THÈSE

En vue de l'obtention du

DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE

Délivré par l' Université Toulouse 1 Capitole
Discipline : Sciences Economiques

Présentée et soutenue par

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Le 05 septembre 2014

Titre :

Essays on Matching, Outsourcing and Social Networks

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UNIVERSITE TOULOUSE 1 CAPITOLE

Abstract

Toulouse School of Economics
Economics Department

Doctor of Philosophy

Essays on Matching, Outsourcing and Social Networks

by Rui Zhang

This thesis consists of three self-contained papers. The three papers study respectively the impact of social network, two-tier unemployment compensation and outsourcing activities on unemployment rate.

Chapter 1 aims to learn the role of social networks formed by unemployed workers in job transmission. We develop a model with an endogenous threshold of workers' job dissatisfaction. This threshold depends on parameters that are related to working conditions, and it affects the frequency of job transmission. Compared with the case in the absence of social networks, it is shown that when social networks are equal in size, unemployed workers' welfare is higher and unemployment rate is lower. In terms of social welfare, social planner prefers the workers to become more selective. When social networks differ in size (some workers have large networks and some have small ones), increasing the size difference is beneficial for unemployed workers with large social networks but detrimental to those with small networks; in addition, the unemployment rate decreases with the size difference. However, because of the dilution effect, as the proportion of unemployed workers with large networks increases, it eventually results in losses for all unemployed workers, and the unemployment rate may follow a non-monotonic pattern. Finally, we analyze the social network investment's strategy and characterize the equilibrium. Chapter 2 analyzes the importance of labor market institutions, more specifically

how the wage is set, in determining the impact of two-tier unemployment compensation reforming. We construct a stylized search model where wages are respectively set through collective and individual Nash bargaining. The model is calibrated with regard to the characteristics of US (12% of workers are covered by collective bargaining) and French labor market (95% of workers are covered by collective bargaining). We first show that reducing the required contribution time of obtaining UI (unemployment insurance) eligibility or increasing the UA (unemployment assistance) reduces the unemployment rate when the wage is determined through collective bargaining, but raises the unemployment rate when the wage is set through individual Nash bargaining. We second show that reducing the UI duration or increasing UI level raises the unemployment rate no matter how wage is negotiated. Last, by doing a counterfactual simulation, we find that the welfare is lower, wage is lower and unemployment rate is higher when the wage is determined through collective bargaining than when the wage is determined through individual Nash bargaining in both US and France.

Chapter 3 studies the impact of increasing service relocation. We integrate Pissarides' equilibrium unemployment model with Grossman and Rossi-Hansberg' model in order to study the impact of offshoring boom in the service sector. We construct a simple two sector model and find that when the offshoring technology makes progress in the service sector, domestic unemployment can be reduced if the marginal task-specific offshoring cost is large enough. Reducing unemployment makes hiring domestic workers become more costly and consequently makes firm in the manufacturing sector expand its offshoring scale too. In addition to the analytical result ,we do a calibration exercise using the parameters of Belgium and the numerical simulation predicts this possibility. Then we show the condition which makes the equilibrium optimal, we also propose an efficient policy instrument to correct the inefficiency when the condition is unsatisfied- the subsidy of hiring domestic workers. Finally, in a simplified two country framework of offshoring, we show that the progress of offshoring technology reduces the unemployment of the low-wage country, raises global welfare and probably raise the global inequality.

Acknowledgements

This dissertation would not have been possible without the support and help from many people. Those people to whom I owe a great deal of thanks and I would like to address my appreciation:

First and foremost, I would like to express my sincere gratitude to my advisor Prof. Gilles Saint-Paul for the continuous support of my Ph.D study and research, for his patience, motivation, enthusiasm, and immense knowledge. I thank him to push me to understand more deeply the economic concepts and express more clearly the ideas. His guidance has helped me in all the time of research and writing of this thesis.

I am also indebted to Prof. Martí Mestieri for introducing and guiding me to the fascinating area of international economics. It is his wiseness, kindness and great patience the most important source, from which I gain my strength to pursue research in this area.

My sincere thanks also goes to Prof. Yann Bramoullé, Prof. Thomas Chaney, Prof. Patrick Fève, Prof. Guido Friebel, Prof. Matthias Kredler, Prof. Shiyuan Pan, Prof. Franck Portier, and Prof. Fabien Postel-Vinay for their helpful discussions and insightful comments.

Besides, I would like to thank the rest of my thesis committee: Prof. Yann Bramoullé and Prof. Fabien Postel-Vinay for generously investing their time in reading my thesis and providing helpful suggestions.

I also thank Toulouse School of Economics for providing me the chance to pursue my study and research in economics. Special thanks to Aude Schloesing, who is always nice and patient for helping me solve numerous problems. I cannot imagine my life in Toulouse without her help. Last but not the least, many thanks to my family and friends for constantly sharing my happiness and hardships all the time.

Contents

Chapter 1

Getting a Job from My Unemployed Friends: A Social Network Perspective

1.1 Introduction

Today, workers searching for jobs have many options: newspapers, internet and word-of-mouth. Many reports suggest that a large proportion of jobs are filled by personal contacts. For example, Franzen and Hangartner (2006) demonstrate that nearly half of the workers in the Unites States and one third of the workers in Germany find their jobs through networking. Obviously, social networks have increasingly become an important source of information in the labor market.

With regard to unemployment, much of the search theory literature implies that all unemployment is voluntary. Workers have an acceptance wage in mind and search until they find a job at or above that wage; the worker's job satisfaction/disatisfaction plays an important role on the job acceptance.

In the present paper, we integrate the social network with the worker's job dissatisfaction which is the main driving force for transmitting unused job information to others. Our main objective is to investigate which factors affect each worker's job acceptance decision and how it determines the job transmission frequency and unemployment rate. To do this, we introduce the workers' job dissatisfaction into the standard search model developed by Pissarides (2000). We assume an economy where the social network is formed only by unemployed workers.[1] When an unemployed worker finds potential employment,

[1] The results do not look much different when we relax this assumption.

his acceptance depends on his disutility of working and his reservation disutility. If the former one is greater than the latter one, the worker will refuse the job and transfer the information to one of his friends randomly. His friend either accepts it and becomes employed instantaneously or refuses and transmits it to someone else through social contacts, and the procedure repeats. The reservation disutility is determined endogenously, and this makes the frequency of job transmission become endogenous as well. When workers become more selective, they are less likely to accept jobs and hence the frequency of job transmission becomes higher.

For the first analysis, we focus on the case where social networks equal in size. An unemployed worker can hear about jobs either through formal channels, like advertisements and newspapers, or through social contacts. As we show above, when the job information arrives, accepting it or not depends on whether the worker's disutility of accepting this job is lower than the threshold disutility. We find that this threshold depends on a group of parameters associated with the state of the labor market. When wages increase or equivalently productivity improves, we have a higher threshold. On this condition, unemployed workers become less selective and more likely to accept jobs, leading to a lower frequency of job transmission. This is because higher wages can raise the expected return on the job. However, when the vacancy rate becomes higher, we have a lower threshold disutility, and unemployed workers become more selective and less likely to accept jobs. This is because unemployed workers place a higher value on their other options. Consequently, this leads a higher frequency of job transmission. When we look at the impact of social networks on the unemployment rate which depends on the job acceptance rate, we find that a higher probability of hearing job information has two effects on the unemployment rate. Extensively it raises the job acceptance rate and has negative impact on unemployment rate. But intensively, workers become more selective because of the better outside options which makes them become less likely to accept the job, and this has positive impact on unemployment rate. With our set-up, the latter effect dominates the former one when the job transmission is not perfectly efficient. And we also find that the unemployment rate decreases with the threshold disutility.

