Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

DIPLOMA THESIS

Endogenous Growth Model, Distance to Frontier, and Labour Market Institutions

Author: **Michal Šoltés**

Supervisor: **PhDr. Jaromír Baxa Ph.D.**

Academic Year: **2015/2016**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature. This thesis was not used to obtain another academic degree.

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Prague, May 11, 2016

Signature

Acknowledgments

I would like to express my gratitude to my supervisor, PhDr. Jaromír Baxa Ph.D, whose help gave rise to this thesis. His guidance helped me in all the time of research and writing of this thesis. A very special thanks goes to Miroslav Palanský, Jaroslav Pavlíček, and Ing. Peter Tomko who were always willing to listen to me and every single discussion with them was stimulating. I am also grateful to three respectable scholars Nikolas Mittag Ph.D, Rocío Sánchez-Mangas Ph.D, and Vera Tolstova M.A. for asking difficult questions, providing useful comments, and giving needed pieces of advice. The remaining mistakes are mine. Last but not least, I would like to thank my family and friends for the support they have provided me.

The study was supported by the Charles University in Prague, project GA UK No. 412216.

Bibliographic record

Šoltés, M., 2016. *Endogenous Growth Model, Distance to Frontier, and Labour Market Institutions*. Diploma thesis. Charles University in Prague.

Character count: 92,297

Abstract

This thesis studies the effect of generosity of unemployment insurance on economic growth. More generous unemployment insurance is argued to cause an increase in unemployment on the one hand and better job match quality on the other. Our model shows that in the developed countries, there may be some level of unemployment insurance which ensures that the productivity gain offsets the loss due to higher unemployment. On the contrary, in the developing countries, any level of unemployment insurance was revealed to harm economic growth. Moreover, we present strong evidence in favour of a positive effect of unemployment insurance on the aggregate productivity growth.

Keywords	Unemployment Insurance, Distance to Frontier, Endogenous Growth Model, Technology Growth, Economic Growth

Author's e-mail	`mich.soltes@gmail.com`
Supervisor's e-mail	`jaromir.baxa@fsv.cuni.cz`

Abstrakt

Tato práce studuje dopad štědrosti pojištění v nezaměstnanosti na ekonomický růst. Má se za to, že štedřejší podpora v nezaměstnanosti má dva dopady na ekonomiku. Na jedné straně způsobuje růst nezaměstnanosti a na straně druhé kvalitnější spojení mezi volným pracovním místem a zaměstnancem. Náš model ukazuje, že ve vyspělé zemi je pravděpodobně možné nastavit podporu v nezaměstnanosti tak, že nárůst produktivity vyrovná ztrátu způsobenou vyšší nezaměstnaností. V rozvojové zemi se naopak každá úrovneň podpory v nezaměstanosti ukazuje jako proti-růstové opatření. Navíc předkladáme silné důkazy, že podpora v nezaměstnanosti má pozitivní vliv na agregovaný růst produktivity.

Klíčová slova	Pojištění v nezaměstnanosti, Vzdálenost k hranici, Endogenní model růstu, Technologický růst, Ekonomický růst

E-mail autora	`mich.soltes@gmail.com`
E-mail vedoucího práce	`jaromir.baxa@fsv.cuni.cz`

Master's Thesis Proposal

Institute of Economic Studies
Faculty of Social Sciences
Charles University in Prague

Author:	**Michal Šoltés**	Supervisor:	Jaromír Baxa, Ph.D.
E-mail:	mich.soltes@gmail.com	E-mail:	jaromir.baxa@fsv.cuni.cz
Phone:	774024143	Phone:	
Specialization:	*Economics and Finance*	Defence Planned:	June 2016

Proposed Topic:

Endogenous Growth Model, Distance to Frontier, and Labour Market Institutions

Motivation:

Endogenous growth model (EGM) has been heavily studied topic in macroeconomics literature in last 15 years and has improved our understanding of economic growth and helped to explain economic convergence of developing countries. Using the EGM most of the authors showed that appropriate policies and institutions should differ contingent on the distance to the technology frontier (e.g., Vandenbussche, Aghion and Meghir, 2004). Aghion, Akcigit and Howitt (2013), for example, analysed the effect of democracy, openness or education on the economic growth. In addition, Accemoglu, Aghion and Zilibotti (2006) studied an effect of a level of competitiveness on economic growth under different distance to the technology frontier. However, there has been no literature devoted to labour market institutions under the EGM and their effects on economic growth in countries with different level of technology.

It appears that several countries such as China[1] have experienced exceptionally fast economic growth in recent years mainly due to their positions of "backward economies". Backward economies are believed to grow via imitation of already well-established technologies rather than via innovation process which may lead to a new technology. Under these circumstances, developing countries are supposed to increase their output faster than developed countries and thus close the GDP gap, nevertheless, as the countries approach the technology frontier the growth rate declines. Chinese economy perfectly exhibits the described process as the Chinese GDP growth rate has been recently increasing slower than 10 years ago (Lin, 2015). Hence, China should consider implementing of structural changes that would enable economic growth similar to the growth in developed countries - via innovation (Zhang, 2014). Chinese economy and financial system, including mortgage market or government budget deficit seem to require, in order to be sustainable, stable and substantial economic growth. Decline in Chinese economic growth might have negative impact not only on their own economy and financial stability, but also on developed economies all over the world. Therefore, introducing new institutions that would enhance innovation activity seems to be one of the most important goals in next years for Chinese economy.

The aim of this thesis is to extend the EGM by implementing labour market institutions and analyse the impact of distance to frontier on the appropriate labour market institutions. Furthermore, the thesis will also suggest policy that may help developing counties to adjust their labour market institutions as they approach the technology

[1] Apart from China also Japan or Singapour have recently experienced decreasing rate of GDP growth, but only China will be considered as country of the main interest in empirical part of the thesis.

frontier.

Hypotheses:

Appropriate labour market institutions are contingent on the distance to the technology frontier:

(i) Higher unemployment benefits in developing countries slow down economic growth.
(ii) Higher unemployment benefits in developed countries increase rate of innovation.
(iii) Overall effect of unemployment benefits in developed countries is ambiguous.

Methodology:

This thesis will introduce its own discrete economy based on EGM. The original EGM model will be extended by a process of accepting a job offer – search model. One of the crucial elements in this economy will be the presence of unemployment benefits affecting consumer's value function and consequently both accepted wage and match quality between vacancy and labour force.

To introduce creative destruction, supply side of the economy shall be divided into several sectors. In every sector there will be a limited number of firms competing with each other by simple rule: if a firm accomplish successful innovation, its production cost will be reduced and it will become a monopoly for a certain period of time. The monopolistic position lasts only until the next successful innovation. Similarly to optimal wages for consumer's problem, the level of innovation will be also solved by dynamic programming methods. The optimal level of innovation activity will depend on equilibrium wages paid to workers and thus also on the level of unemployment benefits chosen by government.

The important premise is that the optimal level of innovation activity depending on a distance to the technology frontier. Countries that are less developed may benefit from imitation of technology (closing the technology gap) and do not need to invest into innovation as much as countries on the edge of the technology frontier. This assumption, however, will be imposed exogenously by assuming that more developed countries have less opportunities to imitate already introduced technology.

Overall, the thesis will introduce a theoretical framework which is appropriate to assess effects of different levels of unemployment benefits to the level of innovation and economic growth under different distance to the technology frontier. Furthermore, under the assumption of balance growth, it will be possible to find the optimal unemployment benefits contingent on a distance to the technology frontier (either analytically or numerically).

Expected Contribution:

The contribution of the thesis is to extend existing EGM by introducing labour market institutions. To the best of my knowledge, there has been no literature studying the optimal labour market institutions (e.g., unemployment benefits, minimum wage, and mobility) under different distance to the technology frontier. This thesis is expected to reveal the relationship between optimal level of unemployment benefits and distance to the technology frontier.

Resulting model may also serve as a guidance for policymakers in countries that have recently experienced a slowdown in economic growth and need to focus more on innovation and less on imitation. It may be particularly relevant for Chinese economy but more countries can utilize from the conclusion of the model.

Outline:

The structure of the thesis will be as follows.

(i) **Introduction** shall provide motivation why developing counties that approach the technology frontier should consider implementing new institutions.

(ii) **Literature review** will consist of two parts; firstly the literature related to EGM and secondly search models literature will be reviewed.
(iii) The **model** shall be introduced and solved.
(iv) **Case study:** The theoretical results from the model will be showed in light of case of China.
(v) **Conclusion** shall summarize both the theoretical model and the case study.

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Chapter 1

Introduction

An importance of a social insurance has been heavily discussed topic among scholars for a long time. Moreover, the issue has become publicly discussed as some European countries are currently considering introduction of basic income pilots or are about to hold a referendum. Some economists view a social insurance, or, in particular, unemployment insurance not only as a measure of social policy, but also as a way to improve job match. In fact, some have been arguing that more generous unemployment benefits provide workers a freedom to wait and search for a better job match, which may even increase productivity and on the aggregate level the output of the economy (Acemoglu and Shimer (2000); Marimon and Zilibotti (1999)). On the contrary, more generous unemployment benefits are known to increase workers' reservation wage and thus boosting level of unemployment, which then tends to reduce the output. It evokes a research question whether the gain from increased productivity can outweigh the loss caused by higher unemployment. Several authors have published theoretical models arguing that under some circumstances more generous unemployment insurance may have a positive effect on economic performance. However, the conclusion is not widely accepted as there are two sources of doubts: (i) a lack of empirical research, which would support or counteract their theoretical conclusions; and (ii) a fact that the theoretical models were calibrated to fit highly developed countries and therefore, do not reflect different optimal institutions in developed and developing countries. As a result, one may be skeptical to consider the results generally credible.

The latter source of doubts, the difference between optimal institutional framework in the developed and the developing countries is not only a matter of

unemployment insurance policy. Recent literature has been able to incorporate the differences into economic models. Specifically, a framework of endogenous growth model appear to be a great tool to capture some distinction in the optimal policies. For example, using the endogenous growth model, an optimal level of democracy, an optimal competitiveness at a market, and an optimal length of business contracts were showed to rely on the level of development (technology advancement) (Acemoglu et al. (2006); Aghion et al. (2013)). Likewise, optimal labor market institutions are believed to depend on a level of development of the economy. On the one hand, suppose developing countries such as India and China, where we have been witnessing almost infinite labor supply. The economic growth in those countries is driven by less skilled intensive industries, which benefit from less (no) insurance against unemployment, even at the price of loosing talents. The Hukou system in China may serve as a good example. On the other hand, in developed countries, where the growth requires more advanced technology also the labor market policies are supposed to encourage workers to search more advanced jobs.

For the reasoning explained above, the suitability of unemployment insurance and its generosity in a particular level of development is crucial question also for all policy makers. While large rapidly growing economies such as China, India, and Brazil may think of the best moment to introduce a western type of unemployment insurance in order to ensure basic level of social security, some western countries might consider whether the possible positive effects of generous unemployment insurance will offset the consequences of higher unemployment caused by the moral hazard problem.

The aim of this thesis is to contribute to the literature and to the public discussion by two novel aspects. In the theoretical section, we argue that under reasonable assumptions of different (optimal) institutions in developing and developed countries, more generous unemployment insurance (or unemployment insurance itself when it has not been adopted yet) is more likely to be harmful to the economic growth in the backward countries. The empirical study reveals that more generous unemployment benefits have positive effect on productivity growth in developed countries. In particular, the focus is on three hypotheses: (i) more generous unemployment insurance harm the economic growth in developing countries; (ii) the effect of unemployment insurance on economic growth in developed countries is neutral or slightly positive; and (iii) the ef-

fect of unemployment insurance on economic growth is non-linear and depends on the level of development. Moreover, for the empirical part we re-state the hypothesis (ii) as: the effect of unemployment insurance on the productivity growth in the developed countries is positive. Note that the alternative hypothesis for empirical study differs in two features. It focuses on the productivity growth instead of the economic growth and it asserts that the effect is positive. In other words, we decompose the effect of unemployment insurance on the economic growth and study only the potential productivity gain leaving the loss arising from higher unemployment out of the the scope.

Using data about 17 developed counties for 20 years from 1990 up to 2010, we analyze the effect of unemployment insurance on the growth of productivity. Specifically, we employ recently created index of generosity of unemployment insurance, described by Scruggs et al. (2014a) and along with several additional variables (as described in Section 5.1) use it to explain total factor productivity (TFP) growth. According to our results, the effect is positive and significant. Increasing the score in that index by 1 point, is expected, for developed countries, to increase the growth of productivity by slightly more than 0.5%. The conclusion appears to be robust against different specifications. Due to data limitation, there are no empirical results concerning the developing countries.

The conclusion drawn from the theoretical model suggests that the economic growth in the developing countries suffers from unemployment insurance more than in the developed countries. In particular, we simulate two representative economies - developing and developed under few different levels of unemployment insurance and compare how much the growth changes. The results show that the loss of economic growth tends to be higher in developing countries; moreover, under low level of unemployment benefits the loss in the developed country is barely significant. These results are in agreement with our hypotheses.

