# ESSAYS IN APPLIED MACROECONOMICS

by
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Submitted to the Institute of Social Sciences
in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

Sabancı University
June 2016

ESSAYS IN APPLIED MACROECONOMICS

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DATE OF APPROVAL: 27.06.2016

**ABSTRACT**

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Ph.D. Dissertation, June 2016

Supervisor: Asst. Prof. Remzi Kaygusuz

*Keywords:* Cross-country income differences, labor mobility, residual wage inequality, heterogeneous firms, frictional markets

This dissertation consists of two chapters each of which investigates different questions in quantitative macroeconomics. In the first chapter, I scrutinize the regional (EU including Turkey) and locational economic implications of removing barriers to labor mobility between Turkey and the EU. I use the growth model with endogenous labor movements developed in Klein and Ventura (2009). I set model parameters so that the model economy is consistent with EU and Turkish economies in 2010. Findings show that removing barriers to labor mobility, fully and partially, generates regional output growth in the long-run at range 6.2%-8% while growth in regional capital is between 6%-8%. Besides, welfare gains for young natives in Turkey are at range 1.06%-2.04%. Yet, young natives in the EU are exposed to welfare losses which changes between 0.08% and 0.13%. In the second chapter, I explore the quantitative role of financial development in the rise of residual wage inequality in the US. I built an incomplete-markets model in which homogenous workers work in firms possessing heterogeneous investment efficiency. Labor and financial markets are frictional. Financial development means an increase in firms' capacity to borrow. I set model parameters so that the benchmark economy -that is pre-financial development economy- is consistent with the US economy in between 1974Q1-1979Q4. Findings show that variance of wages increase by 2.8% after financial development. However, variance of log-wages decreases by 8.6% suggesting that there is a large increase in average wage as a result of overall improvement in the economy after financial development.

# ÖZET

## UYGULAMALI MAKROEKONOMİ ALANINDA MAKALELER

EMİNE ZEREN TAŞPINAR

Doktora Tezi, Haziran 2016

Tez Danışmanı: Yrd. Doç. Dr. Remzi Kaygusuz

*Anahtar Kelimeler*: Ülkelerarası gelir farkları, işgücü hareketliliği, gözlemlenebilir benzer özelliklere sahip çalışanlar arasındaki ücret eşitsizliği, heterojen firmalar, sürtünmeli piyasalar

Bu tez farklı kantitatif makroekonomik soruları inceleyen iki bölümden oluşmaktadır. İlk bölümde Türkiye–AB arasında işgücü hareketliliğini kısıtlayan maliyetlerin kaldırılmasının, bölgesel (Türkiye'yi kapsayan AB) ve yerel ölçekte, ekonomik etkileri araştırılmaktadır. Klein ve Ventura (2009)'da geliştirilmiş olan, işgücü hareketlerinin endojen olduğu bir büyüme modeli kullanılmaktadır. Model parametreleri, modeli 2010 yılı Türkiye ve AB ekonomileriyle tutarlı yapacak şekilde seçilmiştir. İşgücü hareketliliğini kısıtlayan maliyetlerin, tamamen ve kısmen, kaldırılmasıyla yapılan analizlerin sonuçlarına göre uzun dönemde bölgesel üretim %6.2-%8 arasında, bölgesel sermaye ise %6-%8 arasında artmaktadır. Türkiye doğumlu genç neslin refah artışı %1.06 ve %2.04 arasında değişirken, AB doğumlu genç nesil refah kaybına uğramaktadır ve bu kayıp %0.08-%0.13 arasında değişmektedir. İkinci bölümde, finansal piyasalardaki gelişmenin, ABD'de gözlemlenebilir benzer özelliklere sahip (homojen) çalışanlar arasındaki ücret eşitsizliği artışında oynadığı rol araştırılmaktadır. Bu amaçla, homojen çalışanların yatırım yapma kabiliyetlerine göre farklılaşan (heterojen) firmalarda çalıştığı eksik piyasa modeli geliştirilmiştir. Model ekonomisinde işgücü ve finansal piyasalar sürtünmelidir. Finansal piyasalardaki gelişme, sürtünmenin azalması ve firmaların daha çok borçlanabilmesi anlamına gelmektedir. Finansal piyasalardaki gelişme öncesi ekonomiyi temsil eden referans ekonominin parametleri, model ekonominin 1974Ç1-1979Ç4 arası ABD ekonomisiyle tutarlı olmasını sağlayacak şekilde seçilmiştir. Finansal piyasalarda firmaların borçlanma kısıtının azaltılmasıyla yapılan alıştırmanın sonuçlarına göre finansal gelişme sonrası ücretlerin varyansı %2.8 artarken ücretlerin logaritmasının varyansı %8.6 azalmaktadır. Bu sonuç finansal piyasalardaki gelişmenin ekonominin bütününü iyileştirmesinden ve ortalama ücretlerde yüksek bir artış olmasından kaynaklanmaktadır.

*Mete'ye...*

**Acknowledgements**

I owe my sincere gratitude to my supervisor Asst. Prof. Remzi Kaygusuz for the constant support of my Ph.D. study and related research, for his patience, and continuous encouragement. His guidance helped me in all stages of my research and writing of this dissertation. He always had time for me to talk about my research and answer my questions whenever I needed it, even I was a visiting Ph.D. student abroad. And thanks to his mind expanding insights and detailed suggestions, each of these appointments were like an elective course in macroeconomics, computational methods and research methods. I am grateful to him for everything he has done for me during my Ph.D. period.

My sincere gratitude also goes to my co-supervisor Asst. Prof. Hakkı Yazıcı for his enlightening comments and striking suggestions in developing my main research question and for his hard questions which made me think my research in a wider perspective and improve it. I am very thankful to him for always being ready to talk about my research, his patience in answering my questions and continuous support and encouragement.

Besides my supervisors, I would like to thank to my jury members Asst. Prof. İnci Gümüş, Asst. Prof. Şerif Aziz Şimşir, Assoc. Prof. Ozan Bakış and Asst. Prof. Sadettin Haluk Çitçi for their time and effort of reviewing my dissertation and their insightful comments and suggestions improving my research.

I would like to express my special thanks to Assoc. Prof. Thijs van Rens for accepting me to supervise as a visiting Ph.D. student in the University of Warwick for six months. During this period he met me almost every week, gave insightful comments about my research and helped me to fill the gap I have in search and matching literature. I am very thankful to him for his time and effort of guiding me with patience during my visiting period.

I am indebted to Asst. Prof. Esra Durceylan Kaygusuz for allowing me to access her supersonic computer for four years and helping me in all computer-based issues without any complain. I also thank the members of the Faculty of Arts and Social Sciences at Sabanci University who kindly shared their knowledge and experience with me.

I would also like to thank TÜBİTAK BİDEB for providing me financial support during my six months visiting period in the University of Warwick.

I would like to thank my dear friend Gül Demirtaş, for her invaluable friendship and support from the first day of my Ph.D. to the last, even after she moved to abroad. Without her companionship it would be more difficult to overcome the difficulties I faced during this period, particularly in the first years of my Ph.D. I would also like to thank my office mates at FASS 2039, for their company and support throughout this process.

Finally, I would like to thank my parents and brother for the love, care and support they provided me throughout my life and to my husband for his unconditional support and everlasting patience. I am deeply grateful to him for the energy, motivation and peace of mind he gave me during this period.

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# CHAPTER 1

# ECONOMIC IMPLICATIONS OF LABOR MARKET INTEGRATION BETWEEN THE EU AND TURKEY

## 1.1 Introduction

An eventual accession of Turkey to the European Union (EU) has a wide range of economic implications for both locations and for the region, that is EU including Turkey. In this paper, I focus only on one of the major economic changes expected after Turkey's membership to the EU: labor market integration.[1] So, the aim of this study is to explore the long run and transitional economic outcomes of counterfactually removing barriers to labor mobility leading to a free movement of workers in the region and assess quantitatively possible changes in population, output, capital and welfare.[2]

After a probable labor market integration including Turkey and the EU, workers might choose to migrate because of the income differential across these locations. In the presence of labor mobility costs, total factor productivity (TFP) disparity and labor quality differences between Turkey and the EU potentially lead to this income differential so that the per capita incomes are higher in the EU compared to Turkey. This gap creates an incentive for Turkish residents to migrate to the EU and they start to migrate with the removal of barriers to labor mobility. The quantitative implications of this labor movement on output and welfare are unknown.[3] This

[1] It is important to note that labor market integration may happen not only as a result of EU membership but any kind of engagement removing barriers to labor mobility between Turkey and the EU may also create an integrated labor market.

[2] A full evaluation of Turkey's accession to the EU in terms of economic implications is out of this paper's scope. So, economic implications of accession to the internal market affecting trade, foreign direct investments and domestic investments in Turkey; institutional reforms affecting Turkey's competitiveness in the world economy or financial transfers are not considered in this paper.

[3] Previously, Lejour and Mooij (2005), Aydın and Acar (2010), and Özgüzer and Pensieroso

paper fill this gap by quantitatively exploiting the growth model with endogenous labor movements developed in Klein and Ventura (2009).[4]

Klein and Ventura (2009) asserts that barriers to labor movement in the presence of TFP differences cause labor misallocation across locations. The mechanism behind this outcome is as follows: i) barriers that limit labor mobility between locations having different total factor productivities cause a differential in marginal labor productivities across these locations; ii) this differential motivates workers to move from low to high productivity locations; iii) labor mobility costs across these locations limit the movement and lead to labor misallocation. Accordingly, one might expect that lifting labor mobility frictions improves labor allocation across these locations, so leads to a rise in the regional output. Moreover, frictionless movement of capital across locations magnify regional gains from removal of labor mobility costs. It is because in this case marginal product of labor is higher compared to the case where capital movement is limited.

As in Klein and Ventura (2009), model consists of two locations with different TFP levels each of which has access to the same production function. One single dated good is produced by using a constant returns to scale production function with three factors; capital, labor and land. Capital is perfectly mobile across locations and individuals are free to buy and sell land in both locations. Yet, labor is imperfectly mobile. The economy is composed of workers who live for a finite number of periods. They are heterogenous regarding their birth location, age, and utility cost of living in a location different than their birth location. Workers' skill levels differ by their age and birth locations. In each period, workers decide how much to consume, how many units of land to purchase and how much to save, as well as whether and when to move. If a worker chooses to move they are subject to three types of movement cost; utility cost of living in a location other than his birth location, one time resource cost of moving and skill loss for migrants. Finally, workers are not

(2013) explore implications of labor mobility after an eventual Turkish accession to the EU using a general equilibrium setup. However, in none of them migration decision is modeled as a choice variable of a worker. Yet, in the current paper movement decision is taken by a worker. Moreover, skill differential between Turkey and the EU is not considered in the aforementioned papers. Only Lejour and Mooij (2005), evaluates Turkish membership under two cases in order to take into account the skill differential across locations: in the first case they assume that Turkish immigrants and the EU have the same skill distribution and in the second case they assume that Turkish immigrants are composed of only low skilled workers while in the EU there are both low and high skilled workers. In the current paper, the considered skill differential between Turkey and the EU is in line with the educational attainment data in both locations. Besides, the model in the current paper take into account various movement costs and this makes model's assessments about migration outcomes more accurate. Finally, this paper scrutinize transitional implications of migration in addition to its steady state results while the previous general equilibrium analyses examine only the long-run outcomes of migration.

[4] The current paper is a quantitative application of the model provided in Klein and Ventura (2009).

allowed to move in debt or by borrowing.

The model is parameterized to evaluate the outcomes of any kind of engagement mitigating labor mobility costs between Turkey and the EU.[5] Because of data availability I calibrate my benchmark economy to EU and Turkish economies in 2010. The counterfactual analysis I made is removing, partially and fully, the resource cost of moving. Each of these cases are explored for conditions with and without skill loss associated to migration. In the long-run, for the highest value of resource cost of moving and in the presence of skill loss, 76% of the Turkish population migrates to the EU. This leads to an increase in regional capital by 6% and an increase in regional output by 6.2%. On the other hand, when the resource moving cost is fully removed and there is no skill loss 99% of the Turkish population moves to the EU generating 8% of increase in both regional capital and output.

Moreover, I examine transitional welfare implications of labor market integration driven by partial removal of resource moving cost in the presence of a skill loss for economies with high and low utility costs of moving. Since wages and land prices change over time and across locations by migration, its welfare implications differentiate regarding generations and nationalities. Welfare gain of young natives in Turkey is 1.06% in an economy with high utility costs while it is 2.04% in an economy with low utility costs. Meanwhile, young natives in the EU are exposed to welfare losses which are 0.08% and 0.13%, respectively.

**Related Literature**

The current paper is related to the literature that study economic implications of Turkish accession to the EU. Most of the previous studies examining economic outcomes of Turkey's membership to the EU also focus on migration. However, the majority of these studies' interest is on the calculation of potential Turkish immigrants' volume. These studies can be classified in two groups: the first group forecast the volume after estimating a model of migration (Flam (2003), Togan (2004), Erzan et al. (2006)) and the second group use a survey to report the potential volume of immigrants (Krieger and Maitre (2007)).

On the other hand, there are general equilibrium models that scrutinize economic

[5] In this paper, EU is the European Economic Area before the enlargement in 2004. The European Economic Area consists of the European Union, Iceland, Liechtenstein and Norway. I limit myself to the European Economic Area before 2004 because I assume that in any case in which such an engagement comes into force, residents of Turkey who want to migrate move to the old EU member countries. This assumption is consistent with the past immigration data of Turkish residents. They choose to move to Germany in the first place. According to OECD migration data, in between 1985-2011 per year average share of Turkish residents in Germany is 81%. Having 6% of Turkish migrants for the same period, Netherlands is the second country chosen by Turkish residents to migrate. Hosting 3% of Turkish migrants by each, Austria and Belgium are the subsequent most preferred locations to move. Thus, historically more than 90% of Turkish migrants choose to move to old EU countries.

effects of Turkish accession to the EU. Lejour and Mooij (2005) uses WorldScan model and evaluate economic implications of Turkey's membership to the EU in three aspects: accession to the internal European market, institutional reforms in Turkey triggered by EU membership leading to an improvement in competitive position of Turkey, and migration.[6] Aydın and Acar (2010) assesses outcomes of three changes that occur by Turkey's EU membership: free movement of labor, capital and, with a particular focus, a reduction in $CO_2$ emissions, by using Global Trade Analysis Project (GTAP) model.[7] The most recent work on this subject is by Özgüzer and Pensieroso (2013) where they analyze the implications of Turkey's accession to the EU by exploring the effect of financial transfers from the EU to Turkey on Europeans' welfare. They consider change in labor mobility cost only in the context of its impact on welfare implications of financial transfers.

The rest of the paper is organized as follows. Section 1.2 presents the model. Section 1.3 describes the parameterization of the benchmark economy. Section 1.4 explores, respectively, steady-state, transitional and welfare outcomes of the model. Section 1.5 concludes.

## 1.2 The Model

### 1.2.1 Environment

I use the model economy developed in Klein and Ventura (2009).[8] It is a discrete time economy and consists of two locations ($x$), rich ($x = R$) and poor ($x = P$). In each location there is a representative firm with different productivity levels. However, firms use the same production technology with three inputs: capital, labor and land. Land is fixed in each location.

Economy is composed of a continuum of workers of total measure one. In each period $t$, the population in location $R$ is denoted by $N_R(t)$ while it is $N_P(t)$ in location $P$, and the total population in the economy is given by $N_R(t) + N_P(t) = 1$. Workers are born at the beginning of each period and live for $J$ periods. Workers who die are replaced with the same amount of newborns keeping economy's population

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[6] WorldScan model is a computational general equilibrium model based on neoclassical theories of growth and international trade. It is a multi-country and multi-sector model with CES production function.

[7] GTAP is a multi-region, multi-sector computational general equilibrium model with perfect competition and constant returns to scale production function.

[8] I mostly stick to their notation.

stationary.

Workers are heterogenous with respect to their birth location, $y \in \{R, P\}$ and age, $j$. Each worker is endowed with an efficiency units of labor which depends on his age and birth place, $e(j, y)$. This implies that workers' skill levels are differentiated with respect to their age and birth location. In each period $t$, a worker decides how much to consume, $c(j)$, save in capital, $k(j)$, and/or land, $f(j, x)$ as well as whether and when to move, $\varphi(j)$. The worker who chooses to move from his birth location $(y)$ to the other location $(x \in \{R, P\})$, which will be his current location, incurs three types of moving cost. First, he has to pay a fixed cost which is common to all who wants to move. It is a resource cost of moving, $m$. Second, he is subject to a utility cost of living away from his birth location which is specific to a worker. It is psychic moving cost, $\gamma$. The type of worker regarding this cost, which is noted by $i$, is drawn from a distribution function $\alpha(i)$ at his birth and does not change as he gets older. Third, a worker who moves looses a proportion, $\theta$, of his efficiency units of labor, $e(j, y)$. This is called skill cost of moving. $\theta$ is the same for all workers who choose to move. In addition, workers cannot move with debt.

In the model economy capital freely moves within and between two locations equating capital's rate of returns across locations, $r^k(x, t) = r(t)$. As another tool for saving, a worker from one location can buy and sell land in each location at price $p(x, t)$. There is no arbitrage between capital and land.

Although labor mobility across locations is costly, labor market is perfectly competitive in each location. Thus, the wage rate in each location at time $t$ is $w(x, t)$. If a worker has not moved from his birth location, i.e. $x = y$, then his income at period $t$ is $w(x, t)\, e(j, x)$; but if his current location is different from his birth location, i.e. $x \neq y$, then his income is $w(x, t)(1 - \theta)\, e(j, y)$ because of skill loss incurred after migration. Retirement is not considered in the model, so workers earn wage till they die.

### 1.2.2 Worker's Problem

The objective of worker $i$ who is born at time $t$ in location $y$ is to maximize

$$\sum_{j=1}^{J} \beta^{j-1} \left[ U(c(j)) - \gamma(i)\, \chi_{\{x(j) \neq y\}} \right]$$

where $x(j)$ is the current location of the worker at age $j$, and $\chi$ is the indicator function. The function $U(.)$ is continuous, strictly increasing and strictly concave.