For the second analysis, we investigate the social planner's objective which is to maximize the social welfare. When the workers become more selective, both unemployed and employed workers' welfare improve. However, this will lead to higher unemployment rate, making more workers become unemployed and have lower welfare. Therefore, higher cutoff disutility also generates some social costs. We prove that the gain from reducing cutoff disutility outweigh the lose. Consequently social planner prefers that workers become more selective than in the equilibrium. This is due to the externality, when workers become more selective, they not only improve their own welfare, they also have a greater chance of providing job information to others and making other workers better off.

Next, we extend the model by introducing a difference in the size of social networks. In this economy, some unemployed workers have large networks and some have small ones. In each network, people not only have friends with large networks, but also those with small ones. First, we find that when the network's size difference increases(extensively), the unemployed workers who have large networks will benefit and those who have small ones will lose. In addition, the cutoff value of disutility decreases for those unemployed workers who have large networks but increases for those who have small ones. As unemployed workers with large networks are more sensitive to the size difference, an increase in their job acceptance rate dominates the decrease in the job acceptance rate of the unemployed workers with small networks and unemployment rate will decrease. Second, we find that as the proportion of unemployed workers who have large networks increases in each network (intensively), all unemployed workers are hurt because of the dilution effect. When one unemployed worker has relatively more social friends, the probability that they transmit job information to him decreases since they have large networks and he is more likely to get information from a friend with a small network. In terms of the unemployment rate, we find that it may follow a non-monotonicity pattern with respect to the proportion of unemployed workers with large networks. When the proportion of workers who have large networks is very small, the composition effect will dominate and this drives down the unemployment rate.

Lastly, we try to see the strategy of the investment in the social network. To do this, we endogenize the proportion of unemployed workers who have large networks. How large will be the proportion depends on how many unemployed workers make investments in expanding their networks. We show that if the investment cost is high, there will be no investment at all; this is the unique equilibrium. On the contrary, if the investment cost is low, all the unemployed workers with small networks will invest in expanding their networks until all of the unemployed workers have large networks, this is also the unique equilibrium. Finally, if the investment cost is moderate, the condition becomes more complicated. There will be many pure Nash equilibria and symmetric mixed Nash equilibrium. Analytically we illustrate that when the investment cost decreases or the size difference increases, the proportion of unemployed workers with large social networks becomes higher.

1.1.1 Literature Review

These days, there has been much interest in analyzing the role of the social networks. The earliest paper to study social contacts is Boorman [2], in which he analyzes the optimal investment's choice between strong ties and weak ties. Wasserman and Faust (1994) provide a very detailed look at many important issues associated with social network: measuring power and centrality and showing the roles of different social ties. Additionally, as game theory developed significantly over the past few years, some studies use game theoretic reasoning to evaluate the individual's self-organizing network. Based on this, people build social network strategically rather than randomly.[2]

If we wish to analyze the responses of the labor market to the social network, Calvo-Armengol and Matthew O. Jackson(2004) provide the most relevant theoretical perspective. They show that social contacts raise employment probability and wages, while network size differences induce inequality. When Calvo-Armengol and Zenou (2005) re-analyze the effect of the social network, they find that as the network size increases, job matches may decrease and the equilibrium in the decentralized market is not efficient because of the externality. A common feature among these papers is that the unemployed workers get job information from the employed workers. In our paper, however, we propose a new channel of job transmission.

In addition to the theoretical literatures, many empirical studies also demonstrate the importance of social networks in labor market. Mark Granovetter (1995) finds that more than 50 percent of jobs were obtained through social contacts in Massachusetts. Similar evidence is also reported by Franzen and Hangartner (2006), in which they show that more than 40 percent of the workers in the U.S. and one third of the workers in Germany get jobs though social contacts. Many other empirical studies document similar results.

The rest of the paper is organized as follows. In section 2, we construct the basic ingredients and describe a simple model in which job information can be transmitted among unemployed workers. We solve the model under the condition of identical network size. In section 3, we try to analyze the social planner's objective and compare the equilibrium with the social optimum. In section 4, we extend the model by introducing the difference in the size of social networks and try to establish the impact of the increasing size difference and the increasing proportion of workers having large networks. In section 5, we try to see the strategic investment in expanding social networks and characterize the equilibrium. Section 6 concludes.

[2] See Calvo-Armengol , Job Contact Networks, 2000 and M.O. Jackson, A survey of models of network formation, stability and efficiency, 2003

1.2 Social Network with Identical Size

1.2.1 Setup

In our model, we assume that when a worker is employed, he can get benefits, but must simultaneously pay some costs which are dependent on his degree of job satisfaction. The more he dislikes his job, the higher the cost. Here $\alpha \in [0, 1]$ represents this cost of working or disutility.

The value of α is observed before an individual decides whether or not to accept the job and the cost will start when the job and unemployed worker are matched.[3] In addition, α is job-worker-specific. Each unemployed worker will have different α from doing different jobs. Given that the workers are rational, each of them only accepts the job he *does not* dislike that much. That is, working should be at least as good as being unemployed. In order to distinguish between "dislike" and "*does not* dislike" in our model, I define $\underline{\alpha} \in [0, 1]$ as the cutoff disutility above which a worker dislikes the job. Here, workers are homogeneous and have the same cutoff. Larger $\underline{\alpha}$ means that the workers are more selective. If an unemployed worker i, has the working utility α_i, which is lower than the cutoff $\underline{\alpha}$, he will accept the job that he hears about. On the contrary, if $\alpha_i > \underline{\alpha}$, he will refuse it. For each job, different workers have different preferences. Within the social network, the jobs that are rejected will not be wasted; the unemployed workers will transmit them to their friends.

For simplification, we assume that all unemployed workers have an identical social network size s, and members in each network are all unemployed. Time is discrete and continuous, at each end of period t, the unemployment and employment rates are respectively equal to u_t and $1 - u_t$. Period $t + 1$ begins with these unemployment and employment rates. In each period , V vacancies are posted and there is no stock of old job vacancies. If a vacant job is not filled, the firm will repost it in the next period. The job arrival rate in each period is equal to $v = V/n$, where n is the total number of employed and unemployed workers. Each worker can hear job information directly from an employer with identical probability v, or they can hear indirectly from friends in the social network. These two events are not independent, an unemployed worker may hear about more than one vacant job at each period.

As mentioned above, when an unemployed receives job information (which may come from two channels) at time t , he may accept it or refuse it, basing his decision on his own taste α_i, as well as the cutoff disutility level $\underline{\alpha}$. If $\alpha_i > \underline{\alpha}$, he refuses the job and transfers the information randomly to one of his unemployed friends.

[3] I assume that unemployed workers can know perfectly the disutlity of the job he hears.

Next, I analyze the simplest case: a social network with segregation. Under this condition, an unemployed worker only knows unemployed friends. Although this is generally not the case (workers usually have opportunities to know employed as well), this assumption simplifies everything without losing generality.

1.2.2 Social Network Formed by Unemployed Workers

1.2.2.1 Probability of Hearing a Job

Here we consider the social network with segregation; each unemployed worker knows s unemployed friends but does not know any employed friends. To simplify the computation, we assume that the network size is sufficiently large, and the worker's disutility $\alpha \sim F(\alpha)$ is continuously distributed in each network. If everybody can hear job information, a fraction of $1 - F(\underline{\alpha})$ of jobs will be rejected.[4]

We assume that each unemployed worker hears job information with probability h_t at time t. Consequently, the information that can be transmitted in each network is $s[1 - F(\underline{\alpha})]h_t$. We assume that there are some information missing during the transmission. So there is $\lambda s[1 - F(\underline{\alpha})]h_t$ information are eventually circulated in the social network, $\lambda \in [0, 1]$ captures the efficiency of information transmission, the higher λ, the more efficient of job transmission. Moreover, each unemployed worker shares the available information with $s - 1$ other unemployed workers. Therefore, the probability of hearing information from his unemployed friends at time t is $\frac{\lambda s[1-F(\underline{\alpha})]h_t}{s}$, which can be simplified into the form $\lambda[1 - F(\underline{\alpha})]h_t$.