The rest of the thesis is structured as follows. Next chapter provides a summary of literature. Chapter 3 introduces the theoretical model, Chapter 4 is devoted to a solution of the model, including a discussion over the results. Chapter 5 is the empirical part, where we present our data-set including the index of generosity of unemployment insurance, discuss obtained results, and conduct several sensitivity analysis exercises. Finally, Chapter 6 concludes the results

and contributions of this thesis.

Chapter 2

Literature Review

This thesis relates directly to two important strands in economic literature. The first topic is an economic growth with a focus on endogenous growth models. The second research question which has been discussed in the literature and is relevant to this thesis is a growth-enhancing effect of unemployment insurance.

Neoclassical growth models appear to be incapable to explain long run economic growth in developed countries, unless the level of technology is permanently increasing (Aghion and Howitt, 2009). It induced economists to abandon an assumption of an exogenously given growth of technology and consider models where the growth of technology was explained as consequences of a behavior of rational agents. As a result, the literature has begun to pay more attention to models describing endogenously driven growth rate. Romer was a pioneer in endogenous growth literature and his articles were important milestones toward more appropriate description of an economic growth. Romer (1987) built a dynamic model highlighting the importance of diversification. Using production function that is analogous to Dixit-Stiglitz utility function, he argued that specialization and consequent higher variability of goods could lead to increasing returns. In his other article, Romer (1990) introduced an economy, where firms intentionally undertake research in order to innovate, gain monopolistic position and thus increase their profits. One of the key feature of this model is an infinitely lived patent that results from the innovation activity. In other words, once the firm successes and reaches monopolistic position, the position lasts potentially forever. In contrast, Aghion and Howitt (1992) proposed a model that formalizes Schumpeter's notion of creative destruction (henceforth

Schumpeterian growth model), which implies that successful innovation in particular sector destroys the previous monopolistic position. The fact that the incumbent firm may lose its monopoly rent anytime, makes significant difference between Romer's model and Schumpeterian growth model.

The early versions of all endogenous growth models were not able to explain changes in developed economies after World War II. While the endogenous growth models predict a permanent increase in a growth rate as all the growth-enhancing variables (e.g., level of education, trade openness, durable investment etc.) had increased, the growth rate had exhibited little or no increase (Jones, 1995b). Jones (1995b) further argued that the scale effect[1] was the main drawback of endogenous growth models as it cannot be supported by data. In an effort to create a model that would match the data better, two different strands appeared in the literature. On the one hand, Jones (1995a) proposed and Kortum (1997) and Segerstrom (1998) further developed a semi-endogenous model. On the other hand, Howitt (1999), Dinopoulos and Thompson (1998), and Young (1998) considered a fully-endogenous growth model. In a framework of semi-endogenous models, the technological growth is endogenous, but the growth of total factor productivity (TFP) depends on the rate of population growth. The key consequence is that the long run economic growth is independent of public policy (Li, 2000). It also implies that an increase in TFP may be achieved only by a higher rate of population growth. Conversely, in a fully-endogenous model, the TFP depends on research intensity and a scale effect is nullified by an increase in product heterogeneity. As a result, fully-endogenous models no longer suffer from scale effect and despite its potential sensitivity to adopted assumptions (Jones, 2005), seems to be superior to semi-endogenous model as it was showed to fit the data better for both more and less developed countries (Ha and Howitt (2007); Laincz and Peretto (2006); Ang and Madsen (2011)).[2]

The framework of endogenous growth model, or more specifically Schumpeterian growth model, has been used to explain some of the economic puzzles of last years. An advantage and probably also the reason for the usefulness of Schumpeterian growth theory is that unlike the other growth models, it can

[1] Scale effect describes a property of the family of models which causes that an increase in population necessary implies economic growth.

[2] These models are sometimes called second generation of endogenous growth models.

be used to analyze growth policy under different conditions and therefore its predictions of appropriate growth policies depend on country's characteristics.

One of the puzzles concerning economic growth is the widening gap between the richest group of countries[3] and the poorest group of countries (Mayer-Foulkes, 2002). It becomes truly difficult to understand this phenomena, especially if one considers the *advantage of backwardness* - a possibility of the poorer countries to imitate already introduced technology as suggested by Gerschenkron et al. (1962). Using Schumpeterian growth model, Aghion et al. (2005b) offered a possible explanation. They proposed a model implying that countries, in order to converge to the world frontier, have to have a sufficient level of financial development[4], and countries below the threshold will experience slower long run growth rate. These implications were also supported by empirical results. The importance of the financial development in economic growth was also highlighted by Aghion and Howitt (2006). The authors analyzed why the gap between Europe and the U.S. was widening. In particular, they discussed the importance of a competition and firms' mobility, a role of (higher) education, and macropolicy for economic growth in Europe. All the policies should be, as the authors claimed, considered case-by-case with respect to particular circumstances e.g., a level of financial development or a distance to technology frontier which may be key aspects when choosing appropriate policies. In fact, the authors also reported empirical evidence[5] suggesting that appropriate growth policies vary with a country's financial development which may be seen as additional piece of evidence in favor of Schumpeterian theory.

Recent literature, using the extended version of Schumpeterian growth model for more countries, is concerned by a setting optimal policy and institutions under different distance to the technology frontier. Model introduced by Acemoglu et al. (2006) which assumes innovation process and adoption of well-established technology as two sources of growth, has become a main tool to analyze optimal institutions and policies. Acemoglu et al. (2006) argued that as an economy is far from the world technology frontier it is growth-enhancing

[3]The richest group of country also includes middle-GDP *per capita* countries that seem to belong to convergence club.

[4]By a level of financial development the authors mean a quality of services and development of financial intermediation as industry. In empirical analysis, they use a value of private credit i.e., value of credits provided by financial intermediaries to private sector divided by GDP.

[5]Aghion and Howitt (2006) used results from (Aghion and Marinescu, 2008)

to prefer long-term contracts between firms, hire experienced but low-skill managers, and run large investments. However, as the economy approach the frontier the optimal institutions need to be switched for more flexible contracts and high-skill managers who are more likely to innovate. More generally, selection and innovation are more important for more developed countries. For example, Vandenbussche et al. (2006) used the model to assess effects of education and human capital on growth. Specifically, assuming that innovation activity makes a relatively more intensive use of skilled labor, they showed that the closer to the world technology frontier, the more growth-enhancing high-skill labor is. In general, they claimed that economic growth cannot be explained only by stock of human capital or years of schooling, but a composition of human capital matters too. As a result, different stage of development requires different labor. Realizing this and incorporating a structure of labor to the theory may solve a puzzle posed by Krueger and Lindahl (2001) saying that the total amount of human capital is not sufficient variable to explain different growths rates among OECD counties. Most recently, Aghion et al. (2013) employed Schumpeterian growth model to shed a light on several aspects of the economic growth. In particular, the authors[6], analyzed a correlation between growth and competitive policies, and how institutions affect the growth contingent on the distance to the world technology frontier. Introducing a less radical assumption of the step-by-step competition in a sector instead of overleaping one, the authors identified that: (i) escape competition effect; and (ii) Schumpeterian effect. Together these effects can explain an inverted-U shape between the market competition and the growth. The inverted-U shape, was also described and empirically confirmed using data on U.K. firms by Aghion et al. (2005a).

Similarly to Acemoglu et al. (2006), Aghion et al. (2013) evaluated the magnitude of the growth and the effects of trade barriers in countries under different stages of development in the framework, where agents face a trade-off between innovation-based growth and imitation-based growth strategy. In line with the previous results, they concluded that the growth in technologically advanced countries relies more on innovation, whereas backward economies have an opportunity to grow faster as they can adopt established technology from the world technology frontier. They further argued that democracy is more

[6]They also studied microeconomics aspects of endogenous growth as relations between growth and dynamic of firms, and long-term technological waves.

growth-enhancing in more developed countries. Most of these theoretical conclusions were also supported by several pieces of evidence, for example, Aghion et al. (2013) provided evidence of the higher importance of no barriers in more technologically advanced countries as well as the increasing positive effect of democracy as countries approach the world technology frontier. Aghion et al. (2004) used data about U.K. economy during 1980s to show that less entry barriers leads to the faster growth of TFP. This conclusion, as they claimed, demonstrates that new (foreign) firms motivate incumbents to innovate in order to escape competition. There are, however, other possible explanations why free entry policy enhances the growth in developed countries. For example, entrances themselves innovate or new technologies brought by entrances are adopted by incumbents. To further confirm the effects of liberalization, Aghion et al. (2003) conducted a natural experiment and made use of a reform that took place in India in 1991. They found unequal impact of the reforms on different sectors; while sectors that were initially close to the world technology frontier benefit from the reform, backward sectors were harmed. Their results confirmed one of the main predictions of Schumpeterian growth model, optimal policy, optimal institutions, and also suitability of reforms depend on the initial state of the economy (a sector), its institutional structure, and a level of used technology.

This thesis continues to study the dependence of optimal institutions on the level of development in a framework of endogenous growth model. In particular, the contribution lies in modifying models used by Aghion et al. (2013) and Acemoglu et al. (2006) respectively by adding a job search feature in a style of Marimon and Zilibotti (1999). By doing so, we examine consequences of unemployment insurance on the economic growth for two representative countries; where one of them portrays developed economy and the other one developing economy. To the best of our knowledge, no research has been devoted to this question and thus this thesis enriches the Schumpeterian growth model literature.

While the branch of endogenous growth literature is rich, the literature studying a possible positive impact of a generosity of unemployment insurance on economic growth is narrow. In fact, one of the first attempts to highlight a positive effect of unemployment insurance on economic performance was made by Acemoglu and Shimer (1999). The authors constructed a general equilibrium

model of search with a risk aversion and showed that for risk averse consumers, the existence of unemployment benefits is a necessary condition for the maximized output of the economy. In particular, as they argued, the presence of unemployment benefits encourages workers to search for higher wage jobs. Similar results were obtained by Marimon and Zilibotti (1999), who strove to explain differences on European and U.S. labor markets. Specifically, they created an equilibrium search-matching model and calibrated it as: (i) a typical economy of European country with unemployment benefits; and (ii) a U.S.-type *laissez faire* economy with no unemployment insurance. Then they studied the impact of a technological shock (which emphasized the importance of the match between talents and vacancies) on the individual economies and concluded that the European type of economy with unemployment benefits reached a higher growth rate.

In their article, Acemoglu and Shimer (2000) presented a simple static model which captures and formally expresses the notion that higher unemployment insurance allows workers to search for more productive jobs. Moreover, the authors also presented a more complex dynamic model that revealed that under a specific of calibration productivity gain caused by unemployment insurance outweighs the loss of output caused by higher unemployment. All of the studies mentioned suffer from two drawbacks. They provide no empirical evidence supporting their results and their conclusions are drawn from models calibrated to fit developed countries. As a result, it may prevent us from considering their conclusions in general as optimal policy are argued to differ accordingly to the level of development.

The problem of a lack of empirical evidence on potential positive effect of unemployment insurance on the economic growth goes even further. In fact, to the best of our knowledge, there have been almost no empirical research devoted to this topic. However, several articles took half of the way and studied whether a greater unemployment insurance generosity may lead to better worker-job match. Most of the authors measure the job match quality by: (i) a wage of upon unemployment job; or (ii) a duration (tenure) of that job. Using the former, the results are ambiguous. While few authors in 70' found evidence of a positive impact of generosity of unemployment benefits on post-unemployment wage (Ehrenberg and Oaxaca (1976); Burgess and Kingston (1976); Holen (1977)), some more recent studies failed to find strong (if any)

relation (Blau and Robins (1986); Addison and Blackburn (2000)). Literature which have used the duration seem to provided even more mixed evidence. In particular, Centeno and Novo (2006) employed NLSY79 data-set and used tenure[7] of a job after the unemployed period as a proxy of the quality of match and showed that more generous unemployment insurance shifted the distribution of upon unemployment job duration to the right and thus increased, as the authors claimed, the quality of the match. Moreover, the impact seemed to be unequal across educational levels with the highest merit to the least educated. Likewise, Tatsiramos (2009) studied European countries and found evidence suggesting that more generous unemployment insurance tends to lead to more stable post-unemployment job. On the contrary, Van Ours and Vodopivec (2008) took advantage of natural experiment[8] in Slovenia and studied the impact of a change of unemployment insurance law on job match quality and found no detectable results.

In the perspective of literature studying the impact of a generosity of unemployment insurance on output or productivity gain, the contribution of this thesis is twofold. Firstly, in the theoretical part, this thesis is, to the best of our knowledge, first to consider the effect of unemployment benefits in an environment of less developed countries. All the studies which have been published up to recently, used a calibration to fit advanced economies and failed to cover different institutional background and economic conditions in backward countries. Secondly, in the empirical part, we go beyond the impact on the quality of job match and address our research question directly to the growth of productivity; arguing that the better job match is likely to result in a productivity gain.

[7] They also used the wage as proxy.

[8] In 1998, there was a reform which reduced a potential duration of unemployment for most of the workers.

Chapter 3

Model

The aim of the model introduced in this chapter is to formally analyze the different effects of the generosity of unemployment insurance under various level of development. The model is based on two most important notions: (i) while in the less developed countries the economic growth relies mostly on imitation process which requires less precious match between labor and vacancy, in the more advanced economies the quality of a match is crucial; (ii) having more generous unemployment insurance, and thus higher workers' outside options, the workers can afford to wait for a better match. To capture these ideas we create two-rounds matching model in a framework of an endogenous growth model.