The budget constraint of worker $i$, at age $j$ and who has not moved in the past, i.e. $x = y$, is given by

$$\begin{aligned} & c(j) + k(j+1) + \sum_{x \in \{R,P\}} p(x,t) f(j+1,x) + \varphi(j) m \\ = \;& (1 + r(t)) k(j) + \sum_{x \in \{R,P\}} (p(x,t) + R(x,t)) f(j,x) + w(x,t) e(j,y) \end{aligned}$$

where $r(t), p(x,t)$ and $R(x,t)$ are, respectively, return on capital, price of land and return on land in period $t$, in location $x$. Worker chooses $c(j), k(j+1), f(j+1,x)$ for each $j \in [1, J]$ and decides whether to move or not. If he chooses to move at age $j$ then $\varphi(j) = 1$, otherwise it is equal to 0.

On the other hand, the budget constraint of worker $i$, at age $j$ and who has already moved prior age $j$, i.e. $x \neq y$, is given by

$$\begin{aligned} & c(j) + k(j+1) + \sum_{x \in \{R,P\}} p(x,t) f(j+1,x) \\ = \;& (1 + r(t)) k(j) + \sum_{x \in \{R,P\}} (p(x,t) + R(x,t)) f(j,x) + w(x,t)(1-\theta) e(j,y) \end{aligned}$$

Notice that the difference in formulation of two budget constraints stems from moving costs. The worker who has migrated has already incurred to the resource cost of moving and since it is paid for once it does not appear in the budget constraint of immigrant worker. However, because immigrant worker's skill loss is permanent, his income loss due to migration is also permanent. In every period, immigrant worker also chooses $c(j), k(j+1)$ and $f(j+1,x)$.

A worker can save both in capital and land but arbitrage is not possible between them. The no arbitrage condition is given by

$$1 + r(t) = \frac{R(x,t) + p(x,t)}{p(x,t-1)} \text{ for } x \in \{R, P\}$$

By iterating forward the no arbitrage condition, we obtain price of land in location $x \in \{R, P\}$, at period $t$.

$$p(x,t) = \sum_{s=1}^{\infty} \frac{R(x,t+s)}{\Pi_{i=1}^{s} (1 + r(t+i))}$$

Using the no arbitrage condition, if we plug-in the term $(1 + r(t)) p(x, t-1)$ to the budget constraints in place of the term $R(x,t) + p(x,t)$, the budget constraint of the non-immigrant becomes

$$\begin{aligned} & c\left(j\right)+k\left(j+1\right)+\sum_{x\in\{R,P\}}p\left(x,t\right)f\left(j+1,x\right)+\varphi\left(j\right)m \\ = & \left(1+r\left(t\right)\right)\left(k\left(j\right)+\sum_{x\in\{R,P\}}p\left(x,t-1\right)f\left(j,x\right)\right)+w\left(x,t\right)e\left(j,y\right) \end{aligned}$$

while that of the immigrant is given by

$$\begin{aligned} & c\left(j\right)+k\left(j+1\right)+\sum_{x\in\{R,P\}}p\left(x,t\right)f\left(j+1,x\right) \\ = & \left(1+r\left(t\right)\right)\left(k\left(j\right)+\sum_{x\in\{R,P\}}p\left(x,t-1\right)f\left(j,x\right)\right)+w\left(x,t\right)\left(1-\theta\right)e\left(j,y\right) \end{aligned}$$

Moreover, since capital and land are the same asset in equilibrium, a unique asset definition for the current period can be made as follows, $a\left(j\right)\equiv k\left(j\right)+\sum_{x\in\{R,P\}}p\left(x,t-1\right)f\left(j,x\right)$. Then budget constraints of the non-immigrant and the immigrant worker can be, respectively, written as follows

$$c\left(j\right)+a\left(j+1\right)+\varphi\left(j\right)m=\left(1+r\left(t\right)\right)a\left(j\right)+w\left(x,t\right)e\left(j,y\right)$$

$$c\left(j\right)+a\left(j+1\right)=\left(1+r\left(t\right)\right)a\left(j\right)+w\left(x,t\right)\left(1-\theta\right)e\left(j,y\right)$$

By solving the problem described above the agent decides how much to consume, $c\left(j\right)$, how much to save, $a\left(j+1\right)$ and, whether and when to move, $\varphi\left(j\right)$.

Now we are ready to define the problem in a recursive way. Note that in each date, $t$, the state of a worker is given by his current asset level $a$, his psychic cost type $i$, his age $j$, his current location $x$, and his birthplace $y$. Then the choice variables of the agent are $c\left(a,i,j,x,y,t\right)$, $a'\left(a,i,j,x,y,t\right)$ and $\varphi\left(a,i,j,x,y,t\right)$ which will be written as $c,a'$ and $\varphi$ hereafter for notational simplicity. Note that $-x$ is used in order to define the other location so that $-R=P$ and vice versa.

As mentioned before, there are two cases according to which the problem definition differs: in the first case the worker has already moved in the past $(x\neq y)$ and no future migration is allowed by assumption; in the second case the worker lives in his birthplace $(x=y)$ and the migration is still a possible option.

Case 1: $x\neq y$

$$v\left(a,i,j,x,-x,t\right)=\max_{c,a'}\left\{U\left(c\right)-\gamma\left(i\right)+\beta v\left(a',i,j+1,x,-x,t+1\right)\right\} \qquad (1)$$

subject to

$$c + a' \leq (1 + r(t))\, a + w(x,t)(1-\theta)\, e(j,y)$$

$$a' \geq 0, \text{ for } j = J$$

$$v(a, i, J+1, x, y, t) \equiv 0$$

Case 2: $x = y$

$$\begin{aligned} v(a,i,j,x,x,t) &= \max_{c,a',\varphi} \{U(c) + \beta [\varphi v(a', i, j+1, -x, x, t+1) \\ &\quad + (1-\varphi)\, v(a', i, j+1, x, x, t+1)]\} \end{aligned} \tag{2}$$

subject to

$$\varphi = \begin{cases} 1 \text{ if agent chooses to move} \\ 0 \text{ if agent chooses to stay} \end{cases}$$

$$c + a' + \varphi m \leq (1 + r(t))\, a + w(x,t)\, e(j,y)$$

$$\varphi a' \geq 0$$

$$a' \geq 0 \text{ for } j = J$$

$$v(a, i, J+1, -x, x, t) \equiv 0$$

$$v(a, i, J+1, x, x, t) \equiv 0$$

Note that there are two different limitations on asset holdings. Constraint, $a' \geq 0$ for $j = J$, prevents a worker, either immigrant or non-immigrant, from borrowing in the last period of his life while $\varphi a' \geq 0$ deters the movement of a worker with debt when he chooses to move.

### 1.2.3 Firm's Problem

There is one representative firm in each location producing the same single dated good. Each firm produces by Cobb-Douglas production technology using capital, $K(x,t)$, labor, $L(x,t)$ and land, $F(x)$ which is given by

$$Y(x,t) = G(K(x,t), L(x,t), F(x); A(x)) = A(x)\, K^{\lambda}(x,t)\, L^{\eta}(x,t)\, F^{1-\lambda-\eta}(x)$$

Land is fixed in each location generating decreasing returns for each inputs. Firms' productivity levels, $A(x)$, differ with respect to their location but constant across time. The objective of each firm is to maximize its profit which is given by

$$G\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x\right)\right)-\widetilde{r}\left(x,t\right)K\left(x,t\right)-w\left(x,t\right)L\left(x,t\right)-R\left(x,t\right)F\left(x\right)$$

and choose $K\left(x,t\right), L\left(x,t\right)$ and $F\left(x\right)$.

Equilibrium conditions obtained from firm's problem provide market prices which are provided below

$$\widetilde{r}\left(x,t\right)=G_1\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x\right)\right)$$

Since $r^k\left(x,t\right)=\widetilde{r}\left(x,t\right)-\delta$, then

$$r^k\left(x,t\right)=G_1\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x\right)\right)-\delta$$

$$w\left(x,t\right)=G_2\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x\right)\right)$$
$$R\left(x,t\right)=G_3\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x\right)\right)$$

### 1.2.4 Aggregation

Let $\psi\left(B,I,j,x,y,t\right)$ be the mass of people with asset position $a\in B$, type $i\in I$, age $j$, working in location $x$ in period $t$, and born in location $y$. The function $\psi$ is defined for all $B\subset\mathbb{R}$, all $I\subset\mathcal{I}$, all $j\in\mathcal{J}$ where $\mathcal{J}=\{1,2,...,J\}$ and all $x$ and $y$ in $\{R,P\}$. Except newborn workers, i.e. workers with $j=1$, distribution of workers is consistent with workers' decisions (provided in section 1.2.5). Mass of newborns is set exogenously and given by

$$\psi\left(B,I,1,x,y,t\right)=\begin{cases}\frac{N_x(t)}{J}\int_{\mathcal{I}}\alpha\left(i\right)di & \text{if } 0\in B \text{ and } x=y\\ 0 & \text{otherwise}\end{cases}$$

There are two things to note about newborns; they are born with zero assets and their current location is their birth location.

Given the distribution of workers at each state, the aggregate labor supply in location $x\in\{R,P\}$ is provided below:

$$L^S\left(x,t\right)=\sum_{j=1}^{J}\int_{\mathbb{R}\times\mathcal{I}}e\left(j,x\right)d\psi\left(a,i;j,x,x,t\right)+\sum_{j=1}^{J}\int_{\mathbb{R}\times\mathcal{I}}\left(1-\theta\right)e\left(j,-x\right)d\psi\left(a,i;j,x,-x,t\right)$$

Notice that, in each location aggregate labor supply is composed of workforce whose birth location and current location are the same (the first term of RHS) and who has migrated from other location (the second term of RHS).

Similarly, the aggregate asset supply in the economy is given by

$$A^S(t) = \sum_{x\in\{R,P\}} \left\{ \sum_{j=1}^{J} \int_{\mathbb{R}\times\mathcal{I}} a d\psi(a,i;j,x,x,t) + \sum_{j=1}^{J} \int_{\mathbb{R}\times\mathcal{I}} a d\psi(a,i;j,x,-x,t) \right\}$$

### 1.2.5 Equilibrium

An equilibrium consists of a sequence of value functions $v(a,i,j,x,y,t)$, optimal decision rules $a'(a,i,j,x,y,t)$, $c(a,i,j,x,y,t)$ and $\varphi(a,i,j,x,y,t)$, aggregate variables $K(x,t)$, $L(x,t)$ and $F(x)$ a measure $\psi(a,i,j,x,y,t)$ for workers and prices $r^k(x,t)$, $w(x,t)$, and $p(x,t)$ such that

i. Given prices $r^k(x,t)$, $w(x,t)$, $p(x,t)$ and mass of workers $\psi(a,i,j,x,y,t)$, the optimal decision rules $a'(a,i,j,x,y,t)$, $c(a,i,j,x,y,t)$ and $\varphi(a,i,j,x,y,t)$ solve the workers' dynamic problems given by equations (1) and (2) and $v(a,i,j,x,y,t)$ are resulting value functions.

ii. Given prices $r^k(x,t)$, $w(x,t)$, and $p(x,t)$, $K(x,t)$, $L(x,t)$, and $F(x)$ solve the firm's problem.

iii. There are no arbitrage opportunities. This implies that all assets earn a common rate of return $r(t)$, specifically

$$r(t) = r^k(x,t)$$

and

$$1 + r(t) = \frac{R(x,t) + p(x,t)}{p(x,t-1)}$$

for all $x = \{R, P\}$.

iv. Market clearance

*Labor market clearance*

$$L^S(x,t) = L(x,t)$$

for all $x = \{R, P\}$.

*Asset market clearance*

$$A(t) = \sum_{x\in\{R,P\}} K(x,t) + \sum_{x\in\{R,P\}} p(x,t-1) F(x)$$

v. Aggregate resource constraint holds:

$$\begin{aligned}
&\sum_{x\in\{R,P\}} G\left(K\left(x,t\right),L\left(x,t\right),F\left(x\right);A\left(x,t\right)\right)+\left(1-\delta\right)K\left(t\right)\\
=\;&\sum_{x\in\{R,P\}}\left\{\sum_{j=1}^{J}\int_{\mathbb{R}\times\mathcal{I}} c\left(a,i;j,x,x,t\right)d\psi\left(a,i;j,x,x,t\right)\right.\\
&\left.+\sum_{j=1}^{J}\int_{\mathbb{R}\times\mathcal{I}} c\left(a,i;j,x,-x,t\right)d\psi\left(a,i;j,x,-x,t\right)\right\}+K\left(t+1\right)\\
&+\sum_{x\in\{R,P\}}\sum_{j=1}^{J}\int_{\mathbb{R}\times\mathcal{I}}\varphi\left(a,i;j,x,x,t\right)md\psi\left(a,i;j,x,x,t\right)
\end{aligned}$$

vi. Distribution is consistent with workers' decisions:

The mass of population holding asset $a\in B$, of type $i\in I$, at age $j\in\{2,...,J\}$ and who has not migrated yet $(x'=x=y)$ is provided below

$$\begin{aligned}
&\psi\left(B,I,j,x,x,t+1\right)\\
=\;&\int_{\mathbb{R}\times\mathcal{I}}\left(1-\varphi\left(a,i,j-1,x,x,t\right)\right)\chi\left(a'\left(a,i,j-1,x,x,t\right)\in B\right)d\psi\left(a,i,j-1,x,x,t\right)
\end{aligned}$$

where $\chi$ is the indicator function.

The mass of immigrants $(x'=x\neq y=-x)$ holding asset $a\in B$, of type $i\in I$, at age $j\in\{2,...,J\}$ is given by

$$\begin{aligned}
&\psi\left(B,I,j,x,-x,t+1\right)\\
=\;&\int_{\mathbb{R}\times\mathcal{I}}\varphi\left(a,i,j-1,-x,-x,t\right)\chi\left(a'\left(a,i,j-1,-x,-x,t\right)\in B\right)d\psi\left(a,i,j-1,-x,-x,t\right)\\
&+\int_{\mathbb{R}\times\mathcal{I}}\chi\left(a'\left(a,i,j-1,x,-x,t\right)\in B\right)d\psi\left(a,i,j-1,x,-x,t\right)
\end{aligned}$$

Notice that the first part of the summation in the RHS represents the mass, given the state, who chooses to migrate in the current period and the second part describes the mass who has already migrated in previous periods.

## 1.3 Calibration

Since the aim of this study is to evaluate implications of labor market integration between Turkey and EU, the model is calibrated to an economy with these countries. Turkey is the location corresponding to the poor location $(P)$ in the model while EU is the rich location $(R)$. The engagement date is assumed to be 2010 because of data availability.[9]

Parameters are either taken from Klein and Ventura (2009) or calibrated by using their calibration strategy.[10] Table 1 provides the list of parameters used in the current paper. The length of a period in the model economy is 5 years. Workers are assumed to enter the model at age 20 and die at the age of 70 years, so they live for 12 periods implying that $J = 12$.

**Population** As mentioned in Section 1.2.1 the population in the model economy is normalized to 1. Local population shares before migration are calculated using Penn World Tables, version 8.1. They are 0.15 for Turkey and 0.85 for the EU in 2010. Moreover, for each location I assume that population growth is zero suggesting that the population for each age group is equal to $\frac{N_x(t)}{J}$.

**Technology** In both locations production technologies are assumed to be identical. It is a Cobb-Douglas production technology with labor, capital and land. Income shares of these production factors and depreciation rate are taken from Klein and Ventura (2009).[11] As they did, I assume that income shares of each production factor are equal across locations and they are 0.632 for labor, 0.317 for capital and 0.051 for land. Depreciation rate is equal to 0.081. Similarly, land per worker $(F(x)/N(x,t))$ before migration is normalized to 1. I calibrate TFP ratio of EU to Turkey $(A(R)/A(P))$ to match the ratio of output per capita in the EU to output per capita in Turkey $(y_R/y_P)$ which is equal to 2.27 for the benchmark year. The target is calculated using real GDP and population data provided in Penn World Tables, version 8.1. Aggregate output per capita for the EU is calculated by weighting each member country's real GDP per capita ratio with their population shares.

**Preferences** Workers are assumed to have CRRA utility with $\sigma = 2$. $\beta$ is calibrated to match annual $K/Y$ ratio in each location. $K/Y$ ratios are equal in both locations due to the assumption of equal production factor income shares across locations for each factor. The targeted annual $K/Y$ ratio is taken from Klein and Ventura (2009) and it is equal to 2.18.[12]

**Skills** It is assumed that skill distributions across ages (skill-age profile) in both locations are the same, yet skill levels differ. In this regard, efficiency units of labor can be written as $e(j,y) = \widetilde{e}(j)\,h(y), y \in \{R,P\}$. The first term of the

[9]The latest data provided by Barro-Lee on educational attainment, which is used for the calculation of efficiency units of labor, is for 2010.

[10]One of the quantitative exercises in Klein and Ventura (2009) is the enlargement of European Economic Area in 2004 with the participation of Eastern Europe countries.

[11]These parameters are calculated by using the US data and also used for the EU enlargement exercise in Klein and Ventura (2009).

[12]It is calculated by using the US data in Klein and Ventura (2009).

multiplication represents skill-age profile of a worker which is assumed to be the same in both locations. The second term is the average educational attainment in location $y$. For this variable educational attainment data provided in Barro-Lee data set is used. $\widetilde{e}(j)$ is calculated by interpolating skill-age profile provided in Hansen (1993) for six age groups.[13]

**Migration costs** In the benchmark economy the resource moving cost, $m$, is prohibitively high that there is no migration. The efficiency cost of moving, $\theta$, is taken from Klein and Ventura (2009). Two values are used for $\theta$ which are 0 and 0.15, so two benchmark economies calculated.

The benchmark economy is not affected by the distribution of utility cost of moving. However, since it is the same both in the benchmark economy and in the alternative economy where migration is possible, it is useful to mention its calibration in this section. Utility cost of moving is assumed to be drawn exponential distribution with parameter $\rho$. This parameter is calibrated to match the emigration rate in the first 25 years after removal of barriers. Two values of $\rho$ are calibrated, low and high. For the low parameter, which means low cost, the target is 1% per year on average while it is 0.5% per year on average for the high parameter, and it corresponds to high cost. These targets which are used in Klein and Ventura (2009) are set with respect to historical migration data for Europe and North America.

[13]Second order polynomial interpolation is applied.