With segregation, the information received by employed workers will be wasted. Because unemployed workers hear about the jobs either directly from employer with probability v, or indirectly from network contacts with probability $\frac{\lambda s[1-F(\underline{\alpha})]h_t}{s}$, these two events are not exclusive. A worker may get job information from both friends and employers simultaneously.

Therefore, the probability of hearing job information in equilibrium at time t is given by

$$h_t = v + \lambda[1 - F(\underline{\alpha})]h_t \frac{s}{s} \tag{1.1}$$

[4] In fact, problems may arise when the network is not large enough. For example, in one fixed social network, there are four unemployed workers whose $\alpha < \underline{\alpha}$, and five unemployed workers whose $\alpha > \underline{\alpha}$. If one worker's disutility on a job that he hears, α, is lower than the cutoff $\underline{\alpha}$, it means that there are five unemployed workers who may deliver their job information to him. On the contrary, if a worker's $\alpha > \underline{\alpha}$, four unemployed workers may deliver their job information to him. clearly, the probability of hearing job information from the network will be different in those two cases. To solve this problem, I assume the network size is sufficiently large and that tastes and preferences of its members is continuously distributed. Then I can approximate the fraction of unemployed workers who refuse the job offer by $1 - F(\underline{\alpha})$ without taking into consideration each network owner's status.

h_t appears on both sides of the equation but with different senses. On the left hand side, h_t represents the probability of an unemployed worker, i, hearing about a job, and on the right hand side, h_t represents the probability that each i's friends hears a job information. They are equal because all unemployed workers have the same network size and workers are homogenous. In the equilibrium $h_i = h_{-i}, \exists i$. Additionally, from the equation (1), it appears that the size s has no impact on the probability of hearing job information for each unemployed worker. That is because s has two effects on h_t, and when the network sizes are identical, these two effects balance each other. Extensively, as s is larger, each unemployed worker has more contacts, and therefore more potential chances to hear about a job. This will have a positive effect on h_t. But intensively, a larger s means that each of i's network mates also has more contacts, so increasing the number of i's competitors will drive down the probability of hearing job information from his friend, this has a negative effect on h_t.[5]

Since in each period, we have the same number of vacancies V and working population n, we do not need to take into consideration the time difference. After simplification, we have

$$h = v + \lambda[1 - F(\underline{\alpha})]h$$

And then, we have equilibrium probability of hearing job information for each unemployed worker

$$h = \frac{v}{1 - \lambda(1 - F(\underline{\alpha}))} \tag{1.2}$$

To simplify our analysis, I assume that the α is uniformly and continuously distributed $\alpha \sim U[0, 1]$, implying

$$h = \frac{v}{1 - \lambda(1 - \underline{\alpha})} \tag{1.3}$$

Clearly, the probability of hearing job information h is higher than that without network v, $h > v$. Therefore, having a social network can raise the probability of hearing job information.

Then we derive the probability of hearing job information and the probability of accepting job respectively with respect to the cutoff disutility, we have:

[5] We later make an extension where the network size is different across the unemployed population. In that case, positive and negative effects of s on h_t cannot balance each other.

$$\frac{\partial h}{\partial \underline{\alpha}} = \frac{-v\lambda}{[1-\lambda(1-\underline{\alpha})]^2} < 0$$

and

$$\frac{\partial h\underline{\alpha}}{\partial \underline{\alpha}} = \frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha})]^2} > 0$$

Lemma 1.1.

i) When the disutility $\underline{\alpha}$ decreases, the probability of hearing job information becomes higher;

ii) When the disutility $\underline{\alpha}$ decreases, the probability of accepting job information becomes lower.

Therefore, when unemployed workers are more selective, the probability of hearing job information becomes higher since the frequency of job transmission is higher. However, the probability of accepting job information becomes lower.

1.2.2.2 Workers

As each worker has a cost α when he is matched with a job. We assume α is constant and the job turn-over's cost is high enough; there will be no on-the-job search problem.[6]

The welfare of an employed worker at time t is

$$V_{E,t}(\alpha_t) = w - \alpha_t + \frac{1}{1+r}[(1-\delta)E_t V_{E,t+1}(\alpha_t) + \delta E_t V_{U,t+1}]$$

This formula tells us that the welfare of an employed worker today is equal to his wage minus his disutility $w - \alpha_t$ and discount factor, multiplied by his expected future welfare. His expected future welfare is equal to the probability that he is employed $1-\delta$ multiplied by the expected welfare of being unemployed in the future $E_t V_{E,t+1}(\alpha_t)$, plus the probability that he is unemployed in the future δ multiplied by the expected welfare of being unemployed $E_t V_{U,t+1}$.

Similarly, we can measure the welfare of the unemployed worker

$$V_{U,t}(\alpha_t) = 0 + \frac{1}{1+r}[h\int_0^{\underline{\alpha}} V_{E,t+1}(\alpha_{t+1})dF(\alpha) + (1-h\underline{\alpha})E_t V_{U,t+1}]$$

[6] In the next period, each worker may receive new job information which may bring him lower α, but he has to stay in his old position.

An unemployed worker's probability of accepting a job between t and $t+1$ is $hF(\underline{\alpha}) = h\underline{\alpha}$, and his probability of staying unemployed is $1 - h\underline{\alpha}$. The present welfare of an unemployed worker equals the present profit which is 0 and discounted expected future welfare which equals the expected welfare of being employed $h\underline{\alpha}\int_0^{\underline{\alpha}} V_{E,t+1}(\alpha_{t+1})dF(\alpha) = h\int_0^{\underline{\alpha}} V_{E,t+1}(\alpha_{t+1})d\alpha$, plus the expected welfare if he remains unemployed which is $1-h\underline{\alpha}$ times the expected welfare of staying unemployed in the future $E_t V_{U,t+1}$.

The formulas above show us the general form of worker's welfare. Because we assume that each worker's disutility on one job remains constant along the time and there is no on-the-job search, we have constant V_E and V_U for each specific α. This gives the simplified formulas

$$V_E = w - \alpha + \frac{1}{1+r}[(1-\delta)V_E + \delta V_U] \tag{1.4}$$

$$V_U = \frac{1}{1+r}[h\int_0^{\underline{\alpha}} V_E(\alpha)d\alpha + (1-h\underline{\alpha})V_U] \tag{1.5}$$

When the disutility of an unemployed worker α is equal to the cutoff disulity level $\underline{\alpha}$, and the welfare of being employed is the same as for being unemployed, we have the cutoff condition

$$V_E(\underline{\alpha}) = V_U \tag{1.6}$$

From (4), (5) and (6), we obtain the following three equations

$$rV_U = (w - \underline{\alpha})(1+r) \tag{1.7}$$

$$(r+\delta)V_E = (1+r)(w-\alpha) + \frac{\delta(1+r)}{r}(w-\underline{\alpha}) \tag{1.8}$$

$$(r+h\underline{\alpha})V_U = h\int_0^{\underline{\alpha}} V_E(\alpha)d\alpha \tag{1.9}$$

From (7) and (8), we can see that both V_E and V_U decrease with $\underline{\alpha}$, thus the cutoff value of disutility $\underline{\alpha}$ plays a negative role on the welfare of workers. Intuitively, as unemployed workers become more selective, $\underline{\alpha}$ is lower, the profit from working is higher at the cutoff. However, the frequency of job transmission will be higher because more unemployed workers will transfer the job information that they rejected to others. This will raise both the probability of hearing jobs and the expected welfare.