At the beginning of every period, there are two interview rounds in which firms meet workers, they bargain about wage and after that the worker either accepts the job offer or reject. We assume there is a unity of industries ν ($\nu \sim U[0,1]$) and in each of them, only one firm can hire a worker. It can be viewed as that only the most efficient firm in the industry can produce. The mechanisms works as follows; if any of the firms in industry ν hires a worker during the first round of interviews than there is no more interviews in that particular industry during the second round of interviews. Otherwise, firms in the sector have one more opportunity to hire a worker. If a firm does not hire a worker at all, its production in that time period is nothing. When a worker is hired and before the production process takes place, there is an innovation and imitation phase, during which the hired workers attempt to improve a current level of technology in the particular industry. Only after the innovation and imitation process is over, regardless of being successful or not, the production

occurs. The level of technology used in a particular industry affects neither the ability to produce the intermediate goods nor the cost of the production, but it affects how effectively and costly the intermediate good is aggregated into a final good; the higher the level of technology used to produce a final good from the intermediate good, the higher the value of the intermediate production. The framework of the model is applicable to a range of countries, such that some of them are more developed and some of them less. Nevertheless, in every country there are the same industries and differ only in the level of employed technology.

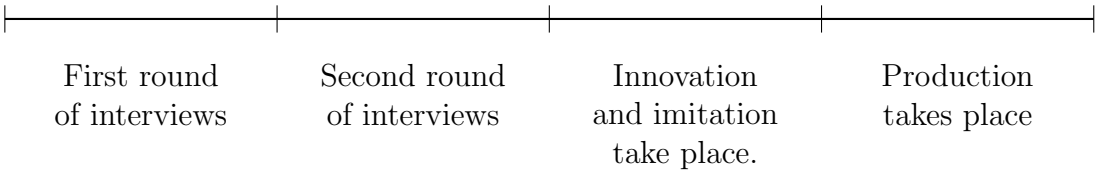


Figure 3.1: Timing of Economy

3.1 Production

In every country, there is a competitive market for final good y that can be seen as aggregated output of all goods from all industries ν. The final good production is characterized by Cobb-Douglass production function

$$y_t = \psi \int_0^1 A_{t,\nu}^{1-\alpha} (x_{t,\nu})^{\alpha} d\nu, \tag{3.1}$$

where $A_{t,\nu}$ captures the technology used in final production of product ν at time t and $x_{t,\nu}$ is number of goods from sector ν. From the competitiveness of final good market follows that price for each intermediate good must equal to its marginal profit

$$p_{t,\nu} = \frac{\partial y_t}{\partial x_{t,\nu}} = \psi \alpha A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha-1}. \tag{3.2}$$

Taking the price as given, intermediate monopoly firm maximizes its profit, using a final good as capital in one-to-one technology. Although the production itself does not depend on labor input, the dynamic of the level of technology under which the firm operates relies on human capital of hired workers. In addition, we impose an assumption that with no labor the firm produces

nothing.

$$\begin{aligned} \max_{x_{t,\nu}} \quad & p_{t,\nu}x_{t,\nu} - x_{t,\nu} \\ \text{subject to} \quad & p_{t,\nu} = \psi\alpha A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha-1} \end{aligned} \tag{3.3}$$

Solving the firm's problem yields the optimal production

$$x_{t,\nu}^{*} = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}. \tag{3.4}$$

Using the optimal level of production, one can find the value function of the maximization problem $\pi_{t,\nu}^{*}$

$$\pi_{t,\nu}^{*} = \begin{cases} \psi^{\frac{1}{1-\alpha}}(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} A_{t,\nu} = \delta A_{t,\nu} & \text{if } l > 0 \\ 0 & \text{if } l = 0 \end{cases} \tag{3.5}$$

The Equation 3.5 shows both the optimal profit for a firm with no labor and for a firm with hired labor. For more detailed elaboration of the optimal profit with labor, please see Appendix A.

3.2 Technology

Technology and its dynamics is a key feature of the model as the economic growth depends purely on a growth of the technology. The growth of the technology is so called endogenous, as it is driven by firms' incentives to improve their monopoly rents. Proposition 3.1 expresses the notion formally.

Proposition 3.1. *Assuming firm's problem as defined in Equation 3.3; more advanced technology under which the industry ν operates leads to higher profit. As a result, firms have an incentive to invest into technological progress.*

Proof. To show that the firm's problem given by Equation 3.3 persuades them to invest into a growth of technology in order to rise their profits, it is enough to consider part of the Equation 3.5 with positive labor and show it is increasing in a technology level. Mathematically,

$$\frac{\partial \pi_{t,\nu}^{*}}{\partial A_{t,\nu}} = \frac{\partial \left(\psi^{\frac{1}{1-\alpha}}(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} A_{t,\nu} \right)}{\partial A_{t,\nu}} = \psi^{\frac{1}{1-\alpha}}(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} = \delta,$$

where the last step follows from definition 3.5, furthermore δ is positive as assumed. □

To project the growth of technology into the economic growth, we need to impose three assumptions. Following recent literature related to endogenous growth models (among others (Acemoglu et al., 2006), (Vandenbussche et al., 2006), and (Aghion et al., 2013)) we incorporate the following assumptions.

Assumption 3.1. A technological growth is driven by innovation and imitation and cannot be negative.

Assumption 3.2. While the process of imitation requires little or no specificity, in order to innovate the specificity (match) is more important.

Assumption 3.3. The closer to the frontier, the innovation process is more likely to be successful and *vise verse*.

Assumption 3.4. The growth caused by imitation activity is independent of the workers.

Note that assumption 3.4 further develops the assumption 3.2 as the imitation activity no longer needs workers. It somewhat simplifies the model, however, the interpretation may be that the workers, who are studied in this model, are high-skilled and, at the same time, there are also present (implicitly) low-skilled workers who generate imitation growth. Having stated all the technology-oriented assumptions, the law of motion of technology which embodies the properties looks as follows.

$$A_{t,\nu} = A_{t-1,\nu} + (1-\lambda)\phi(\bar{A}_{t-1} - A_{t-1}) + \lambda\eta_t A_{t-1}, \tag{3.6}$$

where η represents the match of the worker and the industry saying that probability of innovation increases with a better match, $\bar{A}_{t-1}$ is the technology frontier at time $t-1$ and A_{t-1} represents a technology level in a particular country, defined as the average level of technology through the industries.

$$A_t = \int_0^1 A_{t,\nu} \mathrm{d}\nu. \tag{3.7}$$

3.3 Consumer

Consumers are assumed to live for one period and being endowed with an endowment *end* and a particular skill H which is assumed to be distributed uniformly on interval (0,1) i.e., $H \sim U[0,1]$. At the beginning of the period, she can interview up to 2 firms/industries and discuss their job offers[1]. The meetings go sequentially so first, she learns about the first job offer and either accepts or rejects. In case of the rejection, she meets the second firm/industry and learns the second job offer. However, the vacancy in the second firm may be already taken by a worker who accepted the job during the first round of interviews. If also the second job offer is rejected, then she becomes unemployed with unemployment benefits UB. Formally, she solves the following decision problem.

$$\begin{aligned} V_2(\eta_2, UB) = pu(end - \tau + UB) + \\ + (1-p) \max_{acc,rej} \left\{ u(end - \tau + w^{II}(\eta_2, \beta, UB)), u(end - \tau + UB) \right\} \end{aligned} \tag{3.8}$$

$$V_1(\eta_1, UB) = \max_{acc,rej} \left\{ u(end - \tau + w^{I}(\eta_1, \beta, UB)), \mathbb{E}\left[V_2(\eta, UB)\right] \right\} \tag{3.9}$$

where p stands for probability that the second firm (industry) hired somebody else during the first round of interviews. We assume a utility function u, which satisfies typical properties i.e., being increasing, concave, and satisfying Inada condition; τ stands for a lump-sum tax, used to found the UB. Potential wages in the first and the second round of interviews differ as the negotiators have different outside options and thus different bargaining power. The wage setting process as well as taxation shall be described later.

The probability p that a firm hires a worker during the first round is, however, set endogenously as follows. There is a level of a match $\bar{\eta}_1$ that satisfies $\mathbb{E}\left[V_2(\eta, UB)\right] = u(end - \tau + w^I(\bar{\eta}_1, \beta, UB))$ i.e., if the match is revealed to be $\bar{\eta}_1$, the worker is indifferent between accepting and rejecting the offer. In addition, since the $\frac{\partial w^I(\eta,\beta,UB)}{\partial \eta} > 0$[2], for all $\eta > \bar{\eta}_1$ the worker will accept the

[1] In future studies, the number of interviews may capture a labor market flexibility and thus allows us to study the importance of the flexibility on different labor markets.

[2] See Proposition 3.3

first job offer.

$$p = Prob(\eta > \bar{\eta}_1) = 1 - Prob(\eta < \bar{\eta}_1) = 1 - F_\eta(\bar{\eta}_1). \tag{3.10}$$

During the second round of interviews, she will accept the offered job only if

$$u(end - \tau + w^{II}(\eta_2, \beta, UB)) > u(end - \tau + UB).$$

Since the utility function is assumed to be increasing and has an inverse function, it leads to

$$w^{II}(\eta_2, \beta, UB) > UB.$$

Using this relation we can define $\bar{\eta}_2$ implicitly as follows

$$w^{II}(\bar{\eta}_2, \beta, UB) = UB. \tag{3.11}$$

Proposition 3.3 argues that $w^{II}(\eta, \beta, UB)$ is increasing in the value of η, and therefore the worker will accept the job offer from the second firm (industry) if the match $\eta_2 > \bar{\eta}_2$. Similarly to p let us define q as probability of $\eta > \bar{\eta}_2$, and hence

$$q = Prob(\eta > \bar{\eta}_2) = 1 - Prob(\eta < \bar{\eta}_2) = 1 - F_\eta(\bar{\eta}_2). \tag{3.12}$$

Using the notation of defined probabilities, let us elaborate on the expected value of the value function of workers before the second round of interviews. It is necessary to consider the expected value of the value function, because at the time of the first interview the worker does not know her second match. In particular, not only the quality of the match between the firm and the worker is unknown, but also the industry. Therefore the level of technology from previous period is also only expected. In particular, the expectation of previous technology level equals to the aggregate level of technology in particular country.

Lemma 3.1. *Suppose the industries are distributed uniformly, $\nu \sim U[0,1]$, then the expected value over ν of the previous technology level equals to A_{t_1}*

$$\mathbb{E}\left[A_{t-1,\nu}\right] = \int_0^1 A_{t-1,\nu} \mathrm{d}\nu = A_{t-1}$$

A proof follows from the Equation 3.7. With probability p, her potential in-

terviewer in the second round has already hired a different worker during the first round, and thus she will have no opportunity to meet any firm during the second round and remain unemployed. With a complementary probability $1-p$ she begins a bargaining process over the job offer with the other firm. Once the bargain begins, the probability q to be hired depends on the level of match η_2 and if it successes the worker enjoys $w^{II}(\eta, \beta, UB)$; otherwise she gets unemployment benefits.

$$\begin{aligned}
&\mathbb{E}\left[V_2(\eta, \beta, UB)\right] = \\
&= \mathbb{E}\left[pu(end - \tau + UB) + (1-p)(qu(end - \tau + w^{II}(\eta, \beta, UB)) + \right. \\
&\qquad \left. + (1-q)(u(end - \tau + UB)))\right] = \\
&= (1 - q + pq)u(end - \tau + UB) + q(1-p)\mathbb{E}\left[u(end - \tau + w(\eta))|\eta > \bar{\eta}_2\right] = \\
&= (1 - F_\eta(\bar{\eta}_1) + F_\eta(\bar{\eta}_1)(F_\eta(\bar{\eta}_2)))u(end - \tau + UB) + \\
&\qquad + F_\eta(\bar{\eta}_1)\mathbb{E}\left[u(end - \tau + w^{II}(\eta, \beta, UB)\right] \qquad (3.13)
\end{aligned}$$

Similarly to $\bar{\eta}_2$, we can implicitly express the value of $\bar{\eta}_1$ as conditions under which the worker is indifferent to accept the offer in the first stage of interviews or reject it.

$$u(As - \tau + w^I(\bar{\eta}_1, \beta, UB)) = \mathbb{E}\left[V_2(\eta, \beta, UB)\right] \qquad (3.14)$$

3.4 Matching and Bargaining

The contact between a worker and a firm is not affected by any information asymmetry. Both parties know the value of their match η before the contract is signed. Unlike Marimon and Zilibotti (1999), we do not consider a linear function as appropriate measure to capture a quality of the match. In order to incorporate more curvature and follow the parsimony rule, we assume that the match function $\eta(d)$, where d stands for a distance between the industry ν and the skill of the worker H and n capture the relative advantage of a very good match against a relatively poor one[3], looks as follows

$$\eta(d) = \exp(-dn). \qquad (3.15)$$

Lemma 3.2. *Under assumptions of both human capital H and industries ν being*

[3]The higher the n is, the less weighty the difference between a good match and poor one.