Table 1: Parameter values

| Parameters | Description | Value | Target | Source/Explanation |
|---|---|---|---|---|
| Population | | | | |
| $N_R$ | Initial population in $R$ | 0.847 | | Penn World Table, version 8.1 |
| $N_P$ | Initial population in $P$ | 0.153 | | Penn World Table, version 8.1 |
| Technology | | | | |
| $\lambda$ | Capital share | 0.317 | | Klein and Ventura (2009) |
| $\eta$ | Labor share | 0.632 | | Klein and Ventura (2009) |
| $1-\lambda-\eta$ | Land share | 0.051 | | Klein and Ventura (2009) |
| $\delta$ | Depreciation rate | 0.081 | | Klein and Ventura (2009) |
| $A(R)/A(P)$ | Productivity ratio | 1.3216 | $y_R/y_P$ | Penn World Table, version 8.1 |
| $F(x)/N(x,t)$ | Land per worker in $x \in \{R,P\}$ | 1 | | Klein and Ventura (2009) |
| Preferences | | | | |
| $1/\sigma$ | Intertemporal substitution | 0.5 | | Klein and Ventura (2009) |
| $\beta$ | Annual discount factor | 0.9735 | $K/Y$ | Klein and Ventura (2009) |
| Skills | | | | |
| $\widetilde{e}(j)$ | Efficiency units by age profile | | | Hansen (1993) |
| $h_R/h_P$ | Educational attainment ratio | 1.56 | | Barro-Lee Dataset (2013) |
| Migration costs | | | | |
| $\rho_{low}$ | Distribution of psychic costs | 4 | per year emigration rate of 1% for the first 25 years | Klein and Ventura (2009) |
| $\rho_{high}$ | Distribution of psychic costs | 1.76 | per year emigration rate of 0.5% for the first 25 years | Klein and Ventura (2009) |
| $\theta$ | Loss in efficiency units | $\{0, 0.15\}$ | | Klein and Ventura (2009) |

## 1.4 Quantitative Analysis

The aim of this paper is to study the quantitative implications of labor market integration between the EU and Turkey. In the current paper's setup labor market integration occurs after either removal or decline of resource cost of moving. For this purpose, in this section, first I study the long-run implications of the decline in resource moving cost on aggregates; then, I explore its transitional implications on aggregates; and finally, I conclude the quantitative analysis by investigating its transitional implications on welfare of natives of both locations.

### 1.4.1 Steady-State Implications on Aggregates

In this section, the long-run effects of removing barriers to labor mobility are investigated. Two steady states are compared. In the benchmark steady state the resource cost of moving is so high that there is no movement between Turkey and the EU. In the second steady state this cost is unexpectedly removed, fully and partially, and migration between these locations becomes possible. Steady state analysis is made for three cases. Cases differentiate regarding values of resource cost of moving, $m$. In the first case $m$ is fully removed, in the second case $m$ is equal to half of the annual per capita output in Turkey, and in the last case it is equal to the annual per capita output in Turkey. For each value of $m$, effects of skill cost on migration is investigated for two levels of skill losses. Table 2 presents results of these exercises for both locations and for the region.

After the change in barriers to labor mobility, a large amount of Turkish population migrates to the EU. For different values of $m$, the population share of EU after migration increases to a range between 96.3% and 99.9% from 84.7%. A mass of migration at this range generates an increase in regional capital and output. The range of regional capital increase is between 6% and 8% whilst it is between 6.2% and 8% for the regional output. These variables rise more for lower values of $m$ suggesting that increase in regional output and capital is higher for larger amounts of migration to the EU.

Likewise, the amount of capital and output in the EU rise after migration. The increase is between 12.4% and 16.5% for capital and 12.6% and 16.5% for output. However, migration generates a decrease in these variables in Turkey. The decreases in capital and output in Turkey are at similar amounts and they change between 73.5% and 98.9%. Although there is a large amount of output decrease for each case, output per worker increases in Turkey at range 11%-43.7%. This finding suggests that population decreases more than output in Turkey and this implication is not surprising due to the production technology with decreasing return to labor. Contrary to a large increase in per capita output in Turkey, the output per worker in the EU decreases. However the loss is small and varies between 1.04% and 1.23%. Besides, in both locations the change in output per worker gets smaller as migration costs increase.

Although TFP disparity and labor quality differences across the EU and Turkey are the main driving forces generating these results, there is also a general equilibrium effect induced by free movement of capital which has an additional contribution to these results. Because of CRS production technology, migration leads to an increase in marginal product of capital but a decrease in that of labor in the EU. The former makes the EU more attractive for capital while the latter reduces the wage gap between locations. However, free movement of capital decelerates the decline in marginal product of labor in the EU and induce a long-lasting migration period compared to the case where there is no free movement of capital. Consequently, free movement of capital amplifies the volume of migration, thus the amount of output change in each location and in the region.

Also notice that when there are no skill losses, levels of change in $m$ have negligible effects on results while their impact differentiate quantitatively in the presence of skill losses. This implies that when there is no skill loss the values of $m$ used in this paper are not so high relative to the initial wage gap across locations, so changes in $m$ values do not affect the volume of migration. However, the presence of a skill loss repress the wage gap across locations and makes the migration decision more sensitive to the change in levels of $m$.

The last thing that I want to mention in this section is that the steady state outcomes of decline in $m$ are independent of utility cost of moving distribution. This is because of the assumption that zero is in the support of this cost's distribution. In the benchmark steady state $m$ is prohibitively high that there is no migration, so the distribution of utility cost has no effect in the benchmark economy. On the other hand, alternative economy is reached after migration and the potential migrants in this economy are only the ones whose utility cost is zero, so similarly the alternative economy is independent of utility cost distribution.

Table 2: Steady state effects

| Economy | Regional Output (% change) | Regional Capital (% change) | Output in EU (% change) | Output in Turkey (% change) | Capital in EU (% change) | Capital in Turkey (% change) | Population in EU | Output per worker in EU (% change) | Output per worker in Turkey (% change) |
|---|---|---|---|---|---|---|---|---|---|
| Case 1: No moving cost | | | | | | | | | |
| No skill losses ($\theta$=0) | 8.0 | 8.0 | 16.5 | -98.9 | 16.5 | -98.9 | 0.999 | -1.23 | 43.7 |
| Skill losses ($\theta$=0.15) | 7.6 | 7.5 | 15.5 | -91.7 | 15.4 | -91.7 | 0.990 | -1.18 | 22.2 |
| Case 2: m=GDP per worker TR/2 | | | | | | | | | |
| No skill losses ($\theta$=0) | 7.9 | 7.9 | 16.4 | -98.2 | 16.4 | -98.2 | 0.998 | -1.22 | 38.2 |
| Skill losses ($\theta$=0.15) | 7.1 | 7.0 | 14.5 | -85.3 | 14.4 | -85.3 | 0.981 | -1.13 | 16.7 |
| Case 3: m=GDP per worker TR | | | | | | | | | |
| No skill losses ($\theta$=0) | 7.9 | 7.9 | 16.2 | -97 | 16.2 | -97 | 0.996 | -1.22 | 32.6 |
| Skill losses ($\theta$=0.15) | 6.2 | 6.0 | 12.6 | -73.5 | 12.4 | -73.5 | 0.963 | -1.04 | 11.2 |

Note: This table reports steady-state effects of labor market integration on regional output, capital, and their counterparts in Turkey and EU, population in EU, output per worker in Turkey and EU. Steady-state effects are reported for three values of resource cost of moving (m): m equal to zero, m equal to half of the annual GDP per capita in Turkey and m equal to annual GDP per capital in Turkey. For each value of m results are reported for without skill-loss ($\theta$=0) and with skill-loss ($\theta$=0.15).

### 1.4.2 Transitional Implications on Aggregates

Historical data on past migrations in the EU and the US, provided in Klein and Ventura (2009), shows that migration is gradual over time. In line with the data, the model in this paper also generates a gradual labor movement due to heterogenous psychic moving cost and finite lives assumptions after the decline in resource cost of moving. Similarly, borrowing constraint which does not allow workers to move with debt has an additional impact on gradualness of labor movement. Because of gradual labor movement transitional implications of migration differs from its steady-state implications. Thus, in this section the model is used to explore these transitional implications of the decline in resource cost of moving. For this exercise, the economy is initially assumed to be at the benchmark steady state where $m$ is so high that there is no migration. Then, unexpectedly resource cost of moving is partially removed and migration starts. The first period of transition is assumed to be the period at which resource cost of moving is partially removed. So, in this period there is no migration and, aggregates and prices, except land price, are the same with their counterparts in the benchmark steady state. Moreover, before migration all of the land in each location is assumed to be held by residents. Also, it is assumed that TFP levels of each location do not change across time by migration.

Quantification of transitional implications of migration is made only for the case 3 with $\theta = 0.15$ in the steady state analysis (see Table 2). In this case $m$ is decreased to annual per capita output in Turkey and this is the case where the long-run gains in regional output and capital is the lowest among cases reported in the current paper.[14] Tables 3 and 4 display, respectively, changes in EU population and changes in regional output over time after the decline in $m$. Results are reported for 10 years, 15 years and 25 years after the decline in $m$. Since the distribution of utility cost of moving influence transitional dynamics of migration, results are presented both for high and low psychic costs.

As expected, the increase in EU population and the gains in regional output are larger along transition when psychic costs are low. In spite of these differences in gains across time, both economies reach to the same steady state. This implies that economy converges to the new steady state faster when psychic costs are lower.

Another finding is that the growth rate of output gets larger across time while that of migration rate to the EU gets smaller. The migration from Turkey is large

[14]For the transitional analysis, case 3 in Table 2 with $\theta = 0.15$ is chosen for computational simplicity. As resource moving cost decreases, migration amount increases, and given other costs, this raises the number of transition periods to reach the new steady state. An increase in the number of transition periods means an increase in the size of the state variable $t$ and this raises the computational burden.

Table 3: Population change in EU (%)

| Economy | 10 years | 25 years | 50 years |
|---|---|---|---|
| High psychic costs | 1.20 | 2.11 | 3.57 |
| Low psychic costs | 2.41 | 4.11 | 6.52 |

Note: This table reports immigration rate in the EU 10 years, 25 years and 50 years after the decline in m to the level of annual GDP per capita in Turkey. Results are reported for high and low psychic costs.

just after the resource moving cost decline and it continues across time but with a decreasing trend. After 10 years the population change in the EU is 1.20% for high psychic cost and 2.41% for low psychic cost. After 50 years, they increase by less than three times, and changes are respectively 3.57% and 6.52%. Average population growth rates per year are 0.12% for the first 10 years, 0.08% for the first 25 years and 0.07% for the first 50 years after the decline when psychic costs are high. These rates are, respectively, 0.24%, 0.16% and 0.13% when psychic costs are low. The main reason for this decreasing trend is the change in wage gap between locations over time. At the time of resource moving cost change, the wage gap across location is at its highest level. So there are many Turkish natives who choose to move, even the ones with high psychic moving cost, and this continues for several periods. However, since the wage gap decreases as population increases in the EU and decreases in Turkey, migration decelerates overtime. Even Turkish residents with low psychic moving cost do not move.

Table 4: Regional output change (%)

| Economy | 10 years | 25 years | 50 years |
|---|---|---|---|
| High psychic costs | 0.03 | 0.14 | 0.49 |
| Low psychic costs | 0.13 | 0.26 | 0.96 |

Note: This table reports output growth rate in the region 10 years, 25 years and 50 years after the decline in m to the level of annual GDP per capita in Turkey. Results are reported for high and low psychic costs.

On the other hand, after migration starts growth rates of regional output raise over time. Migration affects the regional output by changing the labor supply across locations, notably in the more productive one, that is the EU. Its impact on the labor supply in EU occurs through three channels: i. mass of migrants, ii. educational attainment gap across locations and iii. skill loss of migrants. Mass of migrants is large just after the removal of barriers but decreases across time due to decreasing migration rate. So its increasing effect on labor supply decelerates along transition. However, the impact of educational attainment gap and skill loss of migrants on labor supply becomes more effective in the long-run. It is because these factors' impacts become visible through descendants of Turkish immigrants. Children of

Turkish immigrants are born with the human capital of European natives which is larger than that of their peers in Turkey because of higher educational attainment in the EU. Moreover, skill loss that Turkish immigrants are subject to disappears with immigrants' descendants. These effects lead to an additional increase in labor supply in the long-run, thus capital accumulation and hence output increase in the EU. This additional increase grows across time as the share of Turkish newborns in the EU raises. Consequently, growth rates of regional output get larger over time. 10 years after the decrease in labor mobility cost, the regional output increases by 0.03% for high psychic cost and by 0.13% for low psychic costs. After 50 years, they grow more than seven times and regional output increases by 0.49% when psychic costs are low and by 0.96% when psychic costs are high. Average annual growth rates make more clear this non-stationary growth rate trends. For high psychic costs average annual growth rates continually get larger across time. It is 0.003% for the first 10 years, 0.006% for the first 25 years and 0.010% for the first 50 years after the decline of resource moving cost. But when psychic costs are low these rates are, respectively, 0.013%, 0.010% and 0.019%. A lower average output growth rate per year for the first 25 years compared to the first 10 years when psychic costs are low imply that the effect of mass of migrants on labor supply is large and dominant for the first 10 years but its effect declines after 10 years decreasing the average annual growth rate. However, a larger average growth rate per year for the first 50 years show that the other two factors' impact dominates the effect of decreasing mass of migrants in the long-run.

### 1.4.3 Transitional Implications on Welfare

In this section, I examine welfare implications of partial removal of resource moving cost for natives of EU and Turkey. As in section 1.4.2, welfare analysis is done for the transition from the benchmark economy to an alternative economy where resource moving cost is decreased to the level of annual GDP per capita in Turkey and skill loss, $\theta$, is 0.15.

Denote the date of the decline in resource moving cost as $t_0$, so at $t_0 - 1$ the economy is in the benchmark steady state. Then, given his state $(a, i, j, x, y, t)$, a worker's welfare is measured as a consumption equivalent. In other words, it is a consumption compensation which is necessary to make the worker indifferent between the benchmark steady state and alternative economy in period $t$. Given functional forms in the model, consumption compensation is obtained as

$$\Delta\left(a,i,j,x,y=x,t\right)=\left[\frac{v\left(a,i,j,x,y,t\right)}{v\left(a,i,j,x,y=x,t_{0}-1\right)}\right]^{1/(1-\sigma)}-1$$

Notice that $v\left(a,i,j,x,y=x,t_0-1\right)$ is the value function of the worker at state $(a,i,j,x,y=x)$ in the benchmark steady state while $v\left(a,i,j,x,y,t\right)$ is his value function in the transition period $t$.

Table 5 presents welfare gains as an average of this consumption compensation across workers regarding their asset holdings, types, and current locations. In other words, welfare gains are reported as an average across workers for a given birth location, i.e. independent of workers' migration status, and for a given generation, i.e. for a given $j$ and $t$.[15] Generation 1 represents the oldest worker ($j=12$) at $t=t_0$ while generation 12 is the group of newborns ($j=1$) at $t=t_0$.

Before analyzing welfare implications for different generations and nationalities, it would be useful to summarize welfare changing forces at work as of the date that migration starts. First, remember that since the marginal product of labor in the EU is higher than its counterpart in Turkey due to its higher level of TFP, the direction of migration is from Turkey to the EU. As a result of this movement, the marginal product of labor in EU decreases while it increases in Turkey. This has a negative effect on welfare for natives of EU while positive effect for natives of Turkey who choose to stay in Turkey. Meanwhile, natives of Turkey who choose to migrate benefit from higher wage rate in the EU which non-surprisingly has an increasing effect on their welfare. Migration has also welfare implications through changes in land price. It increases in the EU due to an increase in future marginal product of land in this location and decreases in Turkey in the same manner. These changes in land prices raise welfare of workers holding land in the EU while decrease welfare of land holders in Turkey.

At time $t_0$ there is no migration, it starts one period after the change. So at this time there are no changes in aggregates and prices but land price. It increases in the EU while decreases in Turkey. The impact of land price on welfare is more effective compared to the impact of wage for the first couple of generations. This result can be seen from Table 5. Generation 1 and 6 of natives of the EU have welfare gains due to increased land price while the same generations of natives of Turkey are exposed to welfare losses as a result of decline in land price. However, as time passes and the population in the EU increases, natives of the EU are subject to welfare losses. Concurrently, welfare of natives of Turkey rise with migration. Natives who migrate benefit from higher wages in the EU and natives who choose to stay in Turkey

[15] Notice that $generation=t+\left(J-j\right).$

benefit from increasing wages in Turkey. Overall, decreasing resource moving cost increases welfare of natives of Turkey, particularly for young ones. On the other hand, it leads to a welfare loss for young natives of EU which is relatively small.

Table 5: Welfare gain (%)

| | Natives of EU | | Natives of Turkey | |
|---|---|---|---|---|
| Generation | Low costs | High costs | Low costs | High costs |
| 1 | 0.13 | 0.05 | −2.05 | −1.06 |
| 6 | 0.11 | 0.07 | −0.49 | −0.23 |
| 12 | −0.13 | −0.08 | 2.04 | 1.06 |
| 24 | −0.61 | −0.39 | 4.67 | 2.51 |

Note: This table reports, separately, welfare gains of natives of EU and natives of Turkey for generations 1, 6, 12 and 24 after a decline in m to the level of annual GDP per capita in Turkey. Results are reported for low and high psychic costs.

### 1.5 Conclusion

There are very few papers that explore economic implications of labor market integration between Turkey and the EU in a quantitative general equilibrium setup. Besides, none of them endogenize migration decision after a labor market integration. This is the first paper that studies economic implications of labor market integration between Turkey and the EU in a general equilibrium setup where migration decision is endogenous. Labor market integration means lifting fully or partially barriers to labor mobility across Turkey and the EU. This might happen as a result of either EU membership or an engagement which only ensures a labor market integration. So the counterfactual analysis I made in this paper by lifting these barriers does not consider other implications of Turkish accession to the EU but labor market integration.

Findings of this paper shed light on economic gains and losses in the region and, separately, in each location after an eventual labor market integration and how they change across time. There is an output increase in the region and in the EU but a decrease in Turkey as a result of a large mass of migration from Turkey to the EU. Nevertheless, welfare of Turkish young natives increases in return for negligible welfare losses for young natives in the EU.

