. Their structural framework is flexible enough to disentangle the two channels from each other as both channels would be summed together in Hsieh & Klenow (2009) type indirect approach. Their results imply a small role for the misallocation but a sizeable effect on the first channel, the entry, and technology adoption.

As stated above, markups are a potential source of misallocation. However, their role in explaining the dispersion in revenue productivities appears to be in the range of 4-15%. David & Venkateswaran (2019) show that for China, the markup's contribution to revenue productivity dispersion is 14% and for the U.S. 4%. Peters (2020) shows that Indonesian data markups explain 15% of the observed variation. Based on these studies, it is safe to say that a large share of revenue productivity variation comes from somewhere else than from the markup variation. When comparing the potential aggregate significance of the observed markup variation, i.e., the misallocation loss that markups cause, results vary. Peters (2020) reports 1% loss and Baqaee & Fahri (2020) report 15% loss in aggregate TFP due to markup variation. In light of the two studies, the markups appear to matter for the TFP. However, it's hard to draw a decisive conclusion on how important markup variation is for the aggregate TFP.

Another potential source of indirectly measured misallocation is uncertainty. The reason indirectly measured misallocation might capture uncertainty is that firms make choices about input usage under incomplete infromation about their productivity or demand for their products. In such a case, the number of employees or capital can be suboptimal after observing the true productivity or demand. This type of mechanism has been discussed in David, Hopenhayn & Venkateswaran (2016), David & Venkateswaran (2019), and Arkolakis, Papageorgiou & Timoshenko (2018). David & Venkateswaran (2019) link the misallocation and uncertainty discussion. They find a modest effect of uncertainty on aggregate productivity. However, as shown in David et al. (2016), such a result is sensitive to the timing of the events. In the second essay of this thesis, the role of uncertainty for aggregate productivity and revenue productivity dispersion is explored. The effect of uncertainty appears to be large and in line with findings of David et al. (2016). Moreover, we show that uncertainty can potentially explain 2/3 of the observed revenue productivity variation. We find this result with a novel indirect measure of misallocation. The measure can disentangle uncertainty from tax-like distortions, and it only requires information of profits to do so. To demonstrate how the method works, we apply it to the Finnish microdata.

Related to the discussion about the factors that explain the variation in revenue productivity, I use a modified version of the Hsieh & Klenow (2009) in this thesis's third essay. I find that markups, which potentially cause variation in revenue productivities and thus can cause misallocation, do not explain the differences in the revenue productivities. A modest role of markups for the revenue productivity variation is consistent with the previous findings.

2 Summary of the Essays

In this chapter, I provide short description of the essays that form the dissertation.

2.1 Economic Growth through Worker Reallocation: The Role of Knowledge Spillovers

In this essay, I study the importance of worker reallocation for aggregate growth in an environment where workers can transmit knowledge. I motivate the essay with empirical evidence suggesting that an establishment can improve its productivity by hiring workers from more productive establishments. To understand the aggregate significance of the mechanism, I develop an endogenous growth model in which producers can improve their productivity through hiring. A key feature of the model is that aggregate growth depends on the knowledge transmitted by the workers and a residual growth mechanism that would generate growth even in the absence of worker-driven knowledge diffusion. In this sense, the model is flexible enough to isolate the contribution of the knowledge transmitted by workers to aggregate growth. Using the empirical findings as targets, I fit the model to the data and explore the significance of the worker transmitted knowledge on aggregate growth and other outcomes. The main findings are that knowledge diffusion through hiring enhances aggregate growth by 0.14 percentage points and enhances welfare in the economy by 2.5 percent. Additionally, I study the policy relevance of the mechanism by testing how the effects of firing costs change because of the knowledge transmission. Results show that the adverse effects of firing costs can be even three times larger in the presence of knowledge diffusion through worker reallocation.

2.2 Uncertainty, Misallocation and the Life-cycle Growth of Firms

This essay develops a measurement framework that can separate firms' uncertainty from misallocation generated by tax-like distortions. The framework we set up is based on Hsieh & Klenow (2009). However, the framework utilizes a different set of timing assumptions and has different requirements for data. To meet the data requirements, we use administrative firm-level data from Finland. Our main finding is that most of the dispersion in revenue productivities appears to stem from uncertainty rather than tax-like wedges. Moreover, the uncertainty that we measure has a strong age-dependent downward trend.

As the static framework lacks any dynamic considerations, we set up a life-cycle model of firm growth to quantitatively evaluate the aggregate significance of uncertainty and tax-like distortions. Our model contains several channels that cause dispersion in revenue productivities, such as adjustment costs, tax-like wedges, and early life-cycle learning. The model allows us to study the effects of each of these channels separately. We calibrate the model to the Finnish microdata, and it successfully captures key features of the Finnish economy. According to our quantitative results, uncertainty suppresses output by 38%, while misallocation has a 26% negative effect on output.

2.3 Unraveling the Sources of Firm Heterogeneity

In this paper, I study the determinants of firm heterogeneity. The aim is to disentangle why firms' revenues and sizes differ considerably even in the same industry. To explore this question, I set up a quantitative framework that allows decomposing differences in revenues and sizes. Through the model's lens, firm heterogeneity can be attributed to differences in productivity, demand, markups, revenue wedges, and capital wedges. Using the model-driven measurement equations on the Finnish microdata, I find that the differences between firms almost entirely arise from demand shifter heterogeneity. At the same time, markups and productivity are the second-largest determinants. As an additional exploration, I analyze the sources of revenue productivity heterogeneity, which offers further insight into the misallocation discussion. The main finding from the analysis is that markups appear not to be a significant determinant for the revenue productivity differences and that differences in revenue wedges can account for the heterogeneity.

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