Plug equations (7) and (8) into equation (9), giving

$$(w-\underline{\alpha})(1+r)+\frac{h(1+r)}{r}\underline{\alpha}(w-\underline{\alpha}) = h[\frac{1+r}{r+\delta}w\underline{\alpha}-\frac{1+r}{r+\delta}\frac{1}{2}\underline{\alpha}^2+\frac{\delta(1+r)}{r(r+\delta)}w\underline{\alpha}-\frac{\delta(1+r)}{r(r+\delta)}\underline{\alpha}^2]$$

After simplifying the equation, we have a very important equation

$$h\underline{\alpha}^2 + 2(r+\delta)\underline{\alpha} = 2(r+\delta)w \tag{1.10}$$

The threshold disutility $\underline{\alpha}$ in the equilibrium is determined by a group of parameters related to the labor market, such as w, h, r, and δ. However we should take into consideration that h is also a function of $\underline{\alpha}$ as $h = \frac{v}{1-\lambda(1-\underline{\alpha})}$, then we have

$$\frac{v\underline{\alpha}^2}{1-\lambda(1-\underline{\alpha})} + 2(r+\delta)\underline{\alpha} = 2(r+\delta)w \tag{1.11}$$

Apparently $\underline{\alpha}$ is determined by r, δ, w and v. We derive $\underline{\alpha}$ with respect to the vacancy rate v, and find that $\underline{\alpha}$ decreases with v

$$\frac{\partial\underline{\alpha}}{\partial v} = \frac{-\frac{\underline{\alpha}^2}{[1-\lambda(1-\underline{\alpha})]}}{\frac{v\underline{\alpha}(2-2\lambda+\underline{\alpha}\lambda)}{[1-\lambda(1-\underline{\alpha})]^2}+2(r+\delta)} < 0$$

Secondly we derive it with respect to the wage rate w and find that $\underline{\alpha}$ increases with w

$$\frac{\partial\underline{\alpha}}{\partial w} = \frac{2(r+\delta)}{\frac{v\underline{\alpha}(2-2\lambda+\underline{\alpha}\lambda)}{[1-\lambda(1-\underline{\alpha})]^2}+2(r+\delta)} > 0$$

Finally, we derive it with respect to the discount rate r and the destruction rate δ, and find that $\underline{\alpha}$ increases both with r and δ

$$\frac{\partial\underline{\alpha}}{\partial r} > 0$$

Proposition 1.2.

i) As the vacancy rate v increases, the cutoff value of disutility $\underline{\alpha}$ decreases;

ii) As the wage w increases, the cutoff value of disutility $\underline{\alpha}$ increases;

iii) The cutoff value of disutility $\underline{\alpha}$ increases both with the discount rate r and the job destruction rate δ.

These results are intuitive, let us first take a look at the impact of vacancy rate v on $\underline{\alpha}$. As the vacancy rate becomes higher, there are more job opportunities for each worker which means that they have higher value of outside option, and therefore become more selective. In particular, those unemployed workers at the margin who would have otherwise accepted the job opportunity will now reject it because there are more opportunities.

Second, as the wage rate w becomes higher, working brings unemployed workers a higher reward and raises their expected return. When given a higher wage level, workers become less selective and more likely to accept the job.

Finally, we can observe that both the discount rate r and the job destruction rate δ have a positive impact on $\underline{\alpha}$. The higher these rates, the lower the present value of the future worker's welfare. Therefore the job's perspective deteriorate, and workers become less selective.

The threshold disutility of working $\underline{\alpha}$ depends on the outside economic environment, and indirectly impacts the frequency of job transmission in each social network, $s(1-\underline{\alpha})\frac{v}{\underline{\alpha}}$. When workers become more selective, $\underline{\alpha}$ is lower, and they transmit job information more frequently.

1.2.2.3 Unemployment Rate in the Steady State

In each period, a job is destroyed with probability δ. u_t is the unemployment rate and $1-u_t$ is the employment rate at the end of period t. The resulting employment rate after the job filling process is $1-u_t+u_th_tF(\underline{\alpha})$, $u_th_tF(\underline{\alpha})$ is the probability that an unemployed worker is newly employed whereas $1-u_t$ is the probability that an existing job is not destroyed. At the end of period t, the employment rate is

$$1-u_{t+1}=(1-\delta)[1-u_t+u_th_tF(\underline{\alpha})]$$

By assuming a uniform distribution of α, we have the steady state unemployment rate

$$u=\frac{\delta}{\delta+(1-\delta)h\underline{\alpha}}=\frac{\delta}{\delta+(1-\delta)\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}} \tag{1.12}$$

We can observe that the unemployment rate is a function of several parameters, such as the job depreciation rate and job arrival rate.The equilibrium condition gives us

$$\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})} + 2(r+\delta) = \frac{2(r+\delta)w}{\underline{\alpha}} \tag{1.13}$$

The derivation of $\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}$ with respect to v is

$$\frac{\partial[\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}]}{\partial v} = -2(r+\delta)w\underline{\alpha}^{-2}\frac{\partial\underline{\alpha}}{\partial v} > 0 \tag{1.14}$$

Therefore when the vacancy rate becomes higher, $\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}$ goes up and unemployment rate becomes lower. Similarly, when the wage becomes higher, $\underline{\alpha}$ increases and $\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}$ also increases, this drives down the unemployment rate.

Proposition 1.3.

i) As the vacancy rate v increases, the unemployment rate decreases;

ii) As the wage w increases, the unemployment rate decreases.

When there are more vacancies, though workers become more selective and have lower probability of accepting jobs, the first order effect of increasing vacancy rate v dominates and drives down the unemployment rate. Higher wages make workers become less selective and accept jobs more frequently, this also drives down the unemployment rate.

1.2.2.4 Network Effect

Clearly, with social networks, unemployed workers can hear job information with higher probability. The total derivative of equation (10) with respect to the job hearing rate h gives

$$\frac{\partial\underline{\alpha}}{\partial h} = -\frac{\underline{\alpha}^2}{2h\underline{\alpha} + 2(r+\delta)} < 0$$

The results show that the cutoff value of disutility decreases with the probability of hearing about a job because the probability of hearing job information with a social network h is greater than without it v. The cutoff value of disutility $\underline{\alpha}^N$ with a network is lower than that without a network $\underline{\alpha}^{NN}$, $\underline{\alpha}^{NN} > \underline{\alpha}^N$. This result shows that unemployed workers are more selective when they have a social network because they now have more outside options. According to equations (7) and (8), we conclude that with a social network, both the unemployed and employed workers' welfare is raised. Employed workers in particular benefit indirectly from the social network since each of them has a probability of losing his job in the next period; the benefit from the social contact lies in the increasing future expected profit.

Additionally, with regard to the welfare difference between the employed and unemployed workers $V_E - V_U$. We find that by introducing the social network, this difference will be shrink because the unemployed workers benefit more than employed workers. Therefore, with social networks, the inequality between employed and unemployed workers is reduced.

In an economy without social networks, unemployed workers can hear job information only through formal channels. So in the steady state, we have

$$1 - u = (1 - \delta)(1 - u) + (1 - \delta)uv\underline{\alpha}$$

The unemployment rate is $u = \frac{\delta}{\delta + (1-\delta)v\underline{\alpha}}$. Compared to the unemployment rate in an economy where there are social networks, we find the unemployment rate is higher when people are unable to receive job information from their social contacts.

Proposition 1.4.

i) The unemployed worker's welfare is raised by introducing social network;

ii) The employed worker's welfare is also raised, but to a less extent.

1.2.3 Non Segregation

In this paper, to focus our analysis on the network formed by unemployed workers, we assume that unemployed workers and employed workers do not know each other. Before going into further analysis, we also spend some time showing the difference between segregated and non-segregated labor markets from the social network perspective.

Without segregation, an unemployed worker knows su_t unemployed friends and $s(1-u_t)$ employed friends. To simplify our analysis, we assume that all workers have identical network size s and composition. Each employed worker also has su_t unemployed friends and $s(1-u_t)$ employed friends. A sorting problem does not arise here. Like before, the network size is assumed to be sufficiently large. Here we assume that all the circulated information will be transmitted to unemployed workers. The probability that an unemployed worker will receive job information becomes

$$h_t = v_t + \lambda[(1 - \underline{\alpha})h_t \frac{su_t}{su_t} + \frac{s(1 - u_t)}{su_t} v_t] \tag{1.15}$$

Without segregation, each unemployed worker can hear job information from two sources: one is his unemployed friends with probability $(1-\underline{\alpha})h_t\frac{su_t}{su_t}$, another one is his employed friends with probability $\frac{s(1-u_t)}{su_t}v_t$.