This paper does not consider convergence of Turkey's productivity to EU's productivity level in the long-run which may potentially affect the endogenous labor movement in the region, so its effect on output and welfare. Moreover, population distribution differential across these locations in terms of age, i.e. the aging population in the EU and younger population in Turkey, and migration's impact on labor supply and social security systems in the EU and Turkey in such an environment is not studied. These issues which have potentially important welfare implications in both locations are left for future research.

**REFERENCES**


Aydın, L., and Acar, M. 2010. Economic and environmental implications of Turkish accession to the European Union: A CGE analysis. Energy Policy, 38(11): 7031-7040.

Erzan, R., Kuzubaş, U., and Yildiz, N. 2006. Immigration Scenarios: Turkey–EU. *Turkish Studies*, 7(1): 33-44.

Flam, H. 2004. Turkey and the EU: Politics and Economics of Accession. *CESifo Economic Studies*, 50(1): 171-210.

Klein, P., and Ventura, G. 2009. Productivity differences and the dynamic effects of labor movements. *Journal of Monetary Economics*, 56(8): 1059-1073.

Krieger, H., and Maitre, B. 2006. Migration Trends in an Enlarging European Union. *Turkish Studies*, 7(1): 45-66.

Lejour, A. M., and Mooij, R. A. 2005. Turkish Delight: Does Turkey's Accession to the EU Bring Economic Benefits?. *Kyklos*, 58(1): 87-102.

Özgüzer, G. E., and Pensieroso, L. 2013. An analysis of Turkey's accession to the European Union. *Canadian Journal of Economics/Revue canadienne d'économique*, 46(4): 1380–1405

Togan, S. 2004. Turkey: Toward EU Accession. *The World Economy*, 27(7): 1013-1045.

## 1.A Appendix: Algorithm

I follow the algorithm provided in Klein and Ventura (2009).

### 1.A.1 Steady State 1 (Benchmark Economy)

1. Set $m$ so high that there is no migration.
2. Guess aggregate capital, $K^*$.
3. Find population ($N_x^*$), labor ($L^*(x)$) and land ($F^*(x)$) in each location.
   (a) Since aggregate population $N$ is normalized to 1, population in each location is equal to population shares of each location obtained from data. Then assuming that population is equally distributed across ages and using skill-age profile and educational attainment ratio find labor in each location.
   (b) Land in each location is equal to its population because, at the initial steady state land per capita is normalized to 1.
4. Using equality of marginal product of capital in each location, find capital ratio of locations, then capital in each location ($K^*(x)$ for $x \in \{R, P\}$) in line with the aggregate capital guess.
5. Find return on assets and prices in each location: $r^*, w^*(x), R^*(x), p^*(x)$.
6. Solve worker's problem and find value functions and policy functions.
7. Using policy functions, calculate distribution of workers, $\psi^*$.
8. Calculate aggregates.
9. If $|Knew^*/K^* - 1| < \epsilon$ stop, otherwise go to step 2 and update the guess.

### 1.A.2 Steady State 2 (Alternative Economy)

In this economy, different from the benchmark economy, I need to find population of each location after migration, i.e. $N_P$ and $N_R$. If I can find one of them I can find the other as $N - N_x$. Following Klein and Ventura (2009), I aim to find $N_P$. It is going to be found by bisection and the search will be in the following interval $\left[\widetilde{N}_P, N\right]$ where $\widetilde{N}_P$ is the lowest population possible in the poor location ($N_P^l$) that makes wage in each location equal, i.e. $w^*(R) = w^*(P)$. In other words, a population level where workers are indifferent to move. $N$ is the highest population possible ($N_P^h$).

1. Decrease $m$ so that migration between two locations is possible.
2. Find $\widetilde{N}_P$ using equality of marginal product of labor in each location and that of marginal product of capital in each location.
3. Guess $N_0 \in \left[N_P^l, N_P^h\right]$.
4. Find labor ($L^*(x)$) in each location which is consistent with $N_0$. Note that land in each location is the same as in the benchmark economy.
5. Guess aggregate capital, $K^*$.
6. Apply steps from 4 to 9 given in the algorithm of the benchmark economy.
7. Check whether there is migration or not in the economy. If there is migration, this means that wage gap is still so high that residents in poor location still want to move to rich location, so lower the upper bound of the population interval in the poor location and set $N_P^h = N_0$. If there is no migration raise the lower bound and set $N_P^l = N_0$. Return to step 3.
8. Continue till $N_P^h$ and $N_P^l$ converge to each other.

### 1.A.3 Transition

By transition I mean departing from the benchmark economy with the decrease in resource cost moving and reaching several periods after to the alternative economy. So, to solve for the transition first I need to set the number of periods, $T$, to reach the second steady state. Then the procedure works as follows:

1. Guess $K(t)$ and $L(x,t)$ for $x \in \{R, P\}$ and for $t \in \{1, 2, ...T\}$.
2. Using equality of marginal product of capital in each location, find capital ratio of locations, then capital in each location ($K(x,t)$ for $x \in \{R, P\}$) for $t \in \{1, 2, ...T\}$.
3. Find return on assets and prices in each location: $r(t), w(x,t), R(x,t), p(x,t)$ for $x \in \{R, P\}$ and for $t \in \{1, 2, ...T\}$.

4. Solve worker's problem and find value functions and policy functions for $t \in \{1, 2, ...T\}$.

5. Using policy functions, calculate distribution of workers, $\psi(t)$ for $t \in \{1, 2, ...T\}$.

6. Calculate aggregates for $t \in \{1, 2, ...T\}$.

7. If $max(|Knew(t)/K(t) - 1|) < \epsilon$ and $max(|Lnew(x,t)/L(x,t) - 1|) < \epsilon$ for $x \in \{R, P\}$ stop, otherwise go to step 1 and update guesses.

# CHAPTER 2

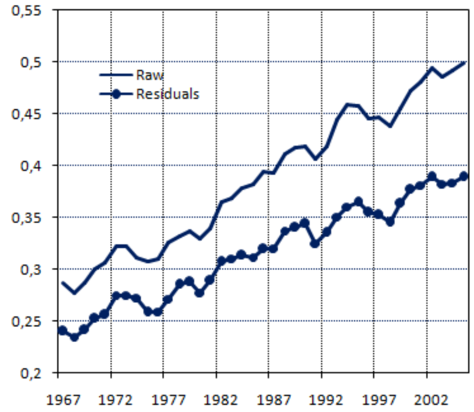
# THE ROLE OF FINANCIAL DEVELOPMENT IN THE RISE OF RESIDUAL WAGE INEQUALITY

## 2.1 Introduction

In the US, residual wage inequality -that is wage dispersion within worker groups having similar observable characteristics like gender, age, education- increases since late 1960s. This increase goes in parallel with the rise in overall wage inequality. Figure 1, replicated by using data provided in Heathcote, Perri, Violante (2010), shows the variance of log male wages between 1967 and 2005. The straight line represents overall wage inequality while the line with circles shows residual wage inequality.[16] Throughout the period, the first rises by 74% and the second increases by 62%. Heathcote, Perri, Violante (2010) presents that the residual wage inequality increase explains almost all of the increase in the overall wage inequality during 1970s, but it explains two third of the overall increase since 1980s. Although observable worker characteristics gain importance in the explanation of overall wage inequality increase by 1980s, rise in residual wage inequality has still a significant share in the overall increase. It accounts for 70% of the overall inequality increase for the whole period. Thus it is important to examine forces leading to a rise in residual wage inequality.

This paper questions only the role of financial development in the residual wage inequality increase in the US. An incomplete-market model in which homogeneous

[16] For both of the series Heathcote, Perri, Violante (2010) uses CPS data and their sample includes households in which the head is male, and in which there are either one or two adults of age 25–60. Residual wage inequality is measured as the variance of error term obtained in the estimation of log hourly wages on observable worker demographics. The observable variables that are controlled for in the regression are race dummies, sex dummies, education dummies, average years of education for all adults, a quadratic in age both for the head and non-head, number of household members below age 25, number of household members above age 60.




Source: Heathcote, Perri, Violante (2010)

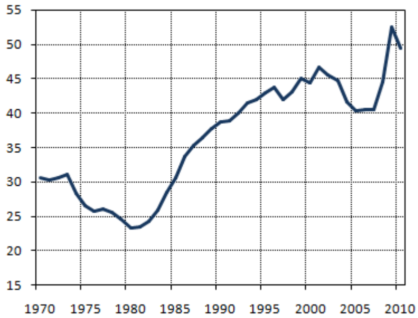
Figure 1: Variance of log male wages

workers work in firms possessing heterogeneous investment efficiency is used to answer this question. In this setup, firms are the main actors that transmit changes in financial market to residual wage distribution. In the presence of frictions in both financial and labor market, a change in firm distribution with respect to capital-labor ratio driven by financial development is the key issue that potentially brings a change in residual wage inequality. Financial development corresponds to an increase in firms' access to finance. After an easing in access to finance, firms which have an efficient investment technology but which are lack of funding are able to borrow more, invest more and hence accumulate more capital compared to firms having inefficient investment technology.[17] The presence of labor market frictions limit these firms to adjust their number of employees in response to the increase in their capital holdings. So, it is expected that firm distribution regarding capital-labor ratio increases. Under an assumption of wage setting as a rent sharing rule, this increase in capital-labor distribution presumably generates an increase in wage dispersion.[18]

Briefly, in the mechanism described above there are two main stages : financial development leads to an increase in capital-labor ratio dispersion and increase in capital-labor ratio dispersion creates an increase in residual wage inequality. The data on financial development and capital-labor dispersion encourage me to explore

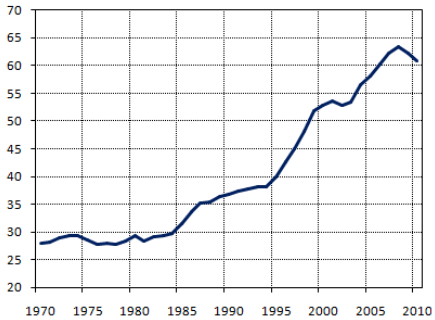
[17] Empirical evidence supports firms' use of external finance for investment funding. Ajello (2015) and Zetlin-Jones and Shourideh (2014) provide that in the US almost 20% of aggregate investment by public firms is financed by external funding. Zetlin-Jones and Shourideh (2014) also shows that the ratio is similar in UK for investment by public firms while it is 80% for investment by private firms.

[18] Wage setting by rent sharing implies that larger and more productive firms pay higher wages. This prediction is in line with evidence establishing positive correlation between firm size and wages (Oi and Idson (1999)) and between firm productivity and wages (Van Reenen (1996), Mortensen (2003)).




Source: Board of Governors of Federal Reserve System, FoF

(A) Share of Credits in Non-Financial Assets (%)




Source: World Bank, Global Financial Database

(B) Credit/Capital Expenses (%)

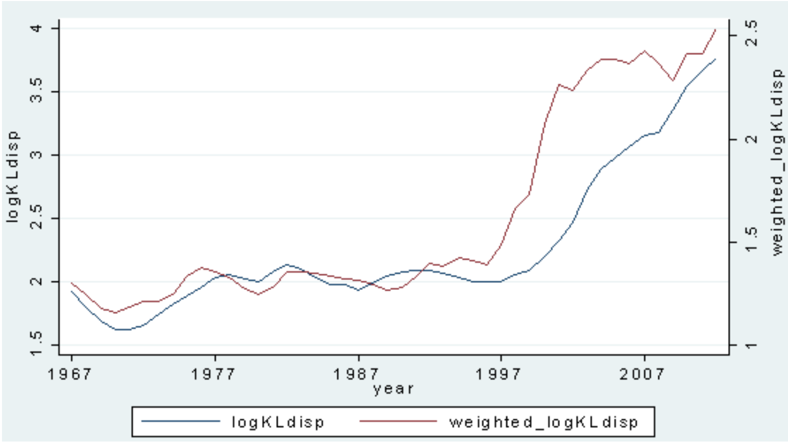
Figure 2: Financial development

my question through such a mechanism whereas they both increase along the period where residual wage inequality increase is observed. In the literature, financial development is commonly captured by an increase in credit-capital ratio. Figure 2 displays the change in private credit-capital ratio in the US between 1967 and 2010. The graph on the left hand side is constructed by using non-financial corporate sector balance sheets provided under Flow of Funds tables. The graph on the right hand side presents ratio of private credit by deposit money banks and other financial institutions to GDP, which is obtained from World Bank Global Financial Database.[19] Both graphs show that credit-capital ratio increased over the period that residual wage inequality increase is observed. Figure 3 shows the variance of log capital-labor ratio. The series which are built-up using Compustat data display that capital-labor dispersion of publicly traded firms increased, notably after mid-90s. Leonardi (2007) documents a similar increase in capital-labor dispersion in the US. Besides, he provides some empirical evidence of a positive correlation between the dispersion of capital-labor ratio and residual wage inequality.[20]

It is worth to note that I do not claim the only reason for the increase in residual wage inequality is financial development. Yet, my aim is to provide its quantitative impact on the residual wage inequality increase. In order to study this quantitative question, I adopt an incomplete-markets model with labor and financial market frictions. There are no aggregate shocks in the model economy. Labor market frictions are standard Diamond-Mortensen-Pissarides search and matching frictions (Pissarides (2000)). It makes firms' labor adjustment costly and limit labor move-

[19]This ratio is adjusted by capital-output ratio targeted in the current paper and transformed to credit-capital ratio.

[20]This relationship is clear for male, but unclear for female (possible reason is a large change in labor force participation). The evidence for male shows a significant impact at the upper part of the male residual wage dispersion and an insignificant impact at the lower part of the distribution These results are hold for two periods studied: 1973-1987 and 1988-2002.




Source: Compustat (Agriculture, Forestry, Fishing, Hunting; Finance and Insurance; Real Estate, Rental and Leasing sectors are eliminated.)

Figure 3: Log capital-labor ratio

ment, thus prevent to have a unique marginal product of labor in the economy. Following the standard search models wages are assumed to be set by Nash bargaining. Financial market frictions are Kiyotaki-Moore (1997, 2012) type borrowing constraints that limit firms' borrowing up to a constant share of their capital holdings. Financial development means an increase in this constant share implying a looser borrowing constraint. In other words, firms can borrow more with the same amount of collateral or borrow the same amount with less collateral.[21] In the model, at each period firms are subject to an idiosyncratic shock to their investment technology rendering firms heterogeneous in terms of investment efficiency. Cost of investment is less for firms having high investment efficiency compared to firms having less efficiency. I follow Wang and Wen (2013) in the aforementioned firm heterogeneity setting. Moreover, I assume there is an exogenous entry and exit of firms à la Khan and Thomas (2013) at each period. The mass of entrants are the same with that of exiting firms, keeping the number of firms stationary. In this setup, after financial development, firms having high investment efficiency can invest more by borrowing more, thus accumulate more capital compared to less efficient firms. Since there are frictions in the labor market, labor cannot move so that all firms have the same capital-labor ratio. Hence, capital-labor dispersion is anticipated to increase after fi-

[21]In an environment with financial frictions which limit firms' borrowing because of collateral requirement, an increase in private credit to capital ratio might be due to: (i) an increase in firms' capital holdings which are used as collateral in borrowing; (ii) the fact that firms are not borrowing constrained previously (i.e. their borrowing constraints do not bind) so they are able to increase their credit use; (iii) a decrease in the amount of collateral demanded implying a decrease in cost of borrowing. In my framework the last reason means an easing in access to finance. Unfortunately, there is no work for the US that searches for the reason of an increase in credit to capital ratio. However, Liberti and Mian (2010) shows that financial development (private credit to GDP) decreases both collateralization rate and collateral spread in 15 developing countries.

nancial development. Because of wage setting with Nash bargaining, this increase in capital-labor dispersion is conceivably translated to wage dispersion. Consequently, residual wage inequality increases.

It is important to note that an improvement in investment technologies after financial development is not considered in the current paper; i.e. efficiency levels of investment technology are the same before and after financial development. In addition, in this paper I limit myself to quantify the change in wage dispersion driven by a change in firm distribution, so I abstract from modelling worker side by assuming hand-to-mouth workers. Therefore, I ignore workers' behavioral responses to financial development, which would affect their asset holdings and change their outside option during bargaining process as discussed in Krusell et al. (2010). Nevertheless, Krusell et al. (2010) shows that the effect of workers' wealth on wages is very slight for most asset levels, when wealth differs among workers only due to past employment luck.

I calibrate the model to the US economy. Benchmark economy corresponds to pre-financial development economy and is calibrated to 1974Q1-1979Q4. Then I counterfactually loose firms' borrowing constraints by rising their parameter value by an amount equal to the increase in aggregate credit-capital ratio between pre-financial development period and post-financial development period. Post-financial development period is 2001Q1-2007Q4.

Findings of this analysis show that after financial development, variance of wages increases by 2.8% while that of capital-labor ratio increases by 25.2% However, contrary to my expectations, they both decrease at the log-level; the variance of log-wages decreases by 8.6% and that of log capital-labor ratio decreases by 8.7%. Changes in mass of firms with respect to capital, and labor, which are the main components of wages, give some insights about these results. After financial development, the share of firms holding large amounts of capital increases in the economy. In other words, firm distribution with respect to capital shifts right and becomes left-skewed, implying that financial development generates overall improvement in the economy. On the other hand, firm distribution in terms of labor stays almost the same. Consequently, changes in the distribution of capital-labor ratio and wage is ruled by the change in firm distribution regarding capital. Variance of capital increases by 26.4% while variance of log-capital decreases by 6.2% generating increases in variances of capital-labor ratio and wages while declines in their log-level counterparts.

**Related Literature**

This paper is related to the literature which explores residual wage inequality increase in the US. Previous studies that examine causes of residual wage inequality increase can be roughly classified in two groups: the first group explains the increase through unobservable worker characteristics while the second explains it by change in firm distribution regarding various variables. Within each group, main mechanisms which generate residual wage inequality increase are similar, but initial driving forces are different. The current paper can be classified under the second group where financial development is the driving force leading to a change in firm distribution regarding capital-labor ratio and hence to a change in residual wage inequality.