distributed according to $U \sim [0,1]$*, then the distance* d*, defined as* $d = |H - \nu|$ *has the following cumulative distribution function*

$$F_d(x) = \begin{cases} 1 & \text{if } x \geq 1 \\ 1 - (1-x)^2 & \text{if } x \in (0,1) \\ 0 & \text{if } x \leq 0 \end{cases}$$

and a corresponding probability density function

$$f_d(x) = \begin{cases} 0 & \text{if } x \geq 1 \\ 2(1-x) & \text{if } x \in (0,1) \\ 0 & \text{if } x \leq 0. \end{cases}$$

Proof. Suppose ν and H are both distributed according $U[0,1]$ and d is defined as

$$d = |H - \nu| .$$

Then, the cumulative distribution function $F_d(x)$ is

$$F_d(x) = Prob(d \leq x) = Prob(|H - \nu| \leq x) = 1 - (1-x)^2$$

To see this, consider a square with a length of its side equal to 1 and suppose that axes represent human capital H and industry ν, respectively. Note that its area equals 1 as well. Furthermore, the diagonal is a set of points where $\nu = H$ and thus the distance d is 0. As the the distance x increases, the area which satisfies the condition of being away from the diagonal less than x increases as well. For given x, there are two right-angled triangles lying at the most distant angles from the diagonal, each with an area $\frac{(1-x)^2}{2}$. The area of our interest is a complement of the sum of these right-angled triangles in the square. See Figure 3.2.

$$1 - (1-x)^2$$

To find probability density function for $x \in (0,1)$, it is enough to take a derivative of cumulative distribution function.

$$f_d(x) = \frac{\partial F_d(x)}{\partial x} = 2(1-x)$$

The rest of the lemma follows from properties of cumulative distribution functions and probability density functions. □

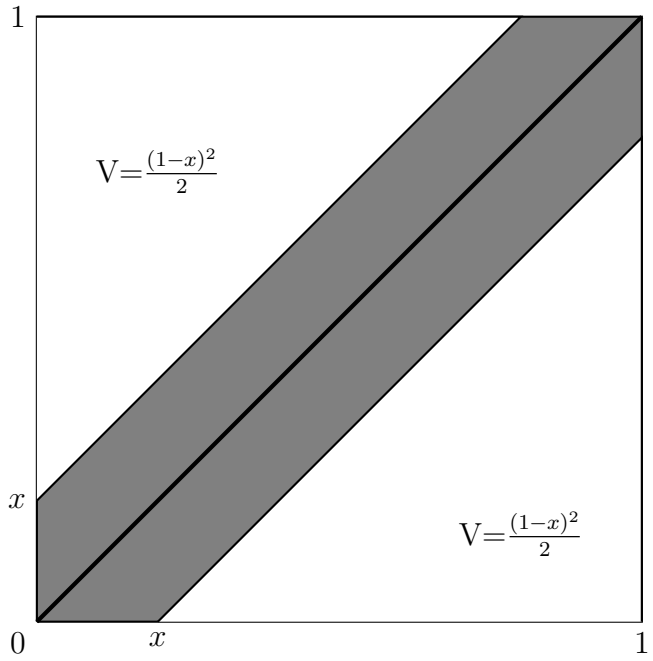


Figure 3.2: Area of Distance Lower than x.

Proposition 3.2. *Suppose the matching function defined by Equation 3.15 and the conclusion of Lemma 3.2, then the cumulative distribution function is*

$$F_\eta(x) = \int_{\exp(-n)}^{x} \frac{2(1+\frac{1}{n}\log(\eta))}{n\eta}\mathrm{d}\eta = 1 + \frac{2\log(x)}{n} + \frac{\log^2(x)}{n^2}$$

Proof. Suppose that the distance d has a pdf $2(1-d)$ for $d \in (0,1)$ and $\eta(d) = \exp(-nd)$. Using the Lemma 3.2

$$F_d(x) = \int_0^x 2(1-t)\mathrm{d}t.$$

One way to find $F_\eta(x)$ is to apply the transformation formula

$$\int_{\eta(1)}^{\eta(0)} f\left(d(\eta)\right)\left|\frac{\mathrm{d}d}{\mathrm{d}\eta}\right|\mathrm{d}\eta.$$

A bit of algebra shows that

$$d(\eta) = -\frac{1}{n}\log(\eta)$$

and

$$\frac{\mathrm{d}d}{\mathrm{d}\eta} = -(n\eta)^{-1}.$$

Plugging $d(\eta)$ into pdf of d yields

$$f(d(\eta)) = 2(1 + \frac{1}{n}\log(\eta)).$$

One also needs to calculate the new boundaries $\eta(1) = \exp(-n)$ and $\eta(0) = 1$. Having found everything what is needed, one can plug it back to the formula and obtain

$$F_\eta(x) = \int_{\exp(-n)}^{x} \frac{2}{n\eta}\left(1 + \frac{1}{n}\log(\eta)\right)\mathrm{d}\eta.$$

The integral can be split into two.

$$F_\eta(x) = \frac{2}{n}\int_{\exp(-n)}^{x} \frac{1}{\eta}\mathrm{d}\eta + \frac{2}{n^2}\int_{\exp(-n)}^{x} \frac{\log(\eta)}{\eta}\mathrm{d}\eta.$$

Solving for the integrals leads to

$$F_\eta(x) = \frac{2}{n}\left(\log(x) + n\right) + \frac{2}{n^2}\left(\frac{\log^2(x)}{2} - \frac{n^2}{2}\right),$$

$$F_\eta(x) = 1 + \frac{2\log(x)}{n} + \frac{\log^2(x)}{n^2}.$$

□

The solution of the bargaining over a wage problem requires to think of two stages, during the first round of interviews both sides - a firm in the industry and a worker - have different outside options than during the second round. Let us start with the second round and define $w_t^{II}(\eta, \beta, UB)$ as a wage from the second interview rounds with a match η, a worker's bargaining power β, and UB a level of unemployment benefits. Since the second round is the last one, the outside option of a firm in case it did not hire a worker is zero production and zero profit (see Equation 3.5). Therefore, a firm can agree on a wage $w_t^{II}(\eta, \beta, UB)$ as big as its gross profit $\delta A_{t,\nu}$. Likewise, it is terminal stage for the worker as she cannot meet any other firm and thus her outside option is a utility level from receiving UB: $u(end - \tau + UB)$. Assuming that the worker has a bargaining power β, than the possible wage from the second round of

interviews is defined as[4]

$$w_t^{II}(\eta, \beta, UB) = \beta \left[\delta A_{\nu,t} - UB\right]. \tag{3.16}$$

The bargaining process is more complicated during the first round of interview as the outside options are less clear. The worker has no incentive to accept a wage than would make her worse than what she can expect from the second round of interviews, mathematically

$$u(end - \tau + w_t^I(\eta_1, \beta, UB)) \geq \mathbb{E}\left[V_{2,t}(\eta, \beta, UB)\right].$$

The firm, however, will not agree on a wage that would make the net profit lower than if it finds a worker in next round of interviews (expectation as the match η is unknown), namely

$$\delta A_{t,\nu} - w_t^I(\eta_1, \beta, UB) \geq F_\eta(\bar{\eta}_1)(\mathbb{E}\left[\delta A_{t,\nu} - w_t^{II}(\eta, \beta, UB)\right]).$$

Combining these two conditions and assuming that β is the worker's bargaining power, the wage $w_t^I(\eta, \beta, UB)$ looks as follows

$$\begin{aligned} w_t^I(\eta_1, \beta, UB) &= u^{-1}(\mathbb{E}\left[V_{2,t}(\eta, \beta, UB)\right]) - end + \tau \\ &+ \beta\left\{\delta A_{t,\nu} - F_\eta(\bar{\eta}_1)(\mathbb{E}\left[\delta A_{t,\nu} - w_t^{II}(\eta, \beta, UB)\right]) - \right. \\ &\left. u^{-1}(\mathbb{E}\left[V_{2,t}(\eta, \beta, UB)\right]) + end - \tau\right\} \end{aligned} \tag{3.17}$$

Note that from the perspective of the worker, the value of the required level of match is uncertain at the time of the first round of bargaining. It is because the technological level of the firm/industry which she will meet during the second round of bargaining is unknown and she can only formulate her expectation over w_t^{II}. The Lemma 3.3 derives the value of $\bar{\eta}_2$.

Lemma 3.3. *Under the definitions 3.6, 3.11, and 3.16, the quality of the match under which the worker is indifferent between accepting the job offer with a wage w^{II} and choosing her outside option of being unemployed with UB is*

$$\bar{\eta}_2 = \frac{1}{\lambda}\left[\frac{1+\beta}{\beta}\frac{UB}{\delta A_{t-1}} - \frac{A_{t-1,\nu}}{A_{t-1}} - \phi(1-\lambda)(a_{t-1}-1)\right],$$

[4]Note that the bargaining power here is considered to be exogenously given.

where $a_{t-1} = \frac{\bar{A}_t - 1}{A_{t-1}}$ *is interpreted as an inverse distance to the frontier.*

Proof. Suppose the level of match $\bar{\eta}_2$ defined by Equation 3.11 and substitute for $w^{II}(\bar{\eta}_2, \beta, UB)$ from Equation 3.16. We obtain

$$UB = \beta \left[\delta A_{t,\nu} - UB\right],$$

where $A_{t,\nu}$ is a function of $\bar{\eta}_2$. Plugging for $A_{t,\nu}$ from Equation 3.6 evaluated at $\bar{\eta}_2$

$$UB = \beta \left[\delta \left(A_{t-1,\nu} + (1-\lambda)\phi(\bar{A}_{t-1} - A_{t-1}) + \lambda\bar{\eta}_2 A_{t-1}\right) - UB\right]$$

$$\bar{\eta}_2 = \frac{(1+\beta)UB - \beta\delta A_{t-1,\nu} - \beta\delta\phi(1-\lambda)(\bar{A}_{t-1} - A_{t-1})}{\beta\lambda\delta A_{t-1}}$$

$$\bar{\eta}_2 = \frac{1+\beta}{\beta\delta\lambda A_{t-1}} UB - \frac{A_{t-1,\nu}}{\lambda A_{t-1}} - \frac{\phi(1-\lambda)}{\lambda}\frac{\bar{A}_{t-1} - A_{t-1}}{A_{t-1}}$$

$$\bar{\eta}_2 = \frac{1}{\lambda}\left[\frac{1+\beta}{\beta}\frac{UB}{\delta A_{t-1}} - \frac{A_{t-1,\nu}}{A_{t-1}} - \phi(1-\lambda)(a_{t-1} - 1)\right]$$

□

Having found the value of $\bar{\eta}_2$, to find the expectation worker anticipates is enough to find $\mathbb{E}\left[\bar{\eta}_2\right]$

$$\mathbb{E}\left[\bar{\eta}_2\right] = \frac{1}{\lambda}\left[\frac{1+\beta}{\beta}\frac{UB}{\delta A_{t-1}} - 1 - \phi(1-\lambda)(a_{t-1} - 1)\right], \tag{3.18}$$

which follows from Lemma 3.1.
The Lemma 3.3 also reveal a key aspect of the model. The expected level of a match in the second round of negotiation depends positively on a level of unemployment benefits. This is the canal, which ensures that unemployment insurance increases the expected value in the first round of negotiation and provide workers with higher outside option.

Having introduced the matching and bargaining process and having set the wages, let us derive properties of wages.

Proposition 3.3. *Suppose the introduced framework and take both* UB *and* β *as given, then both wages* $w^I(\eta, \beta, UB)$ *and* $w^{II}(\eta, \beta, UB)$ *increase with better match* η *at the same rate.*

Proof. To show the stated relation, it is enough to take a derivative of expression for both wages. In particular, for $i \in \{1, 2\}$

$$\frac{\partial w_t^i(\eta_i, \beta, UB)}{\partial \eta_i} = \beta\delta\lambda A_{t-1}.$$

To see this for w_t^{II}, it is enough to realize that neither β, δ, nor UB is a function of the quality of a match. Moreover, current level of technology for a given industry is, according to definition 3.6, a sum of 3 elements and only the last one contains η_t. The same hold for w_t^I, where it is perhaps more complicated as the expression looks more difficult, however, all terms in expectations cannot appear in the results. □

3.5 Government

In the model, government is responsible for redistribution of its income collected as lump-sum taxes as an unemployment benefits to people who stay with no job. In order to impose a time consistent policy, we assume that the government's budget need not to be balanced in every period. Specifically, we simple assume that sum of the unemployment benefits distributed among unemployed in time t has to equal to a tax collection in time $t + 1$. It means, that government can run a debt in every period, but in the subsequent period it must be redeemed.

$$\sum_H UB_{H,t} = \sum_H \tau_{t+1,H} \tag{3.19}$$

Furthermore, this assumption enriches the information set of consumers when taking their decisions as they *ex ante* know the taxation. From economic point of view, it also seems reasonable as in most of the countries today's debt of governments will be redeemed by future generations.