After simplification, the probability of hearing job information is

$$h = \frac{(v + \lambda\frac{1-u}{u}v)}{(1-\lambda(1-\underline{\alpha}))} \tag{1.16}$$

Clearly the probability of hearing job information is higher than that of the previous case in which the labor market is segregated. The dynamics of unemployment rate is

$$1 - u_{t+1} = (1-\delta)[1 - u_t + u_t h_t F(\underline{\alpha})]$$

in steady state, the unemployment rate is

$$u = \frac{\delta}{\delta + (1-\delta)h\underline{\alpha}} \tag{1.17}$$

We can directly observe from equation (14) that the unemployment rate is lower when the labor market is not segregated because the probability of accepting a job $h\underline{\alpha}$ is higher than that with segregation. Additionally, we have the cutoff disutility $\underline{\alpha} = \frac{2(r+\delta)w}{2(r+\delta)+h\underline{\alpha}}$, which indicates that $\underline{\alpha}$ decreases with $h\underline{\alpha}$, therefore the cutoff disutility without segregation is lower than that with segregation, $\underline{\alpha}^{SS} > \underline{\alpha}^{NS}$. In the labor market without segregation, unemployed workers have more opportunities to hear about jobs. Therefore the outside option improves and unemployed workers becomes more selective.

Since the cutoff disutility level $\underline{\alpha}^{NS}$ is lower without segregation, according to equation (8), we have $V_U^{NS} > V_U^{SS}$; unemployed workers benefit from non-segregation of the labor market.

1.3 Social Welfare

There are various ways to calculate the social welfare; normally it equals the sum of the welfare of all agents in the economy, and we denote it as Ω. The objective of the social planner here is to maximize the social welfare

$$\underset{\underline{\alpha_s},u(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[(1-u(s))\int_0^{\underline{\alpha_s}} V_E(\alpha_s)f(\alpha_s)d\alpha + u(s)V_U]ds$$

Normally, through maximization programs, we can obtain the social optimal threshold $\underline{\alpha}^{SO}$. By comparing $\underline{\alpha}^{SO}$ with the $\underline{\alpha}^{E}$ which is cutoff value of disutility in the equilibrium, we can see the social planner's preference. Using equations (4) and (5), we can obtain the value function of both unemployed and employed workers

$$V_U = \frac{h\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r(r+\delta+h\underline{\alpha})} = \frac{v\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r((r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha})} \tag{1.18}$$

and

$$V_E = \frac{(1+r)(w-\alpha)}{r+\delta} + \frac{\delta}{r+\delta}V_U \tag{1.19}$$

The law of motion of unemployment is

$$\dot{u_s} = \delta(1-u_s) - u_s\frac{v\underline{\alpha}_s}{1-\lambda(1-\underline{\alpha}_s)} \tag{1.20}$$

With equations (18), (19),(20) and objective function, we can solve the optimal $\underline{\alpha}^{SO}$. The state variable is unemployment rate u, and the control variable is $\underline{\alpha}$. But it is complicated to obtain the social optimal $\underline{\alpha}^{SO}$ directly. To deal with this problem, we try to plug equilirium $\underline{\alpha}$ into the first order condition of social optimum $\frac{\partial\Omega}{\partial\underline{\alpha}}$. Remember that equilibrium $\underline{\alpha}$ is determined by the equation

$$\frac{v\underline{\alpha}^2}{1-\lambda(1-\underline{\alpha})} + 2(r+\delta)\underline{\alpha} = 2(r+\delta)w$$

If $\frac{\partial\mathcal{H}}{\partial\underline{\alpha}} = 0$, then we can conclude that the equilibrium is social optimum, if $\frac{\partial\mathcal{H}}{\partial\underline{\alpha}} > 0$, then social planner prefers higher $\underline{\alpha}$ than equilibrium, if $\frac{\partial\mathcal{H}}{\partial\underline{\alpha}} < 0$, then social planner prefers lower $\underline{\alpha}$ than equilibrium.

We prove in the appendix that social optimal is lower than equilibrium, $\underline{\alpha}^{SO} < \underline{\alpha}^{E}$.

What is more, when workers become more selective, $\underline{\alpha}$ decreases. On one hand, this will raise the unemployed workers' welfare, and also employed workers' indirectly. This is because when they become more selective, they suffer less from working. On another hand, lower $\underline{\alpha}$ increases the unemployment rate, and make the expected benefit from being employed decrease, driving down the welfare of workers. For example, when $\underline{\alpha}$ is 0, all workers are unemployed, and welfare of workers is 0.

$$\frac{\partial\mathcal{H}}{\partial\underline{\alpha}}(\underline{\alpha}=0) = \frac{v(1+r)}{r}\frac{w}{(r+\delta)(1-\lambda)} + \frac{(1-\delta)v(1+r)}{\delta(1-\lambda)(r+\delta)} > 0 \tag{1.21}$$

Therefore, when unemployed workers are extremely selective, social welfare is not the maximum and there exists the room for improvement. We conclude in the following proposition.

Proposition 1.5. *Social planner prefers the unemployed workers to become more selective.*

The social planner chooses $\underline{\alpha}$ to maximize the social welfare. He wants to choose a lower reservation disutility $\underline{\alpha}^{SO}$ than the equilibrium value of $\underline{\alpha}^{E}$. This is due to the externality. When unemployed workers become more selective, they not only improve their own welfare, they also have a greater chance of providing job information to others and making other unemployed workers and employed workers (indirectly) better off. Since the workers do not take the latter effect into account, the equilibrium is not efficient. Therefore, comparing to the equilibrium condition, the welfare of each worker is higher, but there are more unemployed workers in the market.

In addition to showing that the equilibrium is not social optimum, we also show how the social optimal $\underline{\alpha}$ changes with the wage rate w. Similarly, the social optimal $\underline{\alpha}$ also increases with the wage. When wage becomes higher, social planner hopes unemployed workers become less selective and accept the job information more frequently.

1.4 Heterogeneous Size of Social Network

In the previous section, we discussed social networks in the labor market with and without segregation. A common feature among them is that unemployed workers do not differ in their social network sizes. Now we assume that there exists heterogeneity in the network sizes for unemployed workers, large vs. small. In each network, there is a fraction θ of unemployed workers who have large networks s^L, and $1-\theta$ who have small networks s^S. To simplify our analysis, we assume the labor market is segregated and there is no correlation between θ and s.[7] The probability of hearing job information for an unemployed worker with a large network and a small network are given below

$$h^L = v + \lambda[h^L \frac{\theta s^L(1-\underline{\alpha}^L)}{s^L} + h^S \frac{(1-\theta)s^L(1-\underline{\alpha}^S)}{s^S}]$$

$$h^S = v + \lambda[h^S \frac{(1-\theta)s^S(1-\underline{\alpha}^S)}{s^S} + h^L \frac{\theta s^S(1-\underline{\alpha}^L)}{s^L}]$$

[7] In general, there exists sorting problem. Those unemployed workers with large networks (we can call them "social" people) will cluster together.

h^L is the probability of hearing job information for those unemployed workers with large networks. The first term inside bracket $h^L \frac{\theta s^L(1-\underline{\alpha}^L)}{s^L}$ is the probability of hearing job information from his unemployed friends who also have large networks. The second term $h^S \frac{(1-\theta)s^L(1-\underline{\alpha}^S)}{s^S}$ is the probability of hearing job information from his unemployed friends with small networks. Similarly, h^S is the probability of hearing job information for unemployed workers with small network. The first term inside bracket $h^S \frac{(1-\theta)s^S(1-\underline{\alpha}^S)}{s^S}$ is the probability of hearing information from his unemployed friends who also have small networks, and the second term $h^L \frac{\theta s^S(1-\underline{\alpha}^L)}{s^L}$ is the probability of hearing job information from his unemployed friends who have large networks.