In the first group of study, skilled-biased technological change (SBTC hereinafter) is the most commonly proposed driving-force for the rise in residual wage inequality (also in overall wage inequality). According to this point of view, SBTC leads to an increase in demand for both observable and unobservable skill, thus induces an increase in return to skills (Juhn, Murphy, Pierce (1993), Galor and Moav (2000), Acemoglu (2002))[22]. Yet, Lemieux (2006) claims that the reason for the increase in residual wage inequality changes over time. For early 1980s, decrease in real value of minimum wages and de-unionization leads to an increase in residual wage inequality. And after mid-1980s, the change in labor force composition -that is rising education and experience- which induces an increase in dispersion of unobservable skills accounts for the increase in residual inequality. So, he claims that if this compositional change is controlled then there is no increase in residual wage inequality after 1980s. However, Autor et al. (2008) claims that residual wage inequality continues to increase after 1980s in the upper tail of the distribution (90/50), while it slows down in the lower tail (50/10). They affirm that the increase in residual inequality is explained by a richer version of SBTC, namely asymmetric SBTC. Accordingly, information technology complements high education workers engaged in high-education tasks, substitutes for moderately educated workers in routine tasks, and has less impact on low-skilled workers performing routine tasks. Therefore, asymmetric SBTC increases demand for observable and unobservable skills for high education workers leading to an increase in return to skills for this group. Hence, inequality increases with SBTC in the upper tail of residual wage distribution.

On the other hand, the main idea in the second group of work is that wage inequality among similar workers stems from firm heterogeneity. Consequently, an increase in firm heterogeneity leads to an increase in residual wage inequality. In Helpman et al. (2010), trade liberalization is the reason for an increase in firm heterogeneity which generates residual wage inequality increase. In their setup, firms are heterogenous in terms of productivity and after trade liberalization more productive firms benefit more from trade and increase more their revenues compared to the less productive firms. So, this leads to an increase in firm heterogeneity

[22] These articles are among the mostly referred articles on this subject. See the literature review in Autor et al. (2008) to see other articles on this strand.

in terms of revenues, and in the presence of Diamond-Mortensen-Pissarides labor market frictions and wage setting with Nash bargaining this generates a residual wage inequality increase. In Leonardi (2007), decrease in capital prices accounts for an increase in firm heterogeneity in terms of capital-labor ratio. Similarly, in the presence of Diamond-Mortensen-Pissarides labor market frictions and wages setting with rent sharing, increase in capital labor ratio leads to residual wage inequality increase. The mechanism provided in Leonardi (2007) is the most relevant one to the mechanism described in the current paper.

Another most relevant work is Jerzmanowski and Nabar (2013). It is, to the best of my knowledge, the first and the sole paper that explores financial development as a source of residual wage inequality increase in the US, but only among skilled workers. Although they suggest the same driving force as in the current paper, the mechanism that they formulate is totally different from the one built up in this paper and it can not be classified under neither of groups documented above.[23] Moreover, they do not bring their model to the data, however numerical simulation is done and shown that residual wage inequality increases by rising matching efficiency up to a certain level, then it starts to decrease. Additionally, they empirically show that financial deregulation in 1980s in the US increase standard deviation of residual wages by 1.7% between 1977 and 2006.[24]

The rest of the paper is organized as follows. Section 2.2 presents the model. Section 2.3 describes the parameterization of the benchmark economy. Section 2.4 explores the effect of financial development on the model economy. Section 2.5 concludes.

[23]They scrutinize their question using an endogenous growth model with imperfect capital markets and two sectors, i.e. manufacturing and innovation sector. Both sectors employ skilled workers while the first one also employs unskilled worker. In the manufacturing sector, there are some skilled workers who have a good idea to enter and start to produce in the innovation sector, but who are lack of finance. Financial market provides external finance to these skilled workers to enter and produce in the innovation sector. Financial market frictions are modeled as a search and matching process between skilled workers with potential ideas and financial intermediaries with capital. So, financial development means more efficient matching technology. In this framework residual wage inequality is the wage inequality between skilled workers working in the manufacturing sector and skilled workers working in the innovation sector. Note that, wage in innovation sector is larger than that in manufacturing sector. After financial development, more skilled workers with a good idea match with financial intermediaries and have access to external finance which makes them to enter the innovation sector. Consequently, residual wage inequality increase among skilled workers.

[24]The empirical analysis in Jerzmanowski and Nabar (2013) has two steps: first, they find residual wage time series by regressing logarithm of weekly real wage on observable worker characteristics; second, they regress logarithm of the standard deviation of residuals on financial development variable.

## 2.2 The Model

### 2.2.1 Environment

The model economy is a discrete time, infinite horizon economy without aggregate shocks. The focus is on stationary equilibrium. The economy consists of a unit measure of firms and a unit measure of workers distributed uniformly over $[0, 1]$. Workers are homogenous and they play a little role in the model, i.e. only their value functions are needed in wage determination. So, they do not solve a problem. They inelastically supply labor at each period and they consume what they earn. They do not save or lend.

Firms produce with identical production technology using capital and labor. They own capital but hire labor. They are heterogenous with respect to efficiency of their investment technology. Firms' objective is the same with that of their entrepreneurs. So, in what follows, "firms" and "entrepreneurs" are used interchangeably. In each period, a constant share of firms hit by an exogenous exit shock and the same amount of firms enter to the market keeping the number of firms in the economy stationary.

Firms and workers meet and match in a labor market with standard Diamond-Mortensen-Pissarides search and matching frictions (detailed later). However, different from the standard search and matching literature I assume risk-averse entrepreneurs. There is a frictional financial market à la Kiyotaki-Moore (1997), i.e. firms can borrow up to a constant share of their future level of capital holdings.

### 2.2.2 Labor Market

Firms and workers randomly match in a frictional labor market. Firms are large in the sense that each employs possibly many workers. They participate in the labor market without any cost. However, in order to hire workers they post vacancies which is costly. Workers can be either employed or unemployed. Only unemployed workers search for a job; i.e. no on the job search. There is no cost for unemployed workers to participate in the labor market. Workers inelastically supply labor, so the labor force participation rate is 1.

Vacant jobs match randomly with unemployed workers. The aggregate matching function, $M(U_t, VAC_t)$, represents the number of matches in a period when there are $U_t$ unemployed workers and $VAC_t$ vacancies in the economy. As it is standard in the search and matching literature, matching function is concave, homogenous of degree one and increasing in both terms. It is specified as

$$M(U_t, VAC_t) = \chi U_t^{\gamma} VAC_t^{1-\gamma}$$

where $\chi$ represents the matching efficiency and $\gamma$ is the elasticity of the matching function.

The probability that a vacancy is filled in the current period is $q_t$ and it is equal to $M(U_t, VAC_t)/VAC_t = M(U_t/VAC_t, 1) = M(1/\theta_t, 1)$ where $\theta_t \equiv VAC_t/U_t$ is the labor market tightness. Similarly, the probability that an unemployed worker finds a job is $f_t$ and it is equal to $M(U_t, VAC_t)/U_t = \theta_t q_t$. Notice that both $q_t$ and $f_t$ are functions of $\theta_t$; $q(\theta_t)$ decreases with $\theta_t$ while $f(\theta_t)$ increases. In the rest of the paper, for notational simplicity, I will use $q_t$ instead of $q(\theta_t)$ and $f_t$ instead of $f(\theta_t)$.

In each period, with probability $\lambda$, an exogenous job separation shock occurs and an employed worker becomes unemployed. Workers who have lost their job participate in labor market one period after they become unemployed. So they are unemployed at least one period and earn unemployment benefit which is less than wage, implying that matching is also costly for unemployed workers.

Since matching process is costly for both firms and workers, a realized job match yields a surplus. Following standard Diamond-Mortensen-Pissarides setup it is assumed that this surplus is shared by Nash bargaining. In other words, wages are determined by Nash bargaining and it will be detailed in wage setting section.

### 2.2.3 Firms

**Preferences and technology** There is a continuum of firms which are uniformly distributed over $[0, 1]$. The objective of a firm is to maximize its entrepreneur's utility. Entrepreneurs are risk-averse and they maximize

$$\sum_{t=0}^{\infty} \beta^t \ln(c_t)$$

where $c_t$ is entrepreneur's consumption in period $t$.

Firms behave competitively in goods market and all produce identical homogenous goods using constant return to scale production technology with capital and labor,

$$y_t = k_t^{\alpha} n_t^{1-\alpha}$$

Firms own capital but hire labor in a frictional labor market.

**Capital adjustments** Firms accumulate capital by investing. As in Wang and Wen (2013), they are heterogenous with respect to efficiency level of their investment technology. Efficiency levels are determined by idiosyncratic investment specific-technology shock, $z$, that they face every period. Shocks are assumed to be *i.i.d.* across time and across firms. Idiosyncratic shock $z$ determines the marginal efficiency of investment, $i$. Namely, a firm needs to invest $\frac{1}{z}$ units in order to increase its capital by one unit. Firms assumed to have either high $(z_H)$ or low $(z_L)$ efficiency level. Every period only a fraction $\pi$ of firms have high efficiency level of investment. As capital stock of a firm depreciates at a constant rate $\delta$, the law of motion for capital is given by

$$k_{t+1} = z_t i_t + (1 - \delta) k_t$$

where $z_t \in \{z_L, z_H\}$. Note that, the cost of investment is higher for firms having $z_L$ compared to firms with $z_H$. In other words, firms having $z_H$ accumulate the same amount of capital with firms having $z_L$ by doing a less amount of investment compared to those firms.

Investment is assumed to be irreversible, $i_t \geq 0$ for each $t$. Irreversible investment assumption prevents a firm to have all bargaining power in wage bargaining process and also differentiates capital from risk-free assets, $b$.

**Labor adjustments** As discussed in section 2.2.2, firms open vacancies to hire workers and vacancy posting is costly. Following Gali and van Rens (2010), I assume a quadratic vacancy posting cost function which is given by

$$C(v_t) = \frac{1}{2}\kappa v_t^2$$

where $v_t$ is the number of vacancy posted by a firm at time $t$ and $\kappa$ is a constant.[25]

Vacancy is assumed to be non-negative, $v_t \geq 0$. In each period a fraction $q_t$ of vacancies are filled while a fraction $\lambda$ of match is separated due to the job separation rate. Hence $(1 - \lambda) n_t$ of current period's workers continue to work in the firm while $q_t v_t$ of workers are newly hired and start to work in the following period. As a result, the law of motion for labor is given by

$$n_{t+1} = (1 - \lambda) n_t + q_t v_t$$

[25] Gali and van Rens (2010) indicates, by referring to Cooper and Willis (2004), that convex adjustment costs provide a good approximation for the aggregate dynamics for employment. Moreover, Mortensen (2003) claims that cost function convexity is essential for the existence of differences in employer productivity in equilibrium where the only production factor is labor. In my setup, convexity of labor adjustment cost brings further heterogeneity where the main source of heterogeneity comes from investment efficiency. It also has a limiting effect on opening vacancy by making frictions higher when higher number of vacancies are opened.

**Credit adjustments** All firms have access to bond market. They save by purchasing bonds $(b_t > 0)$ and borrow by issuing bonds $(b_t < 0)$. They are borrowing constrained; i.e. they can borrow up to a constant share, $\varphi$, of their capital holdings of next period, as in Kiyotaki and Moore (1997)

$$(1 + r)\, b_{t+1} \geq -\varphi k_{t+1}$$

where $r$ is the risk-free interest rate on borrowing. I assume small open economy in the sense that $r$ is taken as given in this setup.

Financial development corresponds to an increase in $\varphi$. By this increase in $\varphi$, firms having high investment efficiency but binding borrowing constraints are able to access more to external finance to be used in investing. Hence they increase their capital holdings compared to less efficient firms, and this possibly drives a rise in heterogeneity of capital holdings among firms. However, labor market frictions limit labor movement from less efficient firms to more efficient firms and this prevents occurrence of unique marginal product of labor in the economy. Thus firms' heterogeneity regarding capital-labor ratio is expected to rise after financial development.

**Entry and exit** Every period $\pi_x$ of firms are hit by an exit shock, $x$, and are replaced by an equal number of firms. Since this is an infinite horizon economy, introducing entry-exit ensures that borrowing continues in the market over time. If a firm receives $x = 1$ then it exits. Exiting firms have no choice for the next period, i.e. $k_{t+1} = n_{t+1} = b_{t+1} = 0$. They exit by consuming all of their resources remaining after wage and debt payment. All entrant firms have the same amount of capital holding $(k_{t+1} = k_0 \in K \subseteq \mathbb{R}^+)$, labor $(n_{t+1} = n_0 \in [0, 1])$ and bond holding $(b_{t+1} = b_0 \in B \subseteq \mathbb{R})$ to be used in the subsequent period. All entrants assumed to have high investment efficiency. On the other hand, continuing firms adjust their capital, labor and bond holdings as described above in capital, labor and credit adjustments paragraphs, respectively.

**Timing of events** Timing of events are illustrated in Figure 4. Firms start period $t$ by knowing their capital, labor and bond holding level. At the beginning of period $t$, idiosyncratic investment efficiency levels are revealed and exit shock occurs. Firms which will not survive to the next period produce, pay their wages and debt and uninstall their capital, then finally consume all of their remaining resources. Continuing firms produce and decide their capital $(k_{t+1})$, labor $(n_{t+1})$ and bond holdings $(b_{t+1})$ for the next period.

After posting vacancies, continuing firms enter to the labor market to hire workers. Newly hired workers become employed and start to produce in the next period. Meanwhile, $\lambda$ of employed workers in each firm hit by job separation shock and become unemployed. These unemployed workers and workers who become unemployed because their firms exit the market start to look for a new job in the next period. At the end of period $t$, new firms enter with $k_0$ level of capital, $n_0$ level of labor and $b_0$ level of bond.

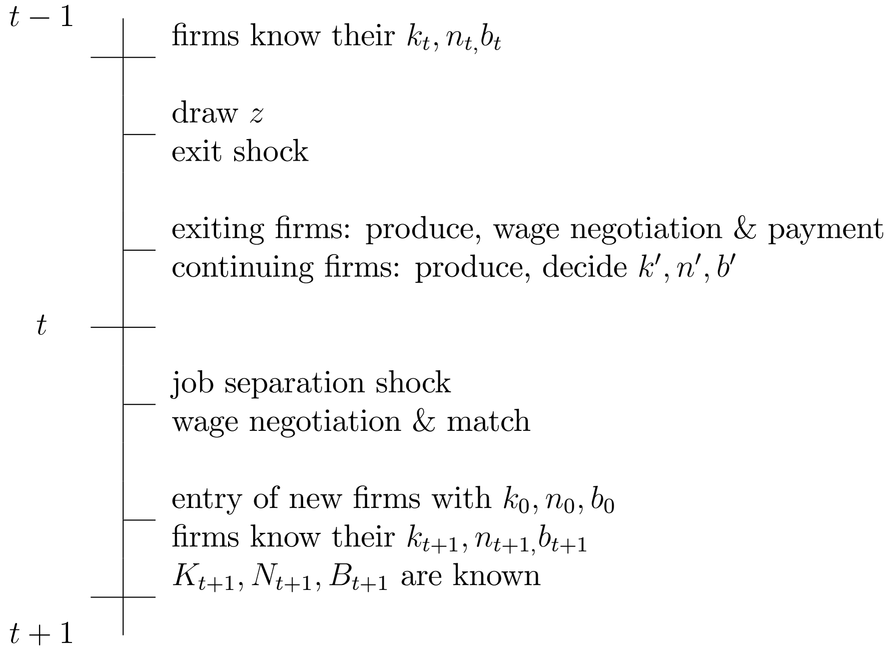



Figure 4: Timing of events

**Firm's Problem**

A firm enters period $t$ with $k \in K \subseteq \mathbb{R}^{+}, n \in [0,1]$ and $b \in B \subseteq \mathbb{R}$ and learns its efficiency level, $z \in \{z_L, z_H\}$, and exit status, $x \in \{0,1\}$, at the beginning of that period. A firm is an exiting firm if $x = 1$, and it is a continuing firm if $x = 0$. The problem solved by a firm at a state $(k, n, b, z, x)$ is provided below by equations (1)-(10).

$$V(k,n,b,z,x) = \max_{\substack{k',n',b' \\ i,v,c}} \{u(c) + (1-x)\beta E_{x'} E_{z'} [V(k',n',b',z',x') \,|k,n,b]\} \tag{1}$$

*subject to*

$$c = \begin{cases} k^{\alpha} n^{1-\alpha} + (1+r)b - wn - i - b' - C(v) & \text{if } x = 0 \\ k^{\alpha} n^{1-\alpha} + (1+r)b - wn + p_k(1-\delta)k & \text{if } x = 1 \end{cases} \tag{2}$$

$$k' = \begin{cases} zi + (1-\delta)k & \text{if } x = 0 \\ 0 & \text{if } x = 1 \end{cases} \tag{3}$$

$$n' = \begin{cases} (1-\lambda)n + qv & \text{if } x = 0 \\ 0 & \text{if } x = 1 \end{cases} \tag{4}$$

$$C(v) = \frac{1}{2}\kappa v^2 \tag{5}$$

$$c \geq 0 \tag{6}$$

$$\begin{array}{ll} i \geq 0 & \text{if } x = 0 \\ i = -p_k (1-\delta) k & \text{if } x = 1 \end{array} \tag{7}$$

$$\begin{array}{ll} (1+r) b' \geq -\varphi k' & \text{if } x = 0 \\ b' = 0 & \text{if } x = 1 \end{array} \tag{8}$$

$$\begin{array}{ll} v \geq 0 & \text{if } x = 0 \\ v = 0 & \text{if } x = 1 \end{array} \tag{9}$$

$$z' = \begin{cases} z_H & \text{with probability } \pi \\ z_L & \text{with probability } (1-\pi) \end{cases} \tag{10}$$

Equation (1) shows that an exiting firm ($x = 1$) does not solve a problem, and only gets utility from its consumption in the current period. Yet, continuing firm ($x = 0$) decides on optimal amount of capital, labor and bond holding for the next period. Equation (2) is the budget constraint of an entrepreneur. Different from a continuing firm, an exiting firm does not spend on investment, vacancy and does not hold bonds for the next period. It only consumes its resources remained after paying its debt and wage cost. Moreover, it has an extra resource coming from salvage capital of which price is lower than a consumption good's price ($p_k < 1$). Equations (3) and (4) are, respectively, law of motions for capital and labor. Second lines of these equations imply that exiting firm does not carry capital and labor for the next period. To understand better the model's intuitions, recall that $z$ in the first row of equation (3) is the efficiency of investment technology of a continuing firm. It implies that a firm with high $z$ accumulate more amount of capital with the same amount of investment done by a firm with low $z$. Equation (5) is the vacancy posting cost function. The convexity of this equation brings further heterogeneity where the main source of heterogeneity comes from investment efficiency. It also has a limiting effect on opening vacancy by making frictions higher when higher number of vacancies are opened. Equations from (6) to (9) are, respectively, non-negative consumption, irreversible investment, borrowing and non-negative vacancy constraints. In addition, as shown by second line of equation (8) a firm can not exit with a debt or do not save for the next period.