3.6 Economic Growth

Having defined all key parts of the model, we can analyze the economic growth under introduced framework. Let g denote an economic growth based on a standard definition; a percentage increase in output is

$$g = \frac{y_t - y_{t-1}}{y_{t-1}}. \tag{3.20}$$

Proposition 3.4. *Under the assumed framework, the growth rate defined by Equation 3.20 equals*

$$g = (1-\lambda)\phi(a_{t-1}-1) + \lambda \int_0^1 \eta_{t,\nu} \mathrm{d}\nu,$$

where $a_{t-1} = \frac{\bar{A}_t - 1}{A_{t-1}}$ *is interpreted as an inverse distance to the frontier.*

Proof. Starting with the definition 3.20 and plugging 3.1 for y_t

$$g = \frac{\psi \int_0^1 A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha} \mathrm{d}\nu - \psi \int_0^1 A_{t-1,\nu}^{1-\alpha} x_{t-1,\nu}^{\alpha} \mathrm{d}\nu}{\psi \int_0^1 A_{t-1,\nu}^{1-\alpha} x_{t-1,\nu}^{\alpha} \mathrm{d}\nu},$$

using the optimal output of intermediate firms /industries $x_{t,\nu}^*$ defined by Equation 3.4 yields

$$g = \frac{\int_0^1 A_{t,\nu}^{1-\alpha} \left(\psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}\right)^{\alpha} \mathrm{d}\nu - \int_0^1 A_{t-1,\nu}^{1-\alpha} \left(\psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}\right)^{\alpha} \mathrm{d}\nu}{\int_0^1 A_{t-1,\nu}^{1-\alpha} \left(\psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}\right)^{\alpha} \mathrm{d}\nu}$$

$$g = \frac{\int_0^1 A_{t,\nu} \mathrm{d}\nu - \int_0^1 A_{t-1,\nu} \mathrm{d}\nu}{\int_0^1 A_{t-1,\nu} \mathrm{d}\nu}.$$

Using the definition 3.6 and 3.7, we can plug for $A_{t,\nu}$

$$g = \frac{\int_0^1 A_{t-1,\nu} + (1-\lambda)\phi(\bar{A}_{t-1} - A_{t-1}) + \lambda A_{t-1} \int_0^1 \eta_\nu \mathrm{d}\nu}{A_{t-1}},$$

$$g = (1-\lambda)\phi(a_{t-1}-1) + \lambda \int_0^1 \eta_\nu \mathrm{d}\nu.$$

□

According to the proposition 3.4, the growth rate is sum of effect following from imitation activity and innovation respectively. It further reveals that highly developed countries ($a_t \to 1$) grow mainly through innovation.

Chapter 4

Simulation of Model

In order to solve the model, we need to incorporate and specify few more features. In particular, we impose a constant relative risk aversion (CRRA) form of utility function

$$u(c) = \begin{cases} \frac{c^{1-\sigma}-1}{1-\sigma} & \text{if } \sigma \neq 1 \\ \log(c) & \text{if } \sigma = 1. \end{cases} \tag{4.1}$$

It is also necessary to specify the path of development of UBs in time. It is understandable that if UBs were fixed at a particular level, their importance would diminish as we suppose a growth model in which all others sources of income increase as the economy grows. Therefore, we assume that the unemployment benefits evolve with respect to the economic growth in previous period

$$UB_t = UB_{t-1}(1 + g_{t-1}), \tag{4.2}$$

where g is defined by Equation 3.20. The theoretical model, namely one of the implication of Proposition 3.4 precisely defines the growth of the frontier economy, however, it is not useable when solving the model with only two representative countries. Hence, we assume an exogenous growth rate of the frontier economy at 5% per period of time. For simplicity, where it is possible and causes no confusion, we omit time indexes.

To calibrate our model, we choose few parameters so they follow literature,

however, the remaining parameters are set to match some styled economics facts. Specifically, β that captures the bargain power of labor is set to 0.62 as is suggested by Karabarbounis and Neiman (2012). To pick a proper value of elasticity of intertemporal substitution, it is difficult to follow literature as the estimated values differ significantly. We decided to follow a suggestion from (Havránek, 2013) and use $\sigma = 3$. Two variables alter with the level of development of the economy a_t - initial endowment of consumers *end* and weight on a growth by innovation λ. The dependence of the former on the level of development follows from (Isaksen et al., 2014), where the authors used OECD data to analyze the households' savings and concluded that households in more developed countries tend to have, on average, higher savings (financial assets). The latter simply implies that countries which may easily benefit from imitation process will do so and highly developed countries will focus on innovation based growth. This further extends the assumption 3.3, in a sense that governments in particular countries are aware of the situation and can adjust their policies. The parameter λ is set to 0.2 for developed countries and 0.4 for developing countries. Note that we do not require the policies to be optimal.

The parameter n, which affects the distribution of the vacancy-job match, is set relatively high to 6. As a result, the difference between a very good match and rather poor one is not so weighty as if n was lower. The value of ϕ capturing a speed of the growth driven by imitation is set to 0.05, ψ which normalizes the product of economy is set to 2.25. Finally, α measuring the importance of input relative to the technology in production function is set to 0.7. Therefore, the input is more important than the technology in a production.

To assess the results we consider two representative countries. On the one hand, one of the countries, henceforth the developed country, is highly developed, its technology is close to the frontier, consumers have relatively high level of savings, and institutions are set in favor of innovation. On the other hand, the other country, henceforth the developing country is rather backward, its technology level is low, policies are oriented toward imitation and households barely owe assets as valued as 2 or 3 times of their disposable incomes.

To solve the model we conduct an exercise studying the cumulative growth rate in 5 sequential periods of time under different setting of unemployment insurance. Apart from economy with no unemployment insurance which is con-

sidered being a baseline and it is further used as a benchmark for a growth in economies under different unemployment benefits settings. We choose reasonable rates of unemployment benefits which satisfy two required conditions: (i) the level of unemployment insurance is reasonable in comparison to the average wage of the economy; and (ii) the same levels of generosity (low, medium, and high) are comparable between the two representative economies. The latter appears to be rather difficult as the two representative economies differ in their performances and outcomes. Moreover, the unemployment benefits in absolute numbers have to differ. In the developed economy, we set low, medium, and high level of unemployment benefits to 10%, 25%, and 50% of an average wage, respectively. To find corresponding values in a framework of the developing economy, we equalize the ratio of unemployment benefits to the economy's outcome. Therefore, for a given period of time it must hold

$$\frac{UB_a}{y_a} = \frac{UB_b}{y_b},$$

where a stands for the developed (advanced) economy and b for the developing (backward) economy. Using Equation 3.1 and the fact that both economies are equal in terms of inputs (industries), the expression can be simplified as follows

$$\frac{UB_a}{UB_b} = \frac{\int_0^1 (A_\nu^a)^{(1-\alpha)} \mathrm{d}\nu}{\int_0^1 (A_\nu^b)^{(1-\alpha)} \mathrm{d}\nu}.$$

In our case, if the two unemployment benefits should be comparable between the economies, the ratio must be approximately $\frac{7}{5}$ [1]. Therefore, if the high unemployment benefits in the developed economy are equal to 1 (representing a 50% of the average wage in the developed country), the level of high unemployment benefits in the developing economy must be $\frac{5}{7}$, which is, however, close to the economy's average wage.

We simulate both economies under each level of unemployment benefits 30-times and Table 4.1 presents the average values. The first column summarizes the average value of a sum of growth rates over 5 periods of time for every setting. The economy with no unemployment insurance is a benchmark. The second column captures the percentage difference in the cumulative growth between the baseline economy with no unemployment insurance and the par-

[1] These results were obtained numerically. The distribution of the technology level across the industries A_ν follows uniform distribution with a mean of A_t^i for a country i and time t.

ticular economy. The third column shows the *t-ratio*[2], which measures the significance of the difference in cumulative growth. Finally, last column displays unemployment rate under the specific setting. The top of the table is devoted to the developed economy, whereas the bottom summarizes the developing country.

To assess the importance of the results for our hypothesis, it is crucial to compare how the increasing generosity of unemployment insurance affects the cumulative growth in the developed and the developing economy. In general, in both economies there is negative impact of unemployment insurance on cumulative growth, however, the magnitude varies significantly. In the developed economy, the effect of introducing the low level of unemployment benefits on the cumulative growth rate is on an edge of statistical significance ($|t\text{-}ratio| = 1.58$). On the contrary, in the developing country, there is no doubt that non-zero unemployment benefits cause a loss in economic output. Moreover, in the case of medium level of unemployment insurance, the developed economy also suffers a less significant decrease in the cumulative growth rate.

Surprisingly, the developing economy performs better in the case of high level of unemployment insurance. However, it is due to an imperfection of the model. In particular, under such extreme conditions of unreasonably generous unemployment benefits and, in turn, high unemployment in both economies, the growth via imitation activity outweighs the effect of innovation. As a result, the model is no longer able to capture the consequences of a quality of match on the growth. Instead, it compares a growth caused by imitation activity and here the developing country benefits from its backwardness and overperforms the developed economy. Overall, these results, even though they may look startlingly, only reflect extreme circumstances under which the model loses its power to explain the studied phenomena. Note that we present these results only with a purpose to describe the model's behavior under unreasonably generous unemployment benefits and we do not consider them to be plausible.

The results show few clear patterns. For example, for both economies it is true that more generous unemployment insurance causes higher unemployment rate. This confirms the moral hazard problem argument. However, the effect between countries is unequal; the unemployment rate in the developed country

[2]For more details, please see Appendix A

for a given level of the generosity of unemployment benefits is always lower than the one in the developing country. In addition, for low and medium level of unemployment benefits, the loss in developed country is lower in comparison with the developing country. The explanation is as follows. While in both countries there is a decrease of output caused by lower employment, in the developed country, the loss is partially offset by better match and more likely successful innovation activity and consequently by higher growth of technology. The developing country cannot gain much technology growth from better match, because its institutional framework is imitation-oriented.

Apart from the main results, there are several outcomes worth commenting. First, the results confirm that developing countries tend to grow faster as they benefit from their backwardness. Comparing the developed and developing economies under no unemployment insurance policy, the 5 periods of time cumulative growth in developing country is almost 144% of the growth during the same period in the developed country. Second, no unemployment insurance policy implies weak (if any) consumers' outside options, which, in turn, imply zero rate of unemployment as the model allows everyone to find a job. This is a truth for both modeled economies, the developed country and the developing country. Third, in case of high level of unemployment insurance in developing country, the unemployment rate is 100%. This is again an extreme result, which is caused by the specification of the model. It is driven by two separated causes: (i) unemployment benefits, under such circumstances, stands for roughly 85% of an average wage[3]; and (ii) due to the construction of the model, the economy is able to grow via imitation activity which does not require labor. Finally, probably the most contra-logical result, the unemployment rate in the developing country under high unemployment benefits policy reaches 100% and yet, the growth rate is decently high. As discussed above, the results suffer from inability of the model to cope with the extreme conditions imposed by such high unemployment benefits and we think of the results as being caused be the imperfections of the model.

All in all, the results tend to support our hypotheses. In particular, one of the hypotheses is confirmed clearly; more generous unemployment insurance in the developing country seems to harm the economic growth. However, the results regarding the developed country leave a space for discussion; while our

[3]Note that the reason for such high unemployment benefits is discussed above.

hypothesis claims that the overall effect of more generous unemployment insurance on economic growth is ambiguous, the results suggest negative impact. Nevertheless, the loss, at least for the low unemployment benefits, is on an edge of significance and thus we cannot completely reject the claim that there may be an optimal level unemployment insurance which causes no negative (or even causes positive) impact on the economic growth as, for example, Acemoglu and Shimer (1999) argued. The hypothesis about an existence of non-linear effect is necessarily a consequence of the first one and the second one.

Table 4.1: Solution

	Developed country			
	Cumulative Growth over 5 Periods of Time	Change against No UBs Case	T-ratio (28 df)	Unemployment Rate
No UBs (Baseline)	60.10 %			0 %
Low UBs	59.62 %	- 0.75 %	-1.58	1.57 %
Medium UBs	52.08 %	- 13.30 %	-30.06	17.5 %
High UBs	36.23 %	- 39.69 %	-77.22	48.15 %
	Developing country			
No UBs (Baseline)	86.64 %			0 %
Low UBs	84.56 %	- 2.40 %	-10.80	8.42 %
Medium UBs	73.61 %	- 15.04 %	-66.42	60.56 %
High UBs	65.06 %	- 24.91 %	-85.36	100 %

Source: Author.

Chapter 5

Empirical Evidence

In this second part of this thesis, we seek empirical evidence of effect of unemployment generosity on the productivity. Unlike the theoretical model in the first part which concerns both the developing and the developed countries, in the empirical analysis we focus solely on the developed countries. The main reason for omitting backward countries is a lack of applicable data. Moreover, the unemployment insurance system has not been blanketly adopted in developing countries and in the countries where some unemployment insurance system have been adopted, it is either hardly comparable as in the case of China[1] or because the system have been reformed many times during its short history of existence (Gerard and Gonzaga, 2011). Due to the lack of the data, the empirical chapter focuses only on one of the hypotheses this thesis states; does generous unemployment insurance increase productivity in developed countries?

5.1 Data

The most challenging part of the empirical analysis is to measure the generosity of unemployment insurance which is widely known as a multi-dimentional variable. Different rules for eligibility, duration, the actual level of payments, waiting period *etc.* make the comparison among countries nearly impossible and even if the systems were set equally, the economic conditions, and informal labor market institutions prevent from a decent comparative analysis. An example of potential problems was pointed by Pallage et al. (2013) "...[w]hile

[1]The social system of China is based on Hukou system, which, among others, ensures that migrant workers are eligible for no unemployment benefits, but they are provided with a farm at her/his place of birth.

duration of benefits is shorter in the United States than in most European countries, it may not imply that UI[2] programs in the United States are less generous since the duration of unemployment is also shorter" (p.2).