We denote $\frac{s^L}{s^S} = \eta > 1$ as the degree of size difference. By rearranging the two equations above, we have the probability of hearing job information for each type of unemployed worker

$$h^L = \frac{v + \lambda v(1 - \underline{\alpha}^S)(1 - \theta)(\eta - 1)}{1 - \lambda(1 - \underline{\alpha}^L)\theta - \lambda(1 - \underline{\alpha}^S)(1 - \theta)} \tag{1.22}$$

$$h^S = \frac{v + \lambda v(1 - \underline{\alpha}^L)\theta(\frac{1}{\eta} - 1)}{1 - \lambda(1 - \underline{\alpha}^L)\theta - \lambda(1 - \underline{\alpha}^S)(1 - \theta)} \tag{1.23}$$

We can see that the probability of hearing job information for an unemployed worker with a large network depends not only on his own cutoff value of disutility $\underline{\alpha}^L$ but also on the cutoff disutility of unemployed worker with a small network $\underline{\alpha}^S$. As for the unemployment rate, in the steady state, we have

$$(1 - u)\delta = \theta u h^L \underline{\alpha}^L + (1 - \theta)u h^S \underline{\alpha}^S$$

So in the equilibrium, the unemployment rate is

$$u = \frac{\delta}{\delta + (1 - \delta)[\theta h^L \underline{\alpha}^L + (1 - \theta)h^S \underline{\alpha}^S]} \tag{1.24}$$

1.4.1 Effects of Degree of Size Difference η

It is not easy to see the effects of size difference η directly on each unknown since $\underline{\alpha}^L$ and $\underline{\alpha}^S$ have cross effects on each other and the equations are non-linear. Here we will simply show the numerical results.We have four equations that determine four unknowns h^L, $\underline{\alpha}^L$, $h^S$and $\underline{\alpha}^S$

$$h^L = \frac{v + \lambda v(1 - \underline{\alpha}^S)(1 - \theta)(\eta - 1)}{1 - \lambda(1 - \underline{\alpha}^L)\theta - \lambda(1 - \underline{\alpha}^S)(1 - \theta)} \tag{1.25}$$

$$h^S = \frac{v + \lambda v(1-\underline{\alpha}^L)\theta(\frac{1}{\eta}-1)}{1-\lambda(1-\underline{\alpha}^L)\theta - \lambda(1-\underline{\alpha}^S)(1-\theta)} \tag{1.26}$$

$$h^L(\underline{\alpha}^L)^2 + 2(r+\delta)\underline{\alpha}^L = 2(r+\delta)w \tag{1.27}$$

$$h^S(\underline{\alpha}^S)^2 + 2(r+\delta)\underline{\alpha}^S = 2(r+\delta)w \tag{1.28}$$

We can observe from equations (25) and (26) that $h^L > h^S$ because the size difference is greater than 1, $\eta > 1$. Using equations (27) and (28), we know that h decreases with $\underline{\alpha}$, therefore we can obtain indirectly

$$\underline{\alpha}^L < \underline{\alpha}^S \tag{1.29}$$

Proposition 1.6. *When there is size difference between the social networks, the unemployed workers with large networks are more selective than those with small networks.*

According to equations (27) and (28), we can also calculate the relationship between the probability of accepting a job $h\underline{\alpha}$ and the cutoff disutility $\underline{\alpha}$

$$h\underline{\alpha} = \frac{2(r+\delta)w}{\underline{\alpha}} - 2(r+\delta) \tag{1.30}$$

Clearly, the unemployed workers with large networks accept jobs with higher probability, and have higher welfare.[8]

As η increases from 1 to 10, the figure below shows us the effect of η on the cutoff disutility of each type of unemployed worker, unemployment and difference in the cutoff disutility between two types of workers. When η increases, the unemployed workers who have large networks become more selective as $\underline{\alpha}^L$ decreases but those who have small networks become less selective as $\underline{\alpha}^S$ increases. This is because the increasing size difference will simply reinforce the advantage of higher probability of hearing job information for the unemployed workers who have large networks. We can observe the simulation results from the figure below.

As the welfare of unemployed workers decreases with the cutoff disutility, we can conclude that the unemployed workers with large networks benefit from the increasing size difference but unemployed workers with small networks are worse off.

[8] Since in the equilibrium, we have $V_E(\underline{\alpha}) = V_U$, implying that $V_U = \frac{1+r}{r}(w - \underline{\alpha})$.

As for unemployment evolution, since $\underline{\alpha}^L$ decreases and $\underline{\alpha}^S$ increases, we have that $h^L\underline{\alpha}^L$ increases and $h^S\underline{\alpha}^S$ decreases. So the unemployed workers who have large networks accept the jobs with higher probability and those with small networks accept the jobs with lower probability. Furthermore, the unemployed workers with large networks are relatively more sensitive to changes in network size difference because they are more dependent on the network for job information. From equation (25) and (26), we can see that the marginal effect of size difference η on probability of hearing job information for unemployed workers with large networks is

$$h^L = \frac{\lambda v(1-\underline{\alpha}^S)(1-\theta)}{1-\lambda(1-\underline{\alpha}^L)\theta - \lambda(1-\underline{\alpha}^S)(1-\theta)} \tag{1.31}$$

And the marginal effect of size difference η on probability of hearing job information for unemployed workers with small networks is

$$h^S = \frac{-\lambda v(1-\underline{\alpha}^L)\theta(\frac{1}{\eta^2})}{1-\lambda(1-\underline{\alpha}^L)\theta - \lambda(1-\underline{\alpha}^S)(1-\theta)} \tag{1.32}$$

Clearly, when size difference η increases, the change in probability of hearing job information for unemployed workers with large networks would be much higher than that for those with small networks, indirectly the increase in probability of job acceptance for unemployed workers with large networks is also much higher than that for unemployed workers with small networks. Therefore, we expect that when size difference η increases, the unemployment rate becomes lower.

1.4.2 Effects of θ

Another parameter which captures the degree of heterogeneity between the two cohorts is the proportion of unemployed workers with large networks θ. It can be seen as a factor which reflects the closeness of the social relationship. A higher θ means that the society becomes more social and personal connections are more intense.

As θ increases from 0 to 1, the figure below shows us the effect of θ on the job acceptance rate of each type of unemployed worker, and the unemployment rate.

By using the equation (25) and equation (26), we can find that both h^L and h^S decrease with θ. Therefore, we can conclude that both $\underline{\alpha}^L$ and $\underline{\alpha}^S$ increase with θ. Looking at the results of the simulation, we can also observe this trend. As society becomes more social, all unemployed workers have a larger number of social friends, and the interaction between people becomes closer. However, the unemployed workers do not benefit from it. For each unemployed worker, the job opportunities available from his friends decreases because when more of his friends become social; the number of competitors for the job information increases. This "dilution effect" makes all unemployed workers become worse off.

In addition, as for the inequality, or equivalently $(\underline{\alpha}^S - \underline{\alpha}^L)$, when θ increases, the difference becomes smaller. Intuitively, as more and more unemployed workers have large networks, it eventually reduces the inequality.