Denote $\digamma$, $\Upsilon$, $\Gamma$ and $\Psi$ as Lagrangian multipliers of constraints (6), (7), (8) and (9), respectively, for continuing firms.[26] Note that these multipliers are functions of state variables $(k, n, b, z, x)$ but for notational simplicity they are omitted. By plugging all constraints holding with equality into relevant constraints, one can

[26] Notice that $\digamma = 0$ when log utility assumption is made.

obtain a continuing firm's Euler equations for capital, labor and bond holding. They are, respectively, given by

$$\begin{aligned}\frac{U_{c,x=0}+\digamma_{x=0}-\Upsilon}{z}-\Gamma\varphi &= \beta E_{z'}\left\{\pi_x\left(U_{c',x=1}+\digamma'_{x=1}\right)\left[\alpha\left(\frac{k'_{x=0}}{n'_{x=0}}\right)^{\alpha-1}+p_k\left(1-\delta\right)\right]\right. \\ &\quad +\left(1-\pi_x\right)\left(\left(U_{c',x=0}+\digamma'_{x=0}\right)\left[\alpha\left(\frac{k'_{x=0}}{n'_{x=0}}\right)^{\alpha-1}+\frac{1-\delta}{z'}\right]\right. \\ &\quad \left.\left.-\frac{\Upsilon'\left(1-\delta\right)}{z'}\right)\right\} \qquad (11)\end{aligned}$$

$$\begin{aligned}\frac{\kappa v\left(U_{c,x=0}+\digamma_{x=0}\right)-\Psi}{q} &= \beta E_{z'}\left\{\pi_x\left(U_{c',x=1}+\digamma'_{x=1}\right)\left[\left(1-\alpha\right)\left(\frac{k'_{x=0}}{n'_{x=0}}\right)^{\alpha}-w'_{x=1}\right]\right. \\ &\quad +\left(1-\pi_x\right)\left(\left(U_{c',x=0}+\digamma'_{x=0}\right)\left[\left(1-\alpha\right)\left(\frac{k'_{x=0}}{n'_{x=0}}\right)^{\alpha}-w'_{x=0}\right.\right. \\ &\quad \left.\left.\left.+\frac{\kappa\left(1-\lambda\right)}{q}v'_{x=0}\right]-\frac{\Psi'\left(1-\lambda\right)}{q}\right)\right\} \qquad (12)\end{aligned}$$

$$\begin{aligned}U_{c,x=0}+\digamma_{x=0}-\Gamma\left(1+r\right) &= \beta\left(1+r\right)E_{z'}\left\{\pi_x\left(U_{c',x=1}+\digamma'_{x=1}\right)\right. \\ &\quad \left.+\left(1-\pi_x\right)\left(U_{c',x=0}+\digamma'_{x=0}\right)\right\} \qquad (13)\end{aligned}$$

The RHS of equation (11) shows expected benefit of capital accumulation in terms of utility while the LHS is its cost. The LHS makes it clear that having high level of investment efficiency decreases the cost of investment.

Similarly, RHS of equation (12) displays expected benefit of hiring in terms of utility while the LHS is the cost of hiring. By plugging $u_c+\digamma$ obtained from equation (11) into equation (12), one can see that hiring costs more for a firm with high current investment efficiency. It is because investing becomes more efficient with higher $z$ and this increases the opportunity cost of hiring. The tension between investment and hiring is due to vacancy posting cost assumption which is a function of vacancy. In other words, if a constant vacancy posting cost was assumed, then the cost would be independent of quantity of posted vacancy, i.e. $\kappa v\left(U_{c,x=0}+\digamma_{x=0}\right)$ term would not appear in LHS, so there would be no tension between investing and vacancy posting. Furthermore, a convexity assumption for vacancy posting cost implies that this tension raises as a firm increases its vacancy level.

Also, RHS of equation (13) presents expected benefit of lending in terms of utility while the LHS is the cost of lending. In the same manner, by plugging $u_c+\digamma$ into equation (13) it is clear that lending also costs more for firm having high investment efficiency in the current period due to its opportunity cost increase.

### 2.2.4 Workers

Workers are assumed to be either employed or unemployed. I assume hand-to-mouth workers who immediately consume their earnings and do not save. So, in this model economy workers do not solve a problem. However, in order to obtain total match surplus which is going to be used in wage determination, it is necessary to know workers' match surplus. And in order to obtain the latter, it is necessary to know workers' value functions when they are employed and unemployed. Each worker supplies labor inelastically. In each period, workers consume all of their income. Income of an employed worker is wage, $w$, while income of an unemployed worker is benefit, $ben$.[27]

An employed worker's value function who works in a firm at a state $(k, n, b, z, x)$ is given by

$$\begin{aligned} W_E(k,n,b,z,x) &= w + \beta\{xW_U + (1-x)[\lambda W_U + \\ &\quad (1-\lambda) E_{x'}E_{z'}(W_E(k',n',b',z',x')|k,n,b)]\} \end{aligned} \tag{14}$$

Employed worker's value function is a function of firm states for which he is working. For the current period he earns wage, $w$. If a worker works in a firm which is hit by an exit shock at the beginning of the period he starts next period as an unemployed worker where $W_U$ denotes his value function. But if he is employed in a continuing firm, then with $\lambda$ probability he will be unemployed and will have $W_U$ and with $1-\lambda$ probability he will continue to work for the same firm. His expected value of being employed in that firm will be a function of that firm's states in the next period.

An unemployed worker's value function is given by

$$\begin{aligned} W_U &= ben + \beta\{(1-\theta q) W_U + \\ &\quad \theta q \left[\sum_{k,n,b}\sum_x\sum_z p_v(k,n,b,z,x) E_{x'}E_{z'}W_E(k',n',b',z',x')\right]\right\} \end{aligned} \tag{15}$$

where

$$p_v(k,n,b,z,x) = \frac{\psi(k,n,b,z,x)\, g_v(k,n,b,z,x)}{\sum_{k,n,b}\sum_x\sum_z \psi(k,n,b,z,x)\, g_v(k,n,b,z,x)} \tag{16}$$

where $g_v(k,n,b,z,x)$ is the policy function of vacancy. Note that

$$\sum_{k,n,b}\sum_x\sum_z p_v(k,n,b,z,x) E_{x'}E_{z'}W_E(k',n',b',z',x') = \overline{W}_E \tag{17}$$

[27]As it is standard in the search and matching literature, income $ben$ is interpreted as unemployment benefit or home production.

Unemployed worker earns *ben* for the current period. In the next period, he will be unemployed with probability $1 - \theta q$ or find a job with probability $\theta q$ in one of the existing firms. Conditional on being employed in the next period, the probability of being employed in a firm which will be at a state $(k', n', b', z', x')$ is a function of the number of vacancies opened by that firm in the current period. More precisely, as shown by equation (16), the probability of matching with a firm at a state $(k', n', b', z', x')$ is given by the share of vacancies opened by those firms in the current period over the aggregate vacancy opened. Thus, the term in the square brackets in equation (15) is the average expected value of being employed, denote as $\overline{W}_E$. Since $ben$ and $\overline{W}_E$ are independent of firm's state, $W_U$ is not a function of any firm states.

#### 2.2.5 Wage Determination

As mentioned before, matching creates a rent to be shared between a firm and a worker because of costs faced by them. In the model economy, unemployed workers bear only time cost. They start to look for a job one period after they become unemployed and during unemployment period they earn unemployment benefit which is less than wage. Similarly, not filling a vacant job is costly for firms because of vacancy posting cost. Since it is paid before matching occurs, it is a sunk cost. I assume that the rent yielded by matching is shared by bilateral bargaining between the firm and the worker. Wage bargaining is continuous, i.e. wage renegotiation happens whenever a new information arrives. This implies that wage of continuing workers employed in continuing firms is updated with new hires. In the same manner, wages of workers employed in exiting firms is renegotiated after the exit shock before the end of the period. Following Pissarides (2000), firms engage in bargaining with each employee separately, by taking the wages of all other employees as given. Thus I assume no intra-firm bargaining in the sense that firms are not able to manipulate strategically wages by changing their labor, capital and bond choices.[28]

Firm surplus obtained from matching is the marginal value of having one ad-

[28] Cahuc and Wasmer (2001) and Cahuc et al. (2008) introduce intra-firm bargaining of Stole and Zwiebel (1996) into search and matching setup of Pissarides (2000) to study effect of wage setting on firm's employment decision. In Stole and Zwiebel (1996) setup, intra-firm bargaining leads to overemployment in equilibrium, thus to wages equal to workers' reservation wage. However, Cahuc (2001) shows that due to prematch hiring costs wages are larger than workers' reservation wage unless costs and/or workers' bargaining power are equal to zero. Moreover, Cahuc et al. (2008) point out that overemployment phenomenon put forth by Stole and Zwiebel (1996) does not play an important role at the macroeconomic level when labor is homogenous regarding their bargaining power even in the presence of capital in production function and an instantaneous change of the latter is not possible when workers quit the firm.

ditional worker in the current period (Merz (1995)). It is given by the envelope condition with respect to labor in the firm's problem and provided below as

$$FS \equiv V_n\left(k, n, b, z, x\right)$$

where

$$V_n\left(k, n, b, z, 1\right) = \left(U_{c,x=1} + \Gamma_{x=1}\right)\left[\left(1-\alpha\right)\left(\frac{k_{x=1}}{n_{x=1}}\right)^{\alpha} - w_{x=1}\right] \tag{18}$$

$$\begin{aligned} V_n\left(k, n, b, z, 0\right) &= \left(U_{c,x=0} + \Gamma_{x=0}\right)\left[\left(1-\alpha\right)\left(\frac{k_{x=0}}{n_{x=0}}\right)^{\alpha} - w_{x=0} \right. \\ &\quad \left. + \frac{\kappa\left(1-\lambda\right)}{q} v_{x=0}\right] - \frac{\Psi\left(1-\lambda\right)}{q} \end{aligned} \tag{19}$$

Equation (18) is the surplus of an exiting firm while equation (19) is continuing firm's surplus. In both cases, marginal utility of consumption, lagrange multiplier of consumption constraint, marginal product of labor and wage are common items of surplus. However, continuing firm's surplus has extra two terms due to having an additional worker. Having an additional worker increases continuing firm's surplus on the one hand. Because it decreases the need for an extra vacancy to hire a worker for the next period and provides a cost advantage to the firm from not opening a vacancy ($\frac{\kappa(1-\lambda)}{q} v_{x=0}$). On the other hand, it tightens the vacancy constraint leading to a decrease in the constraint ($-\frac{\Psi(1-\lambda)}{q}$).

Worker surplus is given by

$$\begin{aligned} WS &\equiv W_E\left(k, n, b, z, x\right) - W_U \\ &= w - ben + \beta sth \end{aligned} \tag{20}$$

where

$$sth = \left[x + \left(1-x\right)\lambda - \left(1-\theta q\right)\right] W_U + \left(1-x\right)\left(1-\lambda\right) E_x E_z \left(W_E\left(s', z', x'\right)|s\right) - \theta q \overline{W}_E$$

For the solution it is important to note that $sth$ is independent of wage, i.e. $\frac{\partial sth}{\partial w} = 0$.

The equilibrium wage paid by a firm at a state $(k, n, b, z, x)$ solves the following problem in equation (21), where the first term is the worker's surplus and the second term is the firm surplus divided by entrepreneur's marginal utility of consumption in order to express both surplus in the same units.

$$\max_{w} WS^{\phi}\left(\frac{FS}{u_c}\right)^{1-\phi} \tag{21}$$

where $\phi \in [0,1]$ is the bargaining power of the worker.

There is no analytical solution for the sharing problem given in (21). The equilibrium wage schedule, $w^*(k,n,b,z,x)$, can be solved computationally by guess and verify. Nevertheless, it is computationally too costly due to existence of large sized endogenous state variables. Therefore, in the numerical exercise I start with a much simpler wage schedule which is the weighted average of marginal product of labor ($MPN$) and unemployment income ($ben$) given below

$$\begin{aligned} w &= \Phi MPN + (1-\Phi)\, ben \\ &= \Phi (1-\alpha)\left(\frac{k}{n}\right)^{\alpha} + (1-\Phi)\, ben \end{aligned}$$

This simplification can be justified with the theory and evidence presented in Haefke et al. (2013). In this paper, they show that job creation decision depends on permanent wage, not on actual wage. Accordingly, wage setting only matters as it affects the response of the permanent wage to changes in permanent labor productivity. Their simulation results show that the elasticity of the permanent wages with respect to labor productivity is very close to the elasticity of wages of newly hired workers with respect to current labor productivity. Moreover, they present that the latter is 0.80 in data. Thus, any wage schedule as a weighted average of labor productivity and worker's outside option that gives a weight close to 1 to labor productivity will be consistent with the labor market equilibrium condition as discussed in Haefke et al. (2013). In this simplification, I use the wage equation given in Haefke et al (2013) which is obtained by solving the standard search and matching model in steady state where $\Phi = 1 - \frac{\left(1/\beta - 1 + \widetilde{\lambda}\right)(1-\phi)}{1/\beta - 1 + \widetilde{\lambda} + \phi f}$. However, for $\beta, \widetilde{\lambda}, f, \phi$ I use my own calibration targets.

### 2.2.6 Equilibrium

Given world interest rate $r$, states of entrant firms $(k_0, n_0, b_0)$, firm exit probability $\pi_x$ and job separation rate $\lambda$; a recursive stationary equilibrium consists of a set of wages $\{w(k,n,b,z,x)\}$, a set of value functions $\{V(k,n,b,z,x), W_E(k,n,b,z,x), W_U\}$, a set of decision rules for firms $\{g_k(k,n,b,z,x),\ g_n(k,n,b,z,x),\ g_b(k,n,b,z,x),\ g_i(k,n,b,z,x),\ g_v(k,n,b,z,x),\ g_c(k,n,b,z,x)\}$, matching probabilities $q(\theta)$ and $f(\theta)$; and the distribution of firms $\psi(k,n,b,z,x)$ which satisfy

i. Given $w(k,n,b,z,x), r, q(\theta), \psi(k,n,b,z,x)$; $V(k,n,b,z,x)$ solve firm's problem. $g_k(k,n,b,z,x), g_n(k,n,b,z,x), g_b(k,n,b,z,x), g_i(k,n,b,z,x), g_v(k,n,b,z,x), g_c(k,n,b,z,x)$ are the associated policy functions for firms.

ii. Given $w(k,n,b,z,x), f(\theta), \psi(k,n,b,z,x)$; $W_E(k,n,b,z,x)$ and $W_U$ are respectively employed and unemployed worker's value functions.

iii. Aggregate resource constraint holds.

$$\begin{aligned}
&\sum_{k,n,b}\sum_x\sum_z g_c(k,n,b,z,x)\,\psi(k,n,b,z,x) \\
&+(1-\pi_x)\sum_{k,n,b}\sum_x\sum_z \frac{(g_k(k,n,b,z,x)-(1-\delta)k)}{z}\psi(k,n,b,z,x) \\
&+\pi_x\sum_{k,n,b}\sum_x\sum_z (k_0-p_k(1-\delta)k)\,\psi(k,n,b,z,x) \\
&+(1-\pi_x)\sum_{k,n,b}\sum_x\sum_z \tfrac{1}{2}\kappa g_v(k,n,b,z,x)^2\,\psi(k,n,b,z,x)+\pi_x\tfrac{1}{2}\kappa\left(\frac{n_o-(1-\lambda)n}{q}\right)^2 \\
&+(1-\pi_x)\sum_{k,n,b}\sum_x\sum_z g_b(k,n,b,z,x)+\pi_x b_0+(1+r)\sum_{k,n,b}\sum_x\sum_z b \\
&=\sum_{k,n,b}\sum_x\sum_z k^\alpha n^{1-\alpha}\psi(k,n,b,z,x)+\pi_x k_0+\pi_x\left(\frac{n_0}{q}\right)^2
\end{aligned}$$

iv. Labor market

a. Total number of employed workers $(N)$ and unemployed workers $(U)$ is equal to the total number of workers in the economy.

$$N+U=1$$

b. The amount of job finding workers is equal to the amount of workers who become unemployed because of either job separation shock or firm exit shock.

$$fU=\widetilde{\lambda}(1-U)$$

where $\widetilde{\lambda}=\pi_x+\lambda(1-\pi_x)$.[29]

v. Matching probabilities $q(\theta)$ and $f(\theta)$ are functions of equilibrium unemployment, $U$, and vacancy, $VAC$.

vi. The wage function, $w(k,n,b,z,x)$, is determined by Nash bargaining between a firm and a worker as a solution of problem given by (21).

vii. Distribution is consistent with firm decisions:

$$\begin{aligned}
\psi(k',n',b',z',x') = &\sum_{k,n,b}\sum_x\sum_z \pi(z)\,\mathcal{I}(k,n,b,k',n',b',z)\,\psi(k,n,b,z,0)+ \\
&\sum_{k,n,b}\sum_x\sum_z \pi(z)\,\mathcal{I}^{ent}(k,n,b,k',n',b',z)\,\psi(k,n,b,z,1)
\end{aligned}$$

[29]Note that there are two reasons that make an employed worker unemployed; either his firm is hit by an exit shock with $\pi_x$ probability or he works in a continuing firm but he is hit by a job separation shock with $\lambda$ probability. Then at each period $\pi_x N+\lambda(1-\pi_x)N$ of employed workers become unemployed, implying that $\widetilde{\lambda}=\pi_x+\lambda(1-\pi_x)$.

where

$$\mathcal{I}(k,n,b,k',n',b',z) = \begin{cases} 1 \text{ if } (k,n,b) = (g_k(k,n,b,z,0), g_n(k,n,b,z,0), g_b(k,n,b,z,0)) \\ \qquad\qquad\qquad\qquad \text{and } z = z_H \\ 0 \text{ otherwise} \end{cases}$$

and

$$\mathcal{I}^{ent}(k,n,b,k',n',b',z) = \begin{cases} 1 \text{ if } (k,n,b) = (k_0,n_0,b_0) \text{ and } z = z_H \\ 0 \text{ otherwise} \end{cases}$$

Note that distribution is stationary, i.e. $\psi' = \psi$.

viii. Aggregate capital is consistent with firm decisions:

$$(1-\pi_x)\sum_{k,n,b}\sum_{x}\sum_{z} g_k(k,n,b,z,0)\,\psi(k,n,b,z,0) + \pi_x k_0 = K'$$

ix. Aggregate employment is consistent with firm decisions:

$$(1-\pi_x)\sum_{k,n,b}\sum_{x}\sum_{z} g_n(k,n,b,z,0)\,\psi(k,n,b,z,0) + \pi_x n_0 = N'$$

## 2.3 Calibration

The length of a period in the model economy is set to be one quarter of a year. Pre-financial development economy is the benchmark economy and calibrated to 1974Q1-1979Q4. Post-financial period is from 2001Q1 to 2007Q4. I assume that the benchmark economy is a small open economy with $r = 0.01$ (this interest rate is consistent with the US long term real interest rate). Parameters can be found in Table 6.