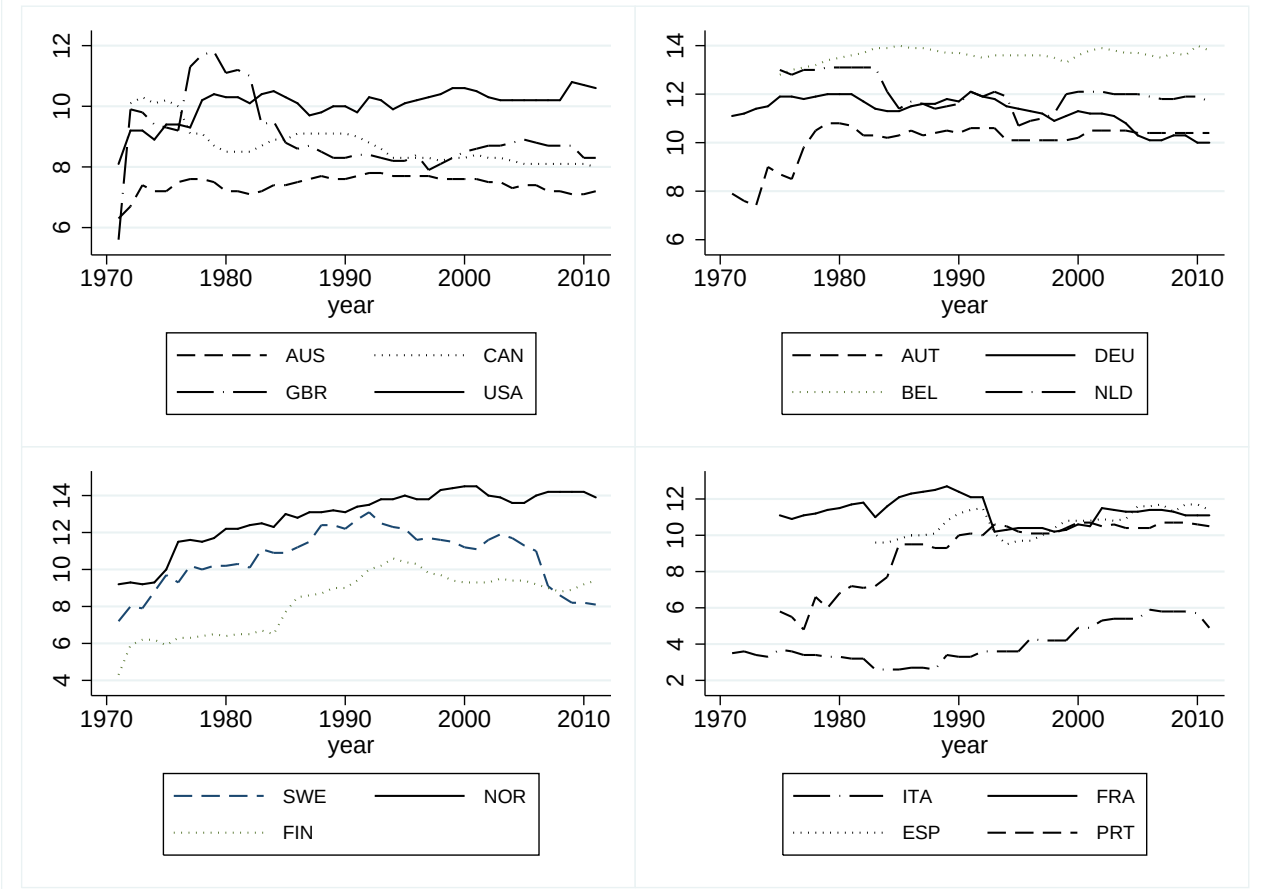
As a result, a respectable comparison of the generosity of all social programs (not only unemployment insurance) is a difficult task and requires consideration of several aspects going beyond the main characteristics of social benefits. The economic literature studying methods of measuring the generosity of social programs has been rather poor and tended to use rather weak proxy variables. One of the most heavily used proxy variable for generosity is a share of GDP spent on labor market or directly on unemployment benefits. Not surprisingly, such a measure has several flaws and may lead to misleading results. For instance, when studying the evolution of the generosity of unemployment insurance in European countries in the last few decades, the proxy fails to count for a population growth and an unemployment increase, which occurred in Europe. Likewise, when comparing different countries, the figures are affected by various taxation policies as the tax burden levied on unemployment benefits differ. Overall, the share of GDP is not a good measure.

When proposing a better measure, Scruggs (2006) focused on replacement rate and coverage rate which, as he argued, are the most important features of unemployment insurance. To extend Scruggs' approach, Pallage et al. (2013) created a model consisting of two comparable economies which vary only in complexity of unemployment insurance. While in the simple model, unemployment benefits are provided for everyone and from the first day of the unemployment period, the more sophisticated model captures more aspects e.g., the unemployment duration, the unemployment rate, the unemployment insurance duration, the actual level of unemployment benefits, taxes, and also a different financial support provided by the government. By comparing household's utilities between both models, the authors estimated an one-dimension measure of the unemployment insurance which provides the same level of utility as the multidimensional structure of the policies. However, when performing a regression of the model's output on variables that are believed to affect the generosity, although authors' acknowledgment of omitting non-linear relations and other potential flaws, only three variables (unemployment benefits, unemployment duration, and wait time) seemed significant.

[2]Unemployment insurance

To conduct our analysis, we make use of a data-set CWED 2 (Scruggs et al., 2014b), which provides systematic data on institutional features of social insurance programs in more than 30 counties since 1970'. Specifically, main variable of our interest is *Uegen* - Unemployment Generosity Index; this particular index along with two more indexes provided in the database are based on Esping Andersen's decommodification index (Esping-Andersen, 1990). The Unemployment Generosity Index, as proposed by Scruggs et al. (2014b), is a weighted average of z-scores, where the most important part is the replacement rate z-score. In addition, the sub-index is multiplied by insurance coverage, so it shows Scruggs' belief of the importance of the replacement rate and the insurance coverage rate. Figure 5.1 depicts several time series of evolution of the index for 4 groups of countries. Specifically, the top left graph shows Anglo-Saxon countries. With an exception for the U.S., the countries have not scored well in recent 20 years and their figures do not even reach the average value of Western European countries such as Germany, Belgium, Austria, and the Netherlands. The bottom left graph shows Nordic countries, which exhibit relatively high level of heterogeneity. While Norway's figures reach maxima from all compared countries in the last decade, Finland performs on average. The bottom right graph shows South European countries including Italy, which has the least generous unemployment insurance in the data-set. For more details, please refer to (Scruggs et al., 2014a). Moreover, in order to perform a robustness check we also employ the criticized spending on unemployment benefits as a share of GDP.

Figure 5.1: Generosity of Unemployment Insurance



Source: Author using data from (Scruggs et al., 2014b)

In order to explain the growth of total factor productivity, we follow literature (Gehringer et al. (2013),Isaksson (2007), and Loko and Diouf (2009)) and use variables which are widely believed to affect TFP growth. In particular, Loko and Diouf (2009) summarized the problem and divided potential determinants into 5 groups. Starting with macroeconomic factors such as inflation or a government size, he argued that TFP growth suffers from unstable environment and thus, for example, high inflation should be associated with low (if any) growth. Probably the most widely agreed variables affecting TFP in literature are variables related to a knowledge spillover e.g., trade openness and FDI. The higher the international contact is, the more likely new technology is adopted and thus the higher the growth of TFP is. Third group of factors is a sectoral composition of (a growth of) an output. In particular, many argued that economies with higher value added share of high-productivity growth sectors have higher aggregate productivity growth. Fourth aspect which may have impact on TFP is an institutional framework of a given economy. More freely thinking and acting society is more likely to innovate. Finally, Loko and Diouf (2009) discussed the importance of labor quality. Essentially, we extend the last group of arguments by adding a generosity of unemployment insurance which is supposed to improve the quality of match and thus the productivity as well. Moreover, Loko and Diouf (2009) also reckoned that higher female labor participation rate should have a positive effect on the growth of TFP, however, they, at the same time, admitted that empirical results offer rather mixed evidence. Apart from the 5 groups discussed above, Isaksson (2007) highlighted the positive effect of knowledge; patents, R&D, and information and communication technology (ICT).

Our data-set contains unbalanced panel data for 17 developed countries spanning from 1991 up to 2010. However, due to data limitation not all variables for all countries and/or all time periods are at our disposal. Table 5.1 shows a brief summary of the key variables and list of studied countries. In particular, for each country we report three characteristics which represent average values of the particular variable in the country for observed period. Following common notation in literature we use variable *Distance*, which is defined as a GDP *per capita* of the particular country divided by GDP *per capita* of the U.S. Therefore, the higher the figure is, the more advance the country is. Note that there are 3 countries with the average GDP *per capita* higher than the U.S., whereas the remaining countries, except for Korea, reach at least half of the

Country	Average Distance	Average Uegen	Average TFP Growth
AUS	.76	7.55	.99
AUT	.88	10.31	1.08
CHE	1.32	13.19	.215
DEU	.84	10.93	.88
DNK	1.12	11.87	.87
ESP	.59	10.98	-.16
FIN	.84	9.55	1.59
FRA	.81	10.95	.78
GBR	.88	8.46	1.46
IRL	1.10	10.83	1.33
ITA	.75	4.745	.13
JPN	.84	5.38	.63
KOR	.43	3.47	3.13
NLD	.95	11.75	.66
NZL	.62	7.08	.40
SWE	.95	11.31	.93
USA	1	10.39	1.28

Table 5.1: Countries' Characteristics

U.S.'s figure. The second column depicts average score in the unemployment insurance generosity index. Once again, Korea performs the worst and along with Japan and Italy are well behind the group of front running countries. On the contrary, the most generous unemployment insurance is in Switzerland. Finally, the last column summarizes the average rate of the growth of TFP in the studied period. While for most of the countries the figure is around 1, there are three extreme cases. On the one hand, Korea performs extraordinary well and reaches a figure as large as 3.13. On the other hand, Italy's growth is only 0.13 and Spain is the only country that has a negative average growth of TFP. A list of all available variables as well as their sources may be found in Appendix A.3.

Based on the Table 5.1, Figure 5.2 depicts a scatter plot of the average value of the generosity of unemployment benefits and the average growth rate of TFP. It graphically depicts the extreme case of Korea.

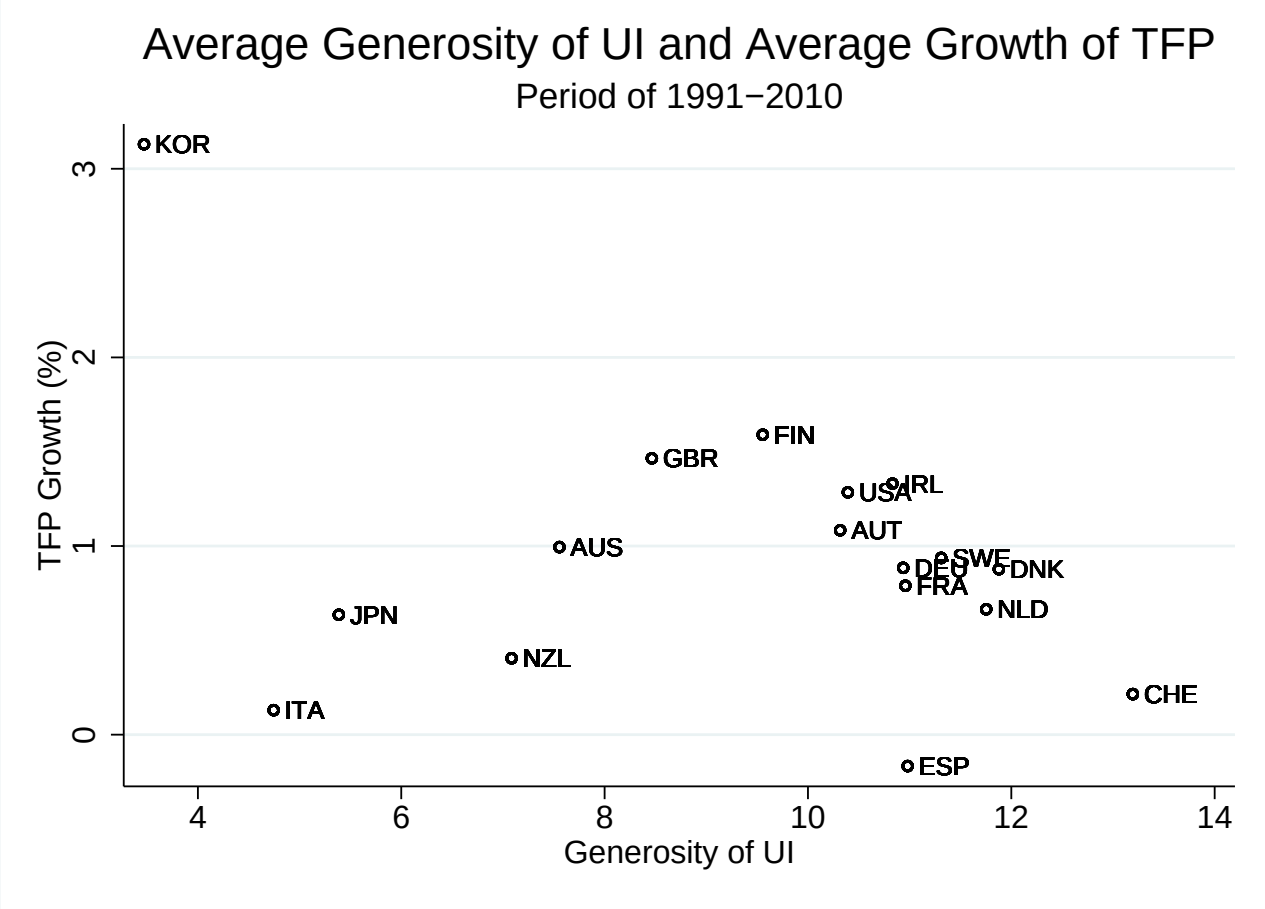


Figure 5.2: Generosity of UI and TFP Growth

Source: Author.