As for the unemployment trend, the term $\theta(h^L\underline{\alpha}^L - h^S\underline{\alpha}^S) + h^S\underline{\alpha}^S$ determines the trend of unemployment rate. The derivative of this term is $h^L\underline{\alpha}^L - h^S\underline{\alpha}^S + \theta\frac{\partial h^L\underline{\alpha}^L}{\partial\theta} + (1-\theta)\frac{\partial h^S\underline{\alpha}^S}{\partial\theta}$. Because $\underline{\alpha}^L < \underline{\alpha}^S$ and $\frac{\partial h\underline{\alpha}}{\partial\underline{\alpha}} < 0$ we have that $h^L\underline{\alpha}^L - h^S\underline{\alpha}^S$ is positive and both $\frac{\partial h^L\underline{\alpha}^L}{\partial\theta}$ and $\frac{\partial h^S\underline{\alpha}^S}{\partial\theta}$ are negative. When θ is close to 0, $h^L\underline{\alpha}^L$ is very large and $h^S\underline{\alpha}^S$ is very small. As θ increases, it puts more weight on the $h^L\underline{\alpha}^L$ and less weight on the $h^S\underline{\alpha}^S$, therefore the composition effect dominates and the unemployment rate decreases. When θ is large enough, however, the decrease in $h^L\underline{\alpha}^L$ and $h^S\underline{\alpha}^S$ can be large enough to dominate the composition effect, thus raising unemployment.

1.5 Investment in Social Network

Our previous results showed that $h^L > h^S$ and $\underline{\alpha}^L < \underline{\alpha}^S$. According to the welfare of unemployed workers in the equilibrium: $rV_U = (w - \underline{\alpha})(1 + r)$, we have $V_U^L > V_U^S$. Therefore, those unemployed workers with small networks have incentive to make an investment in enlarging their networks in order to raise their welfare.

When more workers expand their networks, θ increases and all unemployed workers become worse off because of the dilution effect. However, if unemployed workers with small networks make investments in expanding their size of networks, they will gain a positive benefit. Moreover, the benefit from the investment decreases with the number of investors because the welfare difference between two types of workers $V_U^L - V_U^S$ decreases with the proportion of network members who have large networks θ.

For those unemployed workers who have small networks, there is an investment cost c to enlarge the network size. For example, they have to spend time or exert effort to make more contacts. To simplify our analysis, we assume a constant cost c. If $c < V_U^L - V_U^S$, the benefit from expanding network size is greater than the cost of investment, and it is worth to make such an investment. Furthermore, the highest cost that unemployed workers with small networks can afford $\overline{c(\theta)}$ is $V_U^L(\theta) - V_U^S(\theta) = \frac{(1+r)(\underline{\alpha}^S(\theta) - \underline{\alpha}^L(\theta))}{r}$ decreases with θ as well.

1.5.1 Determination of θ

Currently, the proportion of unemployed workers with large networks θ is endogenously determined. To simply our analysis, we assume that initially all unemployed workers have small networks and workers are able to enlarge their network size. To obtain the equilibrium θ, we keep equations (25), (26), (27) and (28), and add an cutoff condition at which the cost of investment and the benefits of expanding one's network balance each other

$$c = (V_U^L - V_U^S) = \frac{(1+r)(\underline{\alpha}^S - \underline{\alpha}^L)}{r} \tag{1.33}$$

This cutoff condition indirectly determines the equilibrium θ. When the investment cost is larger, less unemployed workers will invest in expanding their network size.

We also do a simulation exercise to illustrate the impact of investment cost on the proportion of unemployed workers with large networks. The parameters value is chosen in the table below.

Then we can see how the θ changes when the cost of investment varies. Clearly, the lower the investment cost, the more unemployed workers will invest to expand their networks.

1.5.1.1 Interaction of η and θ

As we presented before, both η and θ capture the degree of heterogeneity in unemployed workers. Now let us consider the interaction between the two, that is, how the change in η affects θ. As we analyzes before, increase in η raises the difference in welfare of workers and enlarges the inequality of two types of workers. This increases the extra benefit of owning a large network and clearly will make more unemployed workers with small networks make investment.

1.5.2 Comparative Statics

Then we investigate the effects of change in the wage level and vacancy rate on the proportion of unemployed workers with large networks θ. According to equations (25), (26), (27) and (28), we should take a look at the impacts of wage w and vacancy rate v on $\underline{\alpha}^S - \underline{\alpha}^L$, then we can see how they affect θ.

As we analysed before, higher wage compensates more to workers, hence making workers become less selective and can stand for greater disutility of working. Therefore, both $\underline{\alpha}^L$ and $\underline{\alpha}^S$ increases with wage. As for $\underline{\alpha}^S - \underline{\alpha}^L$, an interesting feature is the non monotonicity of the relationship. If the wage is small, i.e. if w is close to zero, then the welfare of both workers are zero and the difference between $\underline{\alpha}^L$and $\underline{\alpha}^S$ is close to 0. When the wage becomes too large, both $\underline{\alpha}^L$ and $\underline{\alpha}^S$ are close to 1, therefore the difference between the two disappears as well.

Similarly, when the vacancy rate v is increases, both $\underline{\alpha}^L$ and $\underline{\alpha}^S$ decrease with wage. As for $\underline{\alpha}^S - \underline{\alpha}^L$, we find it may also follow a non-monotone pattern, when v is small and close to zero, the welfare of both workers are zero and the difference between $\underline{\alpha}^L$and $\underline{\alpha}^S$ is close to 0. And for the same reasoning, when v is too large, both $\underline{\alpha}^L$ and $\underline{\alpha}^S$ are close to 0, therefore the difference between the two also disappears.

Therefore, when the wage or vacancy rate changes, how the proportion of unemployed workers investing in expanding network changes is ambiguous.

1.6 Conclusion

The main goal of this paper is to learn how social networks formed exclusively by unemployed workers play a role in the job search process. We develop a simple model with an endogenous reservation of workers' job dissatisfaction; someone refuses the job because the disutility of working is higher than his reservation disutility. We find that this reservation disutility depends on a set of parameters associated with working conditions like wage rate and the vacancy rate in the labor market. When the wage increases or the vacancy rate decreases, workers become less selective, hence the cutoff disutility of working increases. In addition, the change in the cutoff value of disutility indirectly impacts the frequency of job transmission.

First, when the social networks are equal in size, the unemployed and employed workers' welfare are higher than that in an economy without social networks, because workers have better outside options given that they have higher probability of hearing job information. Moreover, the unemployment rate will be lower. On one hand, when people hear about more jobs, they have a higher probability of accepting a job. On the other hand, when they have better outside options and become more selective, it decreases the probability that they will accept a job. Within our setup, the former effect dominates the latter one, workers accept jobs more often than that without social networks, reducing the unemployment rate.

Second, we prove that the equilibrium is not efficient. This is due to the externality. The social planner prefers that workers be more selective than in the equilibrium because not only are the workers themselves better off, but it also makes it more likely that other unemployed workers who can hear job information more frequently become better off.

Next, we extend the model by introducing the network's size difference, large vs. small. Increasing the size difference between networks is beneficial to unemployed workers who have large networks but harmful to those who have small ones; the unemployment rate decreases along with the size difference. Additionally, we find that all unemployed workers will lose as the proportion of unemployed workers with a large network in each network increases. The unemployment rate may follow a non-monotone pattern. Finally, we investigate investments in developing social networks and see how the proportion of workers investing in expanding social networks is determined. Our quantitative results illustrate that when the investment cost decreases or the size difference increases, the proportion of unemployed workers who have large social networks increases. However, when the wage or vacancy rate change, the impact is ambiguous.