**Preferences** $\beta$ is set so that $r = 0.01$ ($\beta = \frac{1}{1+r}$). Log utility is assumed for entrepreneurs.

**Technology** Production function is specified as Cobb-Douglas production function. $\alpha$ is calibrated to match capital-output ratio in the US economy and it is 7.93 for the benchmark period. $\delta$ is chosen to match investment-capital ratio which is 0.013. For both targets the methodology provided in Cooley and Prescott (1995) is used. The definition of capital used in both targets is the same with the notion of capital defined in Guner et al. (2012). It includes fixed private capital, land, inventories and consumer durables. Idiosyncratic investment efficiency shock is assumed to follow Pareto distribution with parameter $\rho$ which is calibrated to match the share of firms with positive investment in the benchmark period. Following Del Negro et al. (2011) and Kiyotaki and Moore (2012), I use the annual data provided in Gourio and Kashyap (2007) to calculate investor share. Accordingly, the share of firms doing positive investment is 20% for the benchmark period.[30]

**Entry-Exit** Khan and Thomas (2013) reports that annual firm exit rate is 10%. This corresponds to 2.5% at quarterly frequency, implying that $\pi_x = 0.025$. Also, the resale price of capital $p_k$ is taken from Khan and Thomas (2013). Moreover, I assume that entrant firms's state $(k_0, n_0, b_0)$ is the state of already existing firms having minimum capital, minimum labor and zero bond holding.

**Labor Market** Four labor market parameters are calibrated: vacancy filling probability $(q)$, vacancy posting cost parameter $(\kappa)$, matching function efficiency $(\chi)$, and unemployment benefit $(ben)$. The first three of these parameters are calibrated to match the following three targets: job finding probability $(f)$, employment exit probability $\left(\widetilde{\lambda}\right)$ and market tightness $(\theta)$. I set job finding probability to 0.78 and employment exit probability to 0.07 in quarterly frequency. For these targets, using series provided in Shimer (2012), I first calculate their monthly correspondents for the benchmark period which are respectively 0.43 and 0.04 and convert them to quarterly frequency using probability tree.[31] Following Shimer (2005), market tightness is normalized to one, i.e. $\theta \equiv 1$. This target and job finding probability imply that $q = \chi = 0.78$. Using the job separation probability together with the labor market equilibrium condition (see item (iv.b) in the equilibrium definition), equilibrium employment rate is found as 0.91.[32] This value is consistent with the rate obtained from seasonally adjusted CPS data which is equal to 0.93 for the benchmark period. $\kappa$ is calibrated so that equilibrium employment rate is 0.91. $ben$ is calibrated to match benefit-average wage ratio which is equal to 0.40, as given in Shimer (2005). Following Shimer (2005), I set $\gamma = \phi = 0.72$. The first equality is set in order to satisfy Hosios condition which discloses that equilibrium with unemployment is effi-

[30] Gourio and Kashyap (2007) classify firms in the manufacturing sector in seven groups with respect to their investment to capital ratio. Only the first group has zero investment, the rest has non-zero investment. So, the share of firms having positive investment is given by the sum of these six groups.

[31] In frequency conversion, for the job finding probability I assume that a worker is employed if she is employed at the end of third month. In other words, a worker is counted in unemployment ratio even if he found a job at least once during the period but lost it at the end of period (last month). Likewise, if a worker is unemployed for the first two months but finds a job in third month he is counted as employed. In the same manner, for the frequency conversion of the employment exit probability, workers who are unemployed at the end of period are counted in unemployment ratio. Let monthly job finding probability and employment exit probability be $f_m$ and $\widetilde{\lambda}_m$, respectively and their quarterly correspondents be $f$ and $\widetilde{\lambda}$. Then $f = f_m\left(1-\widetilde{\lambda}_m\right)^2 + f_m^2\widetilde{\lambda}_m + (1-f_m)\, f_m\left(1-\widetilde{\lambda}_m\right) + (1-f_m)^2 f_m$ and $\widetilde{\lambda} = \widetilde{\lambda}_m(1-f_m)^2 + \widetilde{\lambda}_m^2 f_m + \left(1-\widetilde{\lambda}_m\right)\widetilde{\lambda}_m(1-f_m) + \left(1-\widetilde{\lambda}_m\right)^2\widetilde{\lambda}_m$.

[32] Since labor force is normalized to 1, employment rate is equal to employment.

cient when the matching function elasticity with respect to unemployment is equal to the worker's bargaining power.

**Financial Market** $\varphi$ is equal to the corporate sector borrowing-capital ratio in the economy for the benchmark period. Using non-financial corporate sector balance sheets issued by Board of Governors of Federal Reserve System, I construct credit to non-financial assets series to find private credit-capital ratio. The credit definition includes commercial papers, municipal securities and loans, corporate bonds, depository institutions loans and other loans and advances, while the definition of non-financial assets includes real estate, equipment, intellectual property products and inventories. For the benchmark period credit-capital is found as 0.07. For the post-financial development period the ratio is 0.11, meaning that the borrowing amount increased by approximately 60%.[33]

[33] I also construct the target by using credit to GDP ratio provided in World Bank Global Financial Development Database (GFDD) and by adjusting it by capital-output ratio which is targeted for $\alpha$ calibration. For the credit to GDP ratio I use private credit by deposit money banks and other financial institutions to GDP series in the database (variable code: GFDD.DI.12). The calculated ratio for the benchmark ratio is very similar to the one obtained from flow of fund accounts and equal to 0.07. However, the ratio for the post-financial development period is larger and equal to 0.18, implying an increase in credit ratio more than double. I prefer to use more the conservative ratio which is 0.11.

Table 6: Parameter values

| Parameter | Description | Value | Target | Source |
|---|---|---|---|---|
| Technology | | | | |
| $\alpha$ | Output elasticity of capital | 0.326 | Capital-output ratio, $\frac{K}{Y}$ | BEA |
| $\delta$ | Depreciation rate | 0.0121 | Investment-capital ratio, $\frac{I}{K}$ | BEA |
| $\rho$ | Pareto distribution parameter | 3.35 | Investor share | Gourio and Kashyap (2007) |
| Entry-Exit | | | | |
| $\pi_x$ | Exit rate | 0.025 | | Khan, Thomas 2013 |
| $p_k$ | Resale price of capital | 0.954 | | Khan, Thomas 2013 |
| $k_0$ | Entrants' capital holding | $min\ k$ | | |
| $n_0$ | Entrants' employment | $min\ n$ | | |
| Labor Market | | | | |
| $q$ | Vacancy filling probability | 0.78 } | job finding probability, $f$ | Shimer (2012) |
| $\chi$ | Matching function efficiency | 0.78 } | tightness, $\theta$ | Shimer (2005) |
| $\kappa$ | Vacancy posting cost parameter | 16 } | employment exit probability, $\widetilde{\lambda}$ | Shimer (2012) |
| $\lambda$ | Employment exit shock parameter | 0.049 | $\left(\widetilde{\lambda} - \pi_x\right) / (1 - \pi_x)$ | |
| $ben$ | Benefit | 0.665 | Benefit-average wage ratio | Shimer (2005) |
| $\gamma$ | Matching elasticity of unemployment | 0.72 | | Shimer (2005) |
| $\phi$ | Unemployed workers' bargaining power | 0.72 | | Shimer (2005) |
| Financial Market | | | | |
| $\varphi$ | Collateral constraint parameter | 0.07 | Borrowing-capital ratio, $\frac{B}{K}$ | Flow of Funds Accounts |

## 2.4 Quantitative Analysis

The goal of this paper is to quantify the impact of financial development on the residual wage inequality increase in the US. For this purpose, I counterfactually relax borrowing constraints that firms are subject to in the benchmark economy (pre-financial development economy). Then I compare the variance of wages in the benchmark economy with its counterpart in the post-financial development economy. In the current setup, relaxing borrowing constraint corresponds to an increase in $\varphi$.

I start the quantitative analysis by evaluating the performance of the model economy built in this paper. Then, I explore how characteristics of the benchmark economy change with financial development and answer my main question. After the counterfactual analysis, I control whether the model is robust to convexity degree of vacancy posting cost function.

### 2.4.1 Benchmark Economy

Table 7 shows values of targeted variables generated by the model together with their counterparts in data. Except the aggregate borrowing-capital ratio, the model performs well in matching targets. The model generates an amount of borrowing lower than the data.

Table 7: Benchmark economy

| Variable | Description | Data | Model |
|---|---|---|---|
| K/Y | Capital-output ratio | 7.93 | 8.01 |
| B/K | Borrowing-capital ratio | 0.07 | 0.05 |
| I/K | Investment-capital ratio | 0.0132 | 0.0132 |
| Investor Share | % of investors | 0.20 | 0.20 |
| f | Job finding probability | 0.782 | 0.788 |
| $\theta$ | Labor market tightness | 1 | 1.01 |
| $\widetilde{\lambda}$ | Employment exit probability | 0.0728 | 0.0726 |
| ben/w | Benefit-average wage ratio | 0.4 | 0.394 |

Note: This table reports values of targeted variables in data and their counterparts generated by the model.

### 2.4.2 Counterfactual Analysis: Financial Development

In this section, I first explore steady-state implications of financial development on aggregates, firm distribution regarding state variables and bond holding behavior of firms in the economy. Then, I answer the main question of this paper and present the quantitative impact of financial development on residual wage inequality increase in the US.

Results on changes in firm distribution and aggregates after financial development are summarized by Figure 5, and Tables 8 and 9. Figure 5 illustrates, separately, the mass of firms with respect to state variables before and after financial development. Chart A presents the distribution of firms regarding bond while Chart B and C show distribution of firms regarding capital and labor, respectively. Firm distributions in the pre-financial development economy are demonstrated by graphs on the left and those in post-financial development economy are shown by graphs on the right. Table 8 shows key aggregates describing the economy before and after financial development. Table 9 displays change in borrowing and lending behavior of firms after financial development.

Figure 5, Chart A shows that there is a big change in the firm distribution in terms of firms' bond holding. It shifts to the left as a result of looser borrowing constraints suggesting that the mass of borrowing firms increases while the mass of lending firms decreases. Not surprisingly, this leads to an increase in aggregate borrowing and a decrease in aggregate lending. Table 8 displays that the aggregate borrowing increases by 123.5% leading to an increase in aggregate borrowing-capital ratio by 83.4%. The increase in borrowing-capital ratio mostly stems from an increase in borrowing of firms with $z_L$, of which borrowing-capital ratio raises by 93.1%. Its counterpart for the firms having $z_H$ is 59.2%. Still, borrowing-capital ratio of firms with $z_H$ is larger than that of firms with $z_L$ indicating that borrowing of efficient firms is larger than that of inefficient firms. Likewise, as Table 9 shows, all of the firms with $z_H$ are borrower both before and after financial development. However, 74% of firms with $z_L$ is borrower in the pre-financial development economy while the share increases to 88% in the post-financial development economy. And these firms are the reason of increase in share of borrowers after financial development.

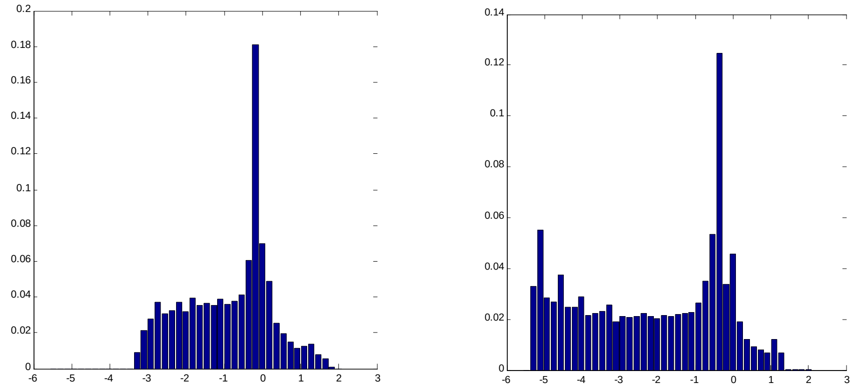
Meanwhile, the firm distribution in terms of capital shifts to the right and becomes more left-skewed as Figure 5, Chart B illustrates. Notice that the reason of a large mass of firms at the minimum level of capital is the entry of new firms. Except these firms, the firm distribution regarding capital becomes more left-skewed in the post-financial development economy, and this implies that the share of firms holding large amounts of capital increases in this new stationary economy. Results presented in Table 8 are in line with this finding. The increase in aggregate capital and investment is 21.9% and it is 12.7% for capital-labor ratio. It is not surprising that the rise in aggregate capital is driven by an investment increase. And, this increase in aggregate investment is generated by firms having high investment efficiency although their share remains the same in the post-financial development economy. On the other hand, there are some firms having low investment efficiency which do not invest in the pre-financial development economy but start to invest in the post-financial development economy. However, their contribution to the increase in aggregate investment is near zero, because their investment amounts are close to zero.

Besides, financial development does not create a distinct variation in the firm distribution regarding labor which can be observed from Figure 5, Chart C. Likewise, Table 8 shows that aggregate labor rises by a very limited amount, which is 0.4%. This amount of rise creates an increase in equilibrium job finding probability by 3.3% and market tightness by 4.7%, but a decrease in job separation rate by 1.3%. These findings can be summarized as follows: in the post-financial development economy, job finding for an unemployed worker is easier while it is relatively difficult for a firm to fill a vacant job compared to the pre-financial development economy. Moreover, after financial development there is an increase in average wage which is equal to 7.8%.

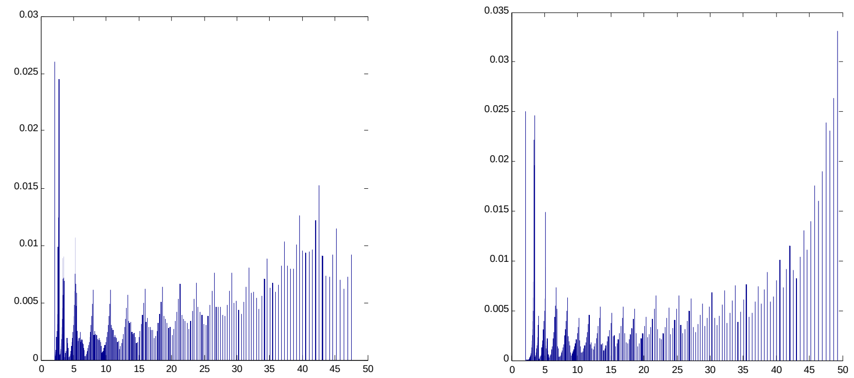
Briefly, with financial development both types of firms start to borrow more. Capital accumulation in the economy increases, and although it is mostly due to firms with $z_H$, there is a small amount of firms with $z_L$ which start to invest. Employment level increases after financial development but the increase is small. Thus, one can talk an overall improvement in the post-financial development economy contrary to my expectation of heterogeneity increase in firm distribution regarding capital-labor ratio. This result can be seen from changes in statistics provided in Table 10. Variance of wage, variance of capital-labor ratio and variance of capital increase at the level while they all decrease at the log level, implying that there are large increases in their mean values supporting my claim of overall improvement in the economy. On the other hand, variance of labor decreases both in level and log-level. Finally, financial development increases variance of wages by 2.8% but decreases variance of log wages by 8.6%.

### 2.4.3 Robustness

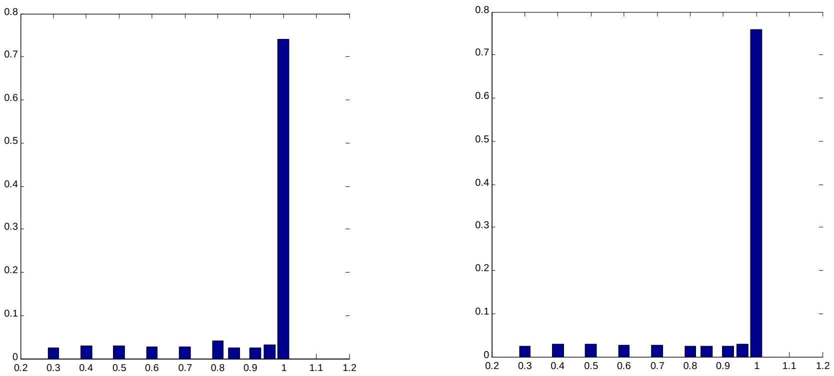
In this section, I investigate whether model results are sensitive to the quadratic vacancy posting cost function assumption. For this purpose, I consider two exercises




(A) Bond




(B) Capital




(C) Labor

Figure 5: Mass of firms with respect to labor, capital and bond holdings before (left) and after (right) financial development

Table 8: Aggregates before and after financial development

| Variable | Benchmark | Alternative | $\Delta$ (%) |
|---|---|---|---|
| BOND | -0.89 | -2.17 | 144.2 |
| BORROW | -0.99 | -2.21 | 123.5 |
| LEND | 0.10 | 0.05 | -54.0 |
| B/K | 0.05 | 0.09 | 83.4 |
| B/K, $z_L$ | 0.05 | 0.09 | 93.1 |
| B/K, $z_H$ | 0.07 | 0.11 | 59.2 |
| | | | |
| CAPITAL | 19.68 | 23.99 | 21.9 |
| K/Y | 8.01 | 9.02 | 12.7 |
| INVEST | 0.26 | 0.32 | 21.9 |
| I/K | 0.0132 | 0.0132 | 0.1 |
| % of investors | 20 | 22 | 7.3 |
| % of investors, $z_L$ | 0 | 2 | 1409.7 |
| % of investors, $z_H$ | 20 | 20 | -0.1 |
| | | | |
| LABOR | 0.9156 | 0.9191 | 0.4 |
| average wage | 1.69 | 1.82 | 7.8 |
| $f$ | 0.79 | 0.81 | 3.3 |
| $\theta$ | 1.01 | 1.06 | 4.7 |
| $\widetilde{\lambda}$ | 0.07 | 0.07 | -1.3 |
| ben/w | 0.39 | 0.37 | -7.2 |

Note: This table reports some of the aggregates in the benchmark economy, their counterparts in the alternative economy and percentage change between them.