5.2 Methodology

Having a panel structure of data brings a need to identify whether the data exhibit a presence of fixed effects. On the one hand, when the fixed effects are incorrectly omitted then the coefficients are not consistent, and on the other hand, including fixed effects when it is not necessary causes inefficiency. Therefore, the proper identification of fixed effects is a key step in panel data analysis. In the literature, there are three standard models used: (i) a pooled OLS model; (ii) a random effects model; (iii) a fixed effects model.

To choose the proper model, we proceed in two steps. First, comparing results from the pooled model and the fixed effects model, we learn that the data exhibit a presence of individual heterogeneity as we reject a hypothesis of all the individual effects being jointly zero. In particular, the associated F-statistic equals to 13.2, see the last row of the Model 1 in Table 5.2. As a result, the pooled model can be shown to be inconsistent (Cameron et al., 2005). Second, knowing that there is an unobservable individual effect in the data, it is crucial whether the effect is correlated with the rest of explanatory variables. If the correlation is present than the random effects model is inconsistent, however, if there is no correlation between the individual heterogeneity and explanatory variables than it is more efficient than the fixed effects model. To decide, we employ Hausman test, where under the null hypothesis they both models reveal the same consistent estimates and thus the difference between them is statistically zero. In our case, Hausman test yields results that suggest rejecting the null hypothesis. For more details, please see A.1. Therefore, the random effects model would result in inconsistent results. Overall, the unobservable individual effects are present and appear to be correlated with the remaining explanatory variables.

The formalized fixed effects model studying the effect of the generosity of unemployment insurance on the TFP growth looks as follows.

$$TFPGrowth_{i,t} = \alpha_i + \mathbf{X}_{i,t}\beta + Uegen_{i,t}\delta + \sum_{j=1}^{J} \phi_j \mathbb{1}[t \in j] + \varepsilon_{i,t}, \qquad (5.1)$$

where α_i captures an individual heterogeneity for country i, $\mathbf{X}_{i,t}$ contains all used control variables, and $Uegen_{i,t}$ is the variable of our interest; and $\mathbb{1}$ is

an indicator function which returns 1 if period t is a subset of time periods j, otherwise returns 0; and $\varepsilon_{i,t}$ stands for the idiosyncratic errors, which change across time as well as across countries. Even though the fixed effect allows $\mathbb{E}[\alpha_i|\mathbf{x}_i]$ to be any function of $\mathbf{x}_i$, in order to the estimator be consistent we need two more assumptions. Considering individual unobserved effect as a random variable, the first assumption can be viewed as zero conditional mean of error term for each time period t:

$$\mathbb{E}[\varepsilon_{i,t}|\mathbf{x}_i, \alpha_i] = 0.$$

The second assumption requires standard rank conditions on the matrix of time varying explanatory variables. Under these two assumptions the fixed effect estimator is consistent. For more details, please see Wooldridge et al. (2010). Moreover, in order to ensure that asymptotic inference are correct, we would need to add additional assumption about the idiosyncratic errors;

$$\mathbb{E}\left[\varepsilon_i\varepsilon_i^{'}|\mathbf{x}_i, \alpha_i\right] = \sigma_\varepsilon^2\mathbf{I}_T,$$

along with the above mentioned assumption of zero conditional mean of idiosyncratic errors it implies that the $\varepsilon_{i,t}$ have a constant variance across time and are uncorrelated. However, when this assumption is not (completely) satisfied, it is still possible obtain an asymptotically valid inference. In particular, using clustering leads to an asymptotically valid inference regardless of a within individual auto-correlation and/or heteroscedasticity problem (Cameron and Miller, 2010). Therefore, when estimating the model, *clustered sandwich estimator* for variance is employed.

It is reasonable to suspect that the average pattern of TFP growth might have changed in time regardless of country. For example, due to a higher usage of modern technology it may tend to increase rapidly or on the contrary, during the crisis it perhaps decreased globally. To capture this effect we extend the model with time dummies; an advantage of time dummies compared to a linear trend is no imposed structure on the effect between two particular years. While the linear trend, if significant, can capture either increasing or decreasing pattern, dummies provide more variability in the patterns. Using dummies, however, brings also a disadvantage. In particular, including a dummy for every year comes at the cost of a lot of coefficients being estimated.

5.3 Results

The model pinned down by the Equation 5.1 shows the benchmark model. The Table 5.2 shows the obtained results with $TFPGrowth$ as the dependent variable. Note that the difference between the models is in the way they capture the time effect. While Model A ignores the time effect completely, Model C includes dummy variables for each year except year 1991 which is taken as a benchmark. A Model B's specification is something between. Specifically, as the time period is considered a half of a decade. The period of years 1991 - 1995 is taken as a benchmark and then every 5 years is associated with one dummy. The names of the dummies are self-explaining.

All of the models use 279 observations for 17 countries with, on average, more than 16 time periods per country. The minimum is 10 observed years for one country. While both Model A and B are able to explain roughly 35% of the total variation of $TFPGrowth$ (note that including time dummies increased also the *Adjusted* R^2), Model C outperforms them both. Starting with the Model A, it suggests that the generosity of unemployment insurance has a positive and significant effect on a growth of TFP. In particular, according to the model, if a country scored by 1 point better in the $Uegen$ index, the estimated effect on TFP is, *ceteris paribus*, by a 0.5% higher growth. For better imagination, 1 point in the index is a difference between the average score of the U.S. and Sweden, see Table 5.1. Moreover, the results also confirm several facts from the literature. The value added from the financial sector has a positive and significant effect; level of investment into IT, communication, and software plays positive role in growth of productivity. Surprisingly, and against previous researches, a growth in agriculture has a positive effect. With regard to variables measuring the spillover effect; FDI has a positive and significant effect; and a positive effect of trade openness is on an edge of a 10% significance level. Remaining variables seem to be insignificant.

Model B provides similar results as Model A does. They differ only in the time dummies. Decomposing the time effect into 4 5-years periods clearly shows that in the period from 2006 up to 2010, the growth of productivity tend to be lower, in a comparison to the benchmark of early 90'. However, it

Table 5.2: Results

	Model A	Model B	Model C
Uegen	.584**	.603**	.52***
	(.234)	(.206)	(.147)
ValueAddedFinGrowth	.217***	.221***	.127***
	(.03)	(.03)	(.028)
Inflation	-.089	-.073	6.7e-03
	(.059)	(.076)	(.067)
IctInvestment	.083**	.087*	.092*
	(.038)	(.047)	(.052)
TradeOpenness	.023	.029*	.039***
	(.014)	(.015)	(.011)
InwardFDIShareGDP	1.5e+06*	1.2e+06	3.9e+05
	(8.0e+05)	(8.5e+05)	(6.8e+05)
ValueAddedAg	.342**	.293**	.242
	(.133)	(.132)	(.196)
GDPPwe	-.026	.039	.049
	(.024)	(.025)	(.037)
FemaleEmployment	-.087	-.063	-.026
	(.054)	(.053)	(.049)
Late90		-.705	
		(.434)	
Early00		-1.14*	
		(.636)	
Late00		-1.85**	
		(.771)	
Constant	-4.24	-7.3**	-9.81***
	(2.72)	(2.58)	(2.7)
YearEffects	No	No	Yes
Observations	279	279	279
R^2	0.353	0.373	0.541
Adjusted R^2	0.331	0.345	0.489
F	13.2	21	.

Robust standard errors in parentheses.

* p < 0.1, ** p < 0.05, *** p < 0.01.

is likely caused by the financial crisis which occurred in years within this period. We do not consider it being a long-lasting pattern in productivity growth. Testing joint significance of the 3 time dummies, they seem to be marginally significant (p-value = 0.10). Finally, Model C yields slightly different results; unlike in Model A and B, the growth in agriculture seems no longer significant; the effect of level of trade openness and thus the spillover effect of technology and knowledge is strongly significant and positive as the literature suggests. Furthermore, the effect of generosity of unemployment remain significant and positive. The time effect decomposed on years demonstrates similar trend as Model B does; taking year 1991 as a benchmark, in three years in early 90' the productivity growth was higher, whereas in years 2008 and 2009 as the crisis occurred, the growth was, on average, lower. The remaining years do not seem significantly different from 1991. The F-test confirms the joint significance of the time effect(p-value = 0.00).

5.4 Sensitivity analysis

To deliver more robust results, we conduct 6 exercises with different specifications. For clarity, it is possible to distinguish two groups of sensitivity analyses: (i) relates to specifications of the model; and (ii) verifies the conclusions using different variables (proxies) for studies phenomena.

It seems reasonable to consider an option that the model is likely dynamic; saying that a growth of productivity in a given country is affected by a growth in the same country previous year. To check this option, we include a growth of the previous year among the explanatory variables. However, this, under a presence of fixed effects, cannot be estimated consistently by OLS. Hence we employ procedure proposed by Arellano and Bond (1991), where they derived a consistent generalized method of moments estimator. One may also argue that the idiosyncratic error suffers from auto-correlation. Therefore, we run the model with a lagged value of individual error terms. Finally, we average observations for 5 years into one observation. For instance, for the growth of TFP we obtain average 5 years growth. It dramatically reduces the number of observations, but the resulting model suppresses the effect of business cycles. Table 5.3 presents the results.

Table 5.3: Sensitivity Analysis I

	Model D	Model E	Model F
L.TFPGrowth	-.067		
	(.06)		
Uegen (5years)	.868***	.596***	.409*
	(.181)	(.156)	(.202)
ValueAddedFinGrowth (5years)	.243***	.218***	.149**
	(.032)	(.033)	(.07)
Inflation (5years)	-.092	-.098	-8.7e-03
	(.072)	(.076)	(.105)
IctInvestment (5years)	.08*	.06	.074
	(.044)	(.048)	(.054)
TradeOpenness (5years)	.018	.03*	.033**
	(.015)	(.016)	(.015)
InwardFDIShareGDP (5years)	9.7e+05	1.5e+06*	1.0e+06*
	(7.8e+05)	(8.9e+05)	(5.4e+05)
ValueAddedAg (5years)	.505**	.599**	.546
	(.231)	(.238)	(.382)
GDPPwe (5years)	-.013	-.023	-.059*
	(.026)	(.027)	(0.03)
FemaleEmployment (5years)	-.087	-.069	.036
	(.063)	(.056)	(0.65)
Constant	-7.26**	-5.99***	-8.14**
	(3.37)	(2.05)	(3.62)
Observations	242	262	62
R^2			0.568
Adjusted R^2		0.246	0.493
F		12.2	12.7

Robust standard errors in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01.

First column, denoted as a Model D, represents results when the lagged value of the dependent variable is included. The fact that the lagged value is insignificant leads to rejecting the dynamic model and preferring the static model. The middle column, Model E, shows output from the model where error terms are assumed to follow AR(1) process. What the table fails to show, is a value of modified Bhargava et al. Durbin-Watson statistics, which is 1.67. Unfortunately, no standard statistical software has implemented critical values and to the best of our knowledge, the only published critical values are those in (Bhargava et al., 1982). Furthermore, the authors stated values for circumstances (number of time periods and individuals) which are not comparable with ours. Therefore, we can say nothing about significance of the lagged value of error term, however, comparing the Model E with the Model A, the results do not differ significantly. As a result, we can conclude that there is no significant problem caused from potential auto-correlation. This is likely due to the usage of the clustering method when estimating the Model A. Finally, Model F provides results for 5-years average observations. Note that there are only 62 observations - roughly 20% of the initial data-set. Furthermore, comparing to previous models, this model is able to explain more of the total variation of the TFP growth, as $R^2 = 0.57$. Similarly to Model C, which also captures time effect and eliminates impact of fluctuation, the trade openness is believed to have positive and significant effect. At regard to the generosity of unemployment insurance, the effect remain significant, even though only at a 10% significant level.

To dissipate potential concerns about used variables, we analyze three models which check a robustness of our results against different choice of variables. In particular, we substitute $TFPGrowth$ by $LabProdG$, which is nothing but a growth of GDP per worked hour; and $Uegen$ by the criticized share of GDP spent on unemployment benefits $PubExpUb$. Table 5.4 presents results for three models with no time effect[3]. Along with the Table 5.2, these results show all possible combinations of $TFPGrowth$ and $PubExpUb$ as the dependent variables and $Uegen$ and $LabProdG$ as variables of the main interest on the right-hand side.

As Model G in the Table 5.4 shows, alternative measure of unemployment

[3]Including the time effect causes no important differences in studied variables

Table 5.4: Sensitivity Analysis II

	Model G TFPGrowth	Model H LabProdG	Model I LabProdG
PubExpUb	.916*** (.231)		1.2*** (.284)
ValueAddedFinGrowth	.246*** (.029)	.106** (.038)	.143*** (.031)
Inflation	-7.6e-03 (.075)	-.111 (.077)	6.4e-03 (.096)
IctInvestment	.103** (.036)	.081* (.043)	.106** (.04)
TradeOpenness	.027* (.014)	.02 (.017)	.025 (.016)
InwardFDIShareGDP	1.8e+06** (7.8e+05)	1.5e+06 (8.8e+05)	1.9e+06* (9.2e+05)
ValueAddedAg	.125 (.158)	.365** (.162)	.076 (.212)
GDPPwe	-.041 (.026)	-.059* (.03)	-.074** (.032)
FemaleEmployment	5.8e-03 (.044)	-.016 (.05)	.09** (.039)
Uegen		.606** (.235)	
Constant	-4.31 (2.49)	-5.28* (2.83)	-6.24** (2.44)
Observations	279	279	279
R^2	0.353	0.214	0.245
Adjusted R^2	0.331	0.188	0.220
F	52.6	10.9	26.5

Robust standard errors in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01.

generosity barely affect our the results; all significant variables from Model A remain significant and moreover, trade openness reaches a 10% significant level; also the R^2 remains unchanged. Comparing to previous models, a change of the dependent variable causes a fall of R^2; otherwise the results are similar. Finally, when both $Uegen$ and $TFPGrowth$ are substituted the positive effect generosity of unemployment insurance on the productivity growth is still present. Overall, the obtained results bring additional pieces of evidence in favor of our hypothesis; more generous unemployment insurance have a positive impact on the productivity growth.

Overall, the empirical study shows that in the developed countries more generous unemployment insurance have a positive effect on productivity. In particular, it seems that more generous unemployment insurance by 1 point in the index results in a roughly 0.5% productivity gain. This conclusion appears to be robust against different specifications. Note that it does not necessary imply higher economic growth as more generous unemployment insurance is likely to cause higher unemployment rate which may outweigh the positive productivity gain.

Chapter 6

Conclusion

This thesis devotes to a problem of the optimal level of the generosity of unemployment insurance and the effect on economic growth rate. In particular, we state and analyze three hypotheses about implications of unemployment benefits in countries with different level of development: (i) more generous unemployment insurance harm the economic growth in developing countries; (ii) the effect of unemployment insurance on economic growth in developed countries is neutral or slightly positive; and (iii) the effect of unemployment insurance on economic growth is non-linear and depends on level of development. The hypotheses are studied from both theoretical and empirical points of view.

The theoretical part combines two strands of literature, on the one hand, it follows a broad research on endogenous growth model (Schumpeterian growth model) and, on the other hand, it significantly extends studies on potential positive impact of unemployment insurance on economic performance. In particular, our theoretical model embodies a mechanism which describes how greater generosity of unemployment insurance results in higher outside option for unemployed workers and thus allows them to wait for a better quality match. The better quality match is, in turn, likely to be associated with a higher productivity of the workers. At the aggregate level, higher productivity leads to higher growth of TFP of the economy.

Unlike most of the scholars (Marimon and Zilibotti (1999), Acemoglu and Shimer (2000)), we study the productivity gain in a framework of endogenous growth model, which allows us to distinguish between developed and developing

economies. Similarly to Vandenbussche et al. (2006) and Aghion et al. (2013) we impose the difference between developed and developing country policy into assumptions about the sources of their growth; while the developing economy benefits from the advantage of backwardness and the developed country growth relies on innovation success. Specifically, we calibrate two representative economies; one corresponds to the developed economy with technology close to the technology frontier; the other one symbolizes a backward economy where the growth depends, in a large scale, on imitation of already well-established technology.

Solving the model brings results that indicate two main conclusions. First, they confirm a stylized fact that the developing countries (e.g., China, India) tend to grow faster than already developed economies. Given a comparable (the same in terms of the ratio to the economy's outcome) unemployment insurance policy, the representative developing country always grows faster than the developed economy. Second, more generous unemployment insurance along with the given development-dependence (optimal) policies seem to be more harmful for the economic growth in the backward countries than in the developed countries. Unlike the recent literature (e.g., Acemoglu and Shimer (2000)), our theoretical model fails to reveal evidence that some particular level of unemployment benefits may have a positive impact on the economic growth. However, a low level of unemployment insurance in the developed economy caused nearly negligible loss of cumulative growth, which may be caused by the specification of the model or particular calibration values. Therefore, based on our results it is difficult to argue in favor of or against beneficial effect of the (some level of) unemployment insurance on the economic growth in advanced countries. However, in all likelihood the unemployment insurance in the developing country affects the economic growth negatively. These conclusions are relevant to our hypotheses; specifically they support the hypothesis that in the developing country the effect of unemployment benefits is negative, whereas the effect in developed countries is, under appropriately chosen level of unemployment benefits, insignificant.

For the purposes of empirical studies we modify our hypotheses. In particular, due to the unavailability of data concerning the developing countries, the focus is solely on the developed countries environment. Furthermore, to connect our research to recent empirical literature, we study the potential effect of

unemployment insurance on productivity growth while omitting the economic growth. In particular, we extend studies of Van Ours and Vodopivec (2008) and Centeno and Novo (2006) on the potential effect of more generous unemployment insurance on a better quality match in post-unemployment job by shifting the focus on the resulting productivity gain.

We collect a data-set of variables that are thought to affect the TFP growth for 17 developed countries covering period of 20 years and use is to study effect of unemployment insurance generosity on the productivity growth. In addition, instead of the commonly used share of GDP spent on unemployment benefits as a proxy for generosity of unemployment insurance, which have been criticized (Pallage et al., 2013), we employ an index of unemployment insurance generosity created by Scruggs et al. (2014a). The obtained results reveal auspicious conclusion; unemployment insurance generosity is likely to enhance the productivity growth. In particular, an increase in the index by 1 point is expected to cause a faster TFP growth by slightly more than 0.5%. This conclusion is robust against different specifications of models and/or used variables.

With respect to our hypothesis, the empirical exercise finds a solid evidence in favor of the existence of a positive effect of unemployment insurance on the productivity growth. Potential policy implications, however, need to be deduced with a caution. While the productivity gain is growth-enhancing, it is ambiguous whether it can outweigh higher unemployment caused by moral hazard problem associated with the unemployment insurance. Hence, the productivity gain does not necessarily implies higher economic growth, not even in the developed countries, where the productivity is of higher importance. With a respect to the modified hypothesis for empirical part, there is no empirical results toward the developing countries.

All in all, this thesis contributes to literature in two different aspects. First, using the theoretical framework of endogenous growth model, this thesis studies an effect of unemployment benefits on TFP growth in developing countries, which has been a neglected topic as most of the authors focus solely on developed countries. Second, in the empirical part we extend recent studies on effect of unemployment insurance on post-unemployed match and shows that the potential better match positively affects the productivity growth. Furthermore, we manage to provide evidence supporting our hypotheses; the theoreti-

cal model suggests that unemployment insurance is more harmful to economic growth in the developing countries, whereas the effect in the developed countries is either neutral or only slightly negative and thus the effect is necessarily non-linear. Based on the data-set, we find empirical evidence in favor of a positive effect on TFP growth in the developed countries.

Natural extension of this strand of literature is to provide empirical evidence whether productivity gain caused by more generous unemployment insurance outweighs the negative impact of increasing unemployment. Moreover, the potential interaction of unemployment insurance with other institutions remain a neglected question in empirical literature. The question could for example be, whether it is the productivity gain more likely to occur in export oriented or consumption oriented countries; or how the level of development of counties affects the productivity gain. Furthermore, the core of the theoretical model can be relatively easily employed to explain effects of different labor market institutions under different distance to frontier. For instance, allowing workers to participate in more interview rounds i.e., letting the labor market be more flexible is also likely to have an impact conditioned on the level of development. More flexible labor market will possibly lead to better job match.

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Appendix A

Appendix

Problem 3.3 Suppose a firm's problem defined by 3.3. Plugging the constraint into the (gross) profit function leads to new objective function of only one control variable - $x_{t,\nu}$

$$\pi(x_{t,\nu}) = \psi\alpha A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha} - x_{t,\nu}.$$

The first order condition looks as

$$\psi\alpha^2 A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha-1} - 1 = 0.$$

Rearranging leads to

$$\psi\alpha^2 A_{t,\nu}^{1-\alpha} = x_{t,\nu}^{1-\alpha},$$

$$x_{t,\nu} = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}.$$

To claim that $\psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}$ is optimal solution, one needs to verify the second order condition

$$\pi_{t,\nu}^{''}(x_{t,\nu}) = (\alpha - 1)\psi\alpha^2 A_{t,\nu}^{1-\alpha} x_{t,\nu}^{\alpha-2}$$

The objective function is concave as long as $(\alpha - 1)\psi\alpha^2 < 0$, which is assumed as $\psi > 0$ and $0 < \alpha < 1$. Having the policy function of the problem, one can calculate the value function π^*

$$\pi_{t,\nu}^* = p(x_{t,\nu}^*)x_{t,\nu}^* - x_{t,\nu}^* = x_{t,\nu}^*(p(x_{t,\nu}^*) - 1),$$

$$\pi_{t,\nu}^* = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}(\psi\alpha A_{t,\nu}^{1-\alpha}(\psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu})^{\alpha-1} - 1),$$

$$\pi_{t,\nu}^* = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu}(\alpha^{\frac{\alpha-1}{1-\alpha}} - 1),$$

$$\pi^*_{t,\nu} = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} A_{t,\nu} (\frac{1-\alpha}{\alpha}),$$
$$\pi^*_{t,\nu} = \psi^{\frac{1}{1-\alpha}} \alpha^{\frac{1+\alpha}{1-\alpha}} A_{t,\nu} (1-\alpha).$$

Definition of T-ratio from Table 4.1 The presented *t-ratio* measures a significance of the difference between means of two random variables. Under the null hypothesis, both series have the same mean, and thus the difference between them equals to zero. From the standard definition of the *t-ratio*

$$t - ratio = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}},$$

where n_x and n_y stand for number of observations and s_x^2 and s_y^2 are sample variances. Mathematically, for $i \in \{x, y\}$

$$s_i^2 = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} (I_j - \bar{I})^2.$$

In our case, both n_x, n_y equal 20 and one of the series is always the 20 simulations of the economy with no unemployment insurance. Rejecting the null hypothesis follows standard rules and critical values.

	—- Coefficients —-			
	(b) fixed	(B) random	$(b-B)$ Difference	$sqrt(diag(V_b - V_B))$ S.E.
Uegen	5837574	-.0433345	.6270919	.115156
ValueAddedFinGrowth	.2170376	.2104976	.0065399	.
Inflation	-.0893044	-.1051543	.01585	.020571
IctInvestment	.0825005	.0805764	.001924	.0286342
TradeOppeness	.0232069	.0093943	.0138126	.012251
InwardFDIShareGDP	1513899	-283719.3	1797619	377692.3
ValueAddedAg	.3415296	-.0735461	.4150756	.176499
GDPPwe	-.0263281	-.0356317	.0093036	.0149806
FemaleEmployment	-.0870769	-.019261	-.0678159	.0369919

b = consistent under Ho and Ha; obtained from xtreg

B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: H_0: difference in coefficients not systematic

$\chi^2(1) = (b-B)'[(V_b - V_B)^{-1}](b-B) = 22.65$

$Prob > \chi^2 = 0.0000$

Table A.1: Hausman Test

Variable	Description	Source
$Uegen$	Index of Unemployment Generosity	CWED 2
$TFPGrowth$	Growth of (Multifactoral) Total Factor Productivity	OECD
$GDPPwe$	GDP per Worked Hours	OECD
$GDPPCReal$	Real GDP *per capita* (Constant 2005 USD)	World Bank
$TradeOpenness$	Sum of Import and Export over GDP	World Bank
$FemaleEmployment$	Employment Rates: Women	OECD
$Inflation$	Inflation	World Bank
$InwardFDIShareGdp$	Inward FDI Stock (USD) Divided by Nominal GDP	OECD & Own Calculation
$ValueAddedAg$	Value Added in Agriculture, Forestry, and Fishing Contribution to VA Growth (percentage)	OECD
$GDPNominal$	Nominal GDP (USD)	World Bank
$IctInvestment$	Investment into IT, Communication, and Software (Percentage of all Investment)	OECD
$ValueAddedFinGr$	Value Added in Financial Sector Growth (Change) of Contribution to VA Growth (Percentage)	OECD
$Distance$	Ratio of $GDPPwe$ and $GDPPwe$ of USA	Own Calculations
$Infrastructure$	Percentage of GDP spent on Infrastructure	World Bank
$PubExpUb$	Share of GDP Spent on Unemployment Benefits	OECD
$PubExpUbDistance$	Product of $PubExpUb$ and $Distance$	Own Calculation
$LabProdG$	Labor productivity growth (growth of $GDPPwe$)	OECD

Table A.3: Dataset