Table 9: Shares of borrowers and lenders

| | Benchmark | Alternative |
|---|---|---|
| Share of Borrowers | 0.790 | 0.903 |
| Share of Lenders | 0.164 | 0.076 |
| Share of Borrowers with $z_L$ | 0.736 | 0.878 |
| Share of Borrowers with $z_H$ | 1 | 1 |
| Share of Lenders with $z_L$ | 0.21 | 0.096 |
| Share of Lenders with $z_H$ | 0 | 0 |

Note: This table reports total share of borrowers and lenders, and share of borrowers and lenders within each firm type in terms of investment efficiency both in the benchmark and the alternative economies.

in which convexity level of vacancy posting cost differentiate and explore whether the implications of financial development on the residual wage inequality change with these different convexity levels. In the first case, I assume a higher level of convexity compared to its counterpart in the benchmark economy and in the second case, I assume a lower convexity level. I set the higher and the lower values following Gali and van Rens (2014).[34] In this paper authors assume an employment adjustment cost function as $\frac{1}{1+\mu}\kappa v^{1+\mu}$ and they report that estimates of the

[34] Gali and van Rens (2014) is the newer version of Gali and van Rens (2010).

| Table 10: Change in statistics (%) | |
|---|---|
| var(w) | 2.83 |
| var(ln(w)) | -8.57 |
| var(k/n) | 25.15 |
| var(ln(k/n)) | -8.71 |
| var(k) | 26.38 |
| var(ln(k)) | -6.22 |
| var(n) | -0.44 |
| var(ln(n)) | -0.07 |

Note: This table reports changes in variances of wage, log-wage, capital-labor ratio, log-capital-labor ratio, capital, log-capital, labor and log-labor after financial development.

convexity of employment adjustment costs vary at a range in between 1.6 and 3.4, so that $1 + \mu \in [1.6, 3.4]$. In the benchmark economy, I use $1 + \mu = 2$. Now, for lower heterogeneity I set $1 + \mu$ to 1.6 and for higher heterogeneity I set it to 3.4. For these new convexity parameters I perform, separately, the same benchmark and counterfactual analysis.

Results make it clear that model implications after financial development are robust to the convexity level of vacancy posting cost function. In both cases the economy improves in overall after financial development. Variations in firm distributions, aggregates, borrowing-lending behaviors are in the same direction. Similarly, in each case variances of wage, capital–labor ratio, capital and labor increase in level but decrease in log-level. Nevertheless, the magnitude of increases, including those of aggregates and variances, gets larger as convexity degree decreases. For instance, aggregate capital increases by 20.4% for the higher convexity level while it increases by 22.3% for the lower convexity level. Likewise, for the higher convexity degree, increase in investor share is 0.6% while it is 7.6% for the lower level of convexity. Concurrently, variance of wage rises by 2.2% in level but decreases by 9.3% in log-level for the higher convexity degree while the increase is 4.5% and the decrease is 6.6% for the lower convexity.

Currently, I only assess the robustness of results to the convexity of vacancy posting cost function. However, it is worth to indicate that, there are some other important robustness checks which would probably give more insights about the model. One of them is to increase the number of firm types regarding their investment efficiency. In the current paper, because of computational burden of the model, I assume only two levels of investment efficiency: $z_H$ and $z_L$ which are relatively far from each other.[35] For the moment, I left solving the computational burden problem

[35] The computational burden of the model which has three endogenous state variables (capital, labor and bond) in large sizes and two exogenous state variables (entry-exit status and investment efficiency type) is already heavy. It takes already too much time to get results. Increasing the

as the next step of this research.

After solving the computational burden problem, increasing firm types probably gives possibility to match more statistics on firm dynamics in the data, like firm-size distribution, and more robustness checks can be made in this new environment which is closer to the data. For instance, the implications of financial development on residual wage inequality can be explored in a closed economy setup. Making $r$ adjust endogenously in the model might differentiate firms' decisions on borrowing and lending. And this might possibly affect capital distribution, so capital-labor heterogeneity in the economy.

## 2.5 Conclusion

Residual wage inequality increase in the US is a widely discussed topic of labor economics. Several reasons as SBTC, minimum wages, compositional changes in the US labor market, trade liberalization, decrease in capital prices and financial development, are put forward previously to explain the rise in this inequality. However, studies exploring the impact of financial development on residual wage inequality increase is rare. In fact, to the best of my knowledge, there is only Jerzmanowski and Nabar (2013).

In the current paper, I also examine the role of financial development in the residual wage inequality increase in the US but in a very different setup provided in Jerzmanowski and Nabar (2013). I built a model where the financial development affects the residual wage inequality increase in the US by changing the firm distribution in terms of capital-labor ratio. Although I set the mechanism with an expectation of an increase in residual wage inequality as a result of an increase in firm distribution in terms of capital-labor ratio which is driven by financial development, findings tell a story other way around. The variance of wages and the variance of capital-labor ratio increase, but they decrease at the log-level, implying an overall improvement in the economy. This is because financial development creates an increase in capital holdings of most of the firms in the economy leading to a more left-skewed firm distribution in terms of capital while the firm distribution with respect to labor remains almost the same. As these are the major components of wages, direction of changes in their distribution induces the results for wages.

Assuming two levels of investment efficiency which are relatively far to each other might be the most critical issue in the setup of the current paper. It would be

number of firm types regarding investment efficiency will increase the time to get results.

useful to check robustness of results with respect to this assumption by increasing the number of firm types regarding investment efficiency. However, computational burden of the model constrained me to do this robustness check. Figuring out the computational burden problem is left as the first follow-up step of this research. Then in an environment where firm types are numerous, various robustness checks which would probably give more insights about the model are going to be possible.

After having more insights about the model, one possible direction for future research is to analyze the role of changes in financial markets (in terms of access to finance) on firm distribution and residual wage inequality for different periods. For instance, exploring the impact of the last financial depression in the US on firm distribution and residual wage inequality would be a good starting point.

## REFERENCES


Acemoglu, D. 2002. Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, 40(1): 7-72.

Ajello, A. 2015. Financial Intermediation, Investment Dynamics and Business Cycle Fluctuations. Working Paper.

Autor, D. H., Katz, L. F., and Kearney, M. S. 2008. Trends in U.S. Wage Inequality: Revising the Revisionists. *Review of Economic Studies*, 90(2): 300-323.

Cahuc, P., and Wasmer, E. 2001. Does Intrafirm Bargaining Matter in the Large Firm's Matching Model?. *Macroeconomic Dynamics*, 5(5): 742-747.

Cahuc, P., Marque, F., and Wasmer, E. 2008. A Theory of Wages and Labor Demand With Intra-Firm Bargaining and Matching Frictions. *International Economic Review*, 49(3): 943-972.

Cooley, T. F. and Prescott, E. 1995. Economic Growth and Business Cycles, in T. F. Cooley, ed., *Frontiers of Business Cycle Research*, Princeton University Press, 1-38

Del Negro, M., Eggertsson, G., Ferrero, A., and Kiyotaki, N. 2011. The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities. Federal Reserve Bank of New York Staff Reports, Staff Report no: 520.

Gali, J. and van Rens, T. 2014. The Vanishing Procyclicality of Labor Productivity. IZA Discussion Paper Series, IZA DP No. 5099.

Gali, J. and van Rens, T. 2014. The Vanishing Procyclicality of Labor Productivity. Working Paper.

Galor, O., and Moav, O. 2000. Ability-Biased Technological Transition, Wage Inequality, and Economic Growth. *Quarterly Journal of Economics*, 115(2): 468-497.

Gourio, F., and Kashyap, A. K. 2007. Investment Spikes: New Facts and A General Equilibrium Exploration. *Journal of Monetary Economics*, 54(Supplement): 1-22.

Guner, N., Kaygusuz, R. and Ventura, G. 2012. Taxation and Household Labour Supply. *Review of Economic Studies*, 79(3): 1113-1149.

Haefke, C., Sonntag, M., and van Rens, T. 2013. Wage Rigidity and Job Creation. *Journal of Monetary Economics*, 60(80): 887-899.

Heathcote, J., Perri, F., and Violante, G. L. 2010. Unequal we stand: An empirical analysis of economic inequality in the United States, 1967–2006. *Review of Economic Dynamics*, 13(1): 15-51.

Helpman, E., Itskhoki, O., and Redding, S. 2010. Inequality and Unemployment in a Global Economy. *Econometrica*, 78(4): 1239-1283.

Jerzmanowski, M., and Nabar, M. 2013. Financial Development And Wage Inequality: Theory And Evidence. *Economic Inquiry*, 51(1): 211-234.

Juhn, C., Murphy, K. M. and Pierce, B. 1993. Wage Inequality and the Rise in Returns to Skill. *Journal of Political Economy*, 101(3): 410-442.

Khan, A., and Thomas, J. K. 2013. Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity, *Journal of Political Economy*, 121(6): 1055-1107.

Kiyotaki, N., and Moore, J. 1997. Credit Cycles. *Journal of Political Economy*, 105(2): 211-248.

Kiyotaki, N., and Moore, J. 2012. Liquidity, Business Cycles, and Monetary Policy. Working Paper.

Krusell, P., Mukoyama, T., and Şahin, A. 2010. Labour-Market Matching with Precautionary Savings and Aggregate Fluctuations. *Review of Economic Studies*, 77(4): 1477-1507.

Lemieux, T. 2006. Increasing Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?. *American Economic Review*, 96(3): 461-498.

Leonardi, M. 2007. Firm Heterogeneity in Capital-Labor Ratios and Wage Inequality. *Economic Journal*, 117(518), 117(518), 375-398.

Liberti, J. M., and Mian, A., R. 2010. Collateral Spread and Financial Development. *Journal of Finance*, 65(1): 147:177.

Merz, M. 1995. Search in the labor market and the real business cycle. *Journal of Monetary Economics*, 36(2): 269-300.

Mortensen, D., T. 2003. Wage Dispersion: Why Are Similar Workers Paid Differently?. *MIT Press Books*, The MIT Press.

Oi, W. Y. and Idson, T. L. 1999. Firm Size and Wages. In O. Ashenfelter and D. Card (ed.), *Handbook of Labor Economics*, Elsevier, 3(3): 2165-2214.

Pissarides, C. A. 2000. Equilibrium Unemployment Theory. *MIT Press Books*, The MIT Press, 2nd edition.

Shimer, R. 2005. The Cyclical Behavior of Equilibrium Unemployment and Vacancies. *American Economic Review*, 95(1): 25-49.

Shimer, R. 2012. Reassessing the Ins and Outs of Unemployment. *Review of Economic Dynamics*, 15(2): 127-148.

Van Reenen, J. 1996. The Creation and Capture of Economic Rents: Wages and Innovation in a Panel of UK Companies. *Quarterly Journal of Economics*, 111(1): 195-226.

Wang, P., and Wen, Y., 2013. Financial Development and Long-Run Volatility Trends. Federal Reserve Bank of St. Louis Working Paper Series, Working Paper 2013-003A.

Zetlin-Jones, A., and Shourideh, A. 2014. External Financing and the Role of Financial Frictions over the Business Cycle: Measurement and Theory. Working Paper.

## 2.A Appendix: Algorithm

1. Discrete grid on $(k, n, b, z, x)$ is used for value functions and wage function. $x = 0$ for continuing firms and $x = 1$ for entrant firms.

   (a) Set lower and upper limits and grid points for endogenous state variables

$$k_1, k_2, ...k_{N_k}$$
$$n_1, n_2, ...n_{N_n}$$
$$b_1, b_2, ...b_{N_b}$$

   (b) Obtain grids for exogenous state variable by discretizing Pareto distribution; $z_L, z_H$

2. Given $r$ and $\theta$ set wage

$$w(k, n, b, z, x) = \Phi MPN + (1 - \Phi)\, ben$$

3. Solve continuing firm's problem

   (a) Guess an initial value function for firms at each state, $V^0(k, n, b, z, 1)$.

   (b) Penalize (i.e. assign very low values to utility) states violating non-zero consumption, irreversible-investment, borrowing and non-zero vacancy constraints.

   (c) Maximize the firm's problem given in (1), find $V^1(k, n, b, z, 1)$.

   (d) If $|V^1 - V^0| < \epsilon^V$ stop, otherwise make a new guess for value function. Return to 3c and use $V^1$ as a new guess.

   (e) Obtain $g_k(k, n, b, z, 1)$, $g_n(k, n, b, z, 1)$, $g_b(k, n, b, z, 1)$, $g_c(k, n, b, z, 1)$, $g_v(k, n, b, z, 1)$, $g_i(k, n, b, z, 1)$.

4. Knowing capital, employment and borrowing decisions of continuing firms and initial states of entrant firms, calculate invariant distribution of firms, $\psi(k, n, b, z, x)$.

5. Calculate aggregates: $K, N, B, VAC, I, Y$.

$$K = \sum_{k,n,b} \sum_{x} \sum_{z} k(k, n, b, z, x)\, \psi(k, n, b, z, x)$$

$$N = \sum_{k,n,b} \sum_{x} \sum_{z} n(k,n,b,z,x)\, \psi(k,n,b,z,x)$$

$$B = \sum_{k,n,b} \sum_{x} \sum_{z} b(k,n,b,z,x)\, \psi(k,n,b,z,x)$$

$$VAC = (1-\pi_x) \sum_{k,n,b} \sum_{z} g_v(k,n,b,z,1)\, \psi(k,n,b,z,1) + \pi_x \frac{n_0}{q}$$

$$\begin{aligned} I &= (1-\pi_x) \sum_{k,n,b} \sum_{z} g_i(k,n,b,z,1)\, \psi(k,n,b,z,1) + \\ &\quad \pi_x \left( k_0 - p_k (1-\delta) \sum_{k,n,b} \sum_{z} k(k,n,b,z,0)\, \psi(k,n,b,z,0) \right) \end{aligned}$$

$$Y = \sum_{k,n,b} \sum_{x} \sum_{z} (k(k,n,b,z,x))^{\alpha} (n(k,n,b,z,x))^{1-\alpha} \psi(k,n,b,z,x)$$

Original Version - Before simplification (normalization of $\theta$, wage setting, small open economy assumption)

1. Discrete grid on $(k,n,b,z,x)$ is used for value functions and wage function. $x=0$ for continuing firms and $x=1$ for entrant firms.

   (a) Set lower and upper limits and grid points for endogenous state variables

   $$k_1, k_2, \ldots k_{N_k}$$
   $$n_1, n_2, \ldots n_{N_n}$$
   $$b_1, b_2, \ldots b_{N_b}$$

   (b) Obtain grids for exogenous state variable by discretizing Pareto distribution; $z_L, z_H$

2. Guess a wage function $\omega(k,n,b,z,x)$

3. Guess $r$

4. Guess $\theta$

5. Solve continuing firm's problem

   (a) Guess an initial value function for firms at each state, $V^0(k,n,b,z,1)$.

   (b) Penalize (i.e. assign very low values to utility) states violating non-zero consumption, irreversible-investment, borrowing and non-zero vacancy constraints.

(c) Maximize the firm's problem given in (1), find $V^1(k,n,b,z,1)$.

(d) If $|V^1 - V^0| < \epsilon^V$ stop, otherwise make a new guess for value function. Return to 5c and use $V^1$ as a new guess.

(e) Repeat until convergence.

(f) Obtain $g_k(k,n,b,z,1)$, $g_n(k,n,b,z,1)$, $g_b(k,n,b,z,1)$, $g_c(k,n,b,z,1)$, $g_v(k,n,b,z,1)$, $g_i(k,n,b,z,1)$.

6. Knowing capital, employment and borrowing decisions of continuing firms and initial states of entrant firms, calculate invariant distribution of firms, $\psi(k,n,b,z,x)$.

7. Calculate aggregates: $K, N, B, VAC, I, Y$.

$$K = \sum_{k,n,b}\sum_{x}\sum_{z} k(k,n,b,z,x)\,\psi(k,n,b,z,x)$$

$$N = \sum_{k,n,b}\sum_{x}\sum_{z} n(k,n,b,z,x)\,\psi(k,n,b,z,x)$$

$$B = \sum_{k,n,b}\sum_{x}\sum_{z} b(k,n,b,z,x)\,\psi(k,n,b,z,x)$$

$$VAC = (1-\pi_x)\sum_{k,n,b}\sum_{z} g_v(k,n,b,z,1)\,\psi(k,n,b,z,1) + \pi_x\frac{n_0}{q}$$

$$\begin{aligned} I &= (1-\pi_x)\sum_{k,n,b}\sum_{z} g_i(k,n,b,z,1)\,\psi(k,n,b,z,1) + \\ &\quad \pi_x\left(k_0 - p_k(1-\delta)\sum_{k,n,b}\sum_{z} k(k,n,b,z,0)\,\psi(k,n,b,z,0)\right) \end{aligned}$$

$$Y = \sum_{k,n,b}\sum_{x}\sum_{z} (k(k,n,b,z,x))^{\alpha}(n(k,n,b,z,x))^{1-\alpha}\,\psi(k,n,b,z,x)$$

8. If $B > 0$ decrease $r$.

9. If $\theta < target$ decrease cost (decrease $\kappa$), and vice-versa.

10. Iterate workers' value functions and find $W_E(k,n,b,z,x)$ and $W_U$.

11. Nash bargaining: Solve the problem (21) for $w$, and find $w^1$.

12. If $|w^1 - w^0| < \epsilon^w$ stop, otherwise make a new guess for the wage schedule. Return to 2 and use $w^1$ as a new guess.

13. Repeat until convergence.