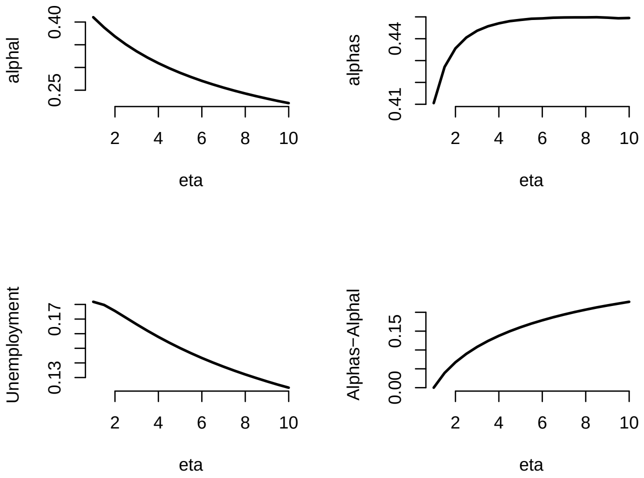


FIGURE 1.1: Impact of Size Difference

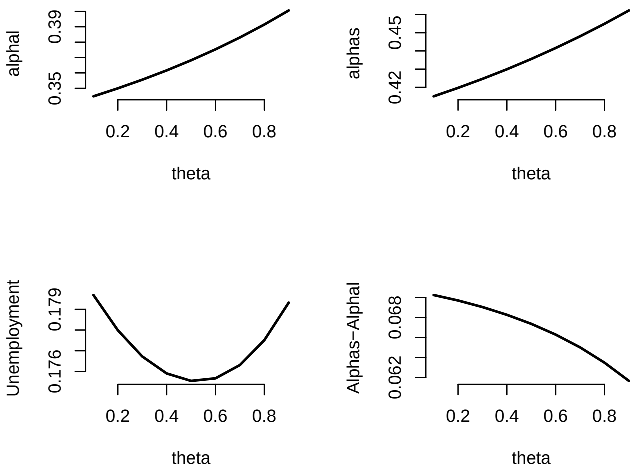


FIGURE 1.2: Effect of Composition Difference

TABLE 1.1: Parameters for Simulation Exercise

η	δ	r	w	v	θ_o
1.1	0.1	0.03	1	0.5	0.05

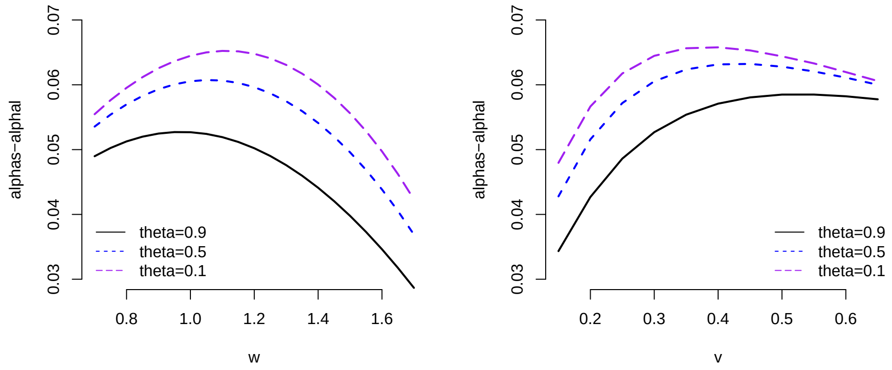


FIGURE 1.3: Effect of Wage and Vacancy Rate on $\underline{\alpha}^S - \underline{\alpha}^L$

Chapter 2

Another Look at Two-Tier Unemployment Compensation Reforming: The Role of Labor Market Institutions

2.1 Introduction

There has been an increasing of interest in analyzing the impact of unemployment compensation on unemployment rate and welfare these days. Most recent papers use search models where wages are set through individual Nash bargaining between the worker and the employer, and they do not take into account the impact of collective bargaining in the wage setting process. However, the impact is important because for many European countries, collective bargaining plays an important role in the wage setting process, for example, according to OECD report, 95% of workers are covered by collective bargaining in France, 92% in Sweden and 90% in Finland. However, in countries like the U.S., Canada, and Japan, very low percentage of workers are covered by collective bargaining.[1]

In a two-tier compensation regime, after unemployment insurance exhausted, unemployment assistance program and other social security begin to work, the objective of which are to provide financial assistance to people who have no other income to meet their basic needs of food, clothing and shelter. Both unemployment insurance (UI) and unemployment assistance (UA) vary across countries. European countries have more generous system than U.S., for example, Sweden's UI achieves 70% and UA achieves 40% of the

[1] In U.S., only 12% of workers are covered by collective bargaining.

salary, France's UI achieves 57% and UA achieves 20% of salary. However, in U.S., UI only achieves 30% of the salary and there is no formal unemployment assistance. Referring to the recent literatures that study the two-tier compensation reforming, Freriksson and Holmlund (1998) first show that two-tier compensation system is superior to a system with constant unemployment insurance. In a model which is similar to the one of Fredriksson and Holmlund, Cahuc and Lehmann (1999) study the importance of two-tier compensation system on wage formation. Most recently, Ortega and Rioux (2010) build a new channel for the re-entitlement effect where non-automatic eligibility accounts for the wage difference between entitled and non-entitled employed workers. They analyze re-entitlement effects for three countries, showing that the optimal compensation system is characterized by time-decreasing unemployment benefits and non-automatic eligibility for UI. However, in all these relevant literatures, authors use benchmark matching model developed by Pissarides (1992), wages are determined through individual Nash bargaining. They do not analyze the role of wage setting schemes in determining the impact of two-tier compensation reforming.

The present paper re-analyzes the impact of two-tier unemployment compensation reforming taking into account of the role of labor market institutions, specifically how the wage is set. We construct a stylized Pissarides style search model where wages are respectively set through collective and individual Nash bargaining. Collective bargaining is modeled using a monopoly union model where the union sets the wage at first, then the firm chooses employment at second. Union includes all types of workers, entitled and non-entitled, and it posts the same wage for all workers, this is different with that when the wage is set through individual Nash bargaining.

The model is calibrated using parameters for one country with pervasive individual Nash bargaining, U.S., and for another country with pervasive collective bargaining, France. We mainly investigate the effectiveness of two-tier unemployment compensation reforming when the wage is set through collective bargaining and compare it with that when the wage is set through individual Nash bargaining. We show that when the contribution time required to obtain UI eligibility becomes shorter, both unemployment and wage decrease when the wage is determined through collective bargaining, and unemployment rate goes up when the wage is determined through individual Nash bargaining. Therefore, the re-entitlement effects on unemployment are different when the wage is determined differently. Similarly, when the unemployment assistance improves, we can observe the same results. Moreover, when the duration of eligibility after becoming unemployed becomes shorter or when the level of unemployment insurance decreases, unemployment rate goes down no matter how the wage is determined. In addition, we also do a counterfactual simulation for each country. We show that for both countries, if the wage is set collectively, the unemployment rate and wage become higher, and workers' welfare and social surplus are lower. Therefore, setting wage through individual Nash bargaining is more efficient.

This paper is the first one which studies the role of wage-setting scheme in affecting the effectiveness of the two-tier compensation reforming. It shows that the different wage-setting schemes have quite different impacts on the unemployment and wage trends.

The rest of the paper is organized as follows. In section 2, we construct the basic ingredients of the model and obtain the optimal solution of the firm. In section 3 and section 4, we solve the equilibrium respectively when the wage is set through collective bargaining and individual Nash bargaining. In section 5, we undertake a calibration exercise using U.S. labor market data and French labor market data. Based on the calibrated models, we do simulation exercises to see how the the two-tier compensation reforming policies affect the unemployment rate and wage levels. In addition, we also do a counterfactual exercise to see the results when the U.S. and France adopt different compensation policies. In section 6, we make an extension where the union has different preferences on different types of workers. Section 7 concludes.

2.2 Model set up

We consider a two-tier labor market with two types of unemployed workers, entitled with unemployment insurance (UI) and non-entitled with unemployment assistance (UA). When a non-entitled worker becomes employed, he can not obtain eligibility automatically, but has to wait until his or her contribution time on work is long enough. The required length of time belongs to institutional policy and varies across countries.[2] And once an entitled worker becomes unemployed, he or she will not lose eligibility instantaneously but receive UI benefits for some period. We call this benefit duration or UI spell, as we can observe from data, the UI spell has big difference across countries.[3] After worker loses the eligibility of UI, he or she will be entitled with unemployment assistance (UA) which is normally lower than UI.[4] Additionally, not all countries provide UA program, like in U.S., there is no official unemployment assistance but other programs usually provide assistance for those unemployed workers who have lost UI eligibility in form of food stamps. At last, if an entitled unemployed worker (who did not lose his previous UI eligibility) becomes re-employed, his entitlement will continue.

[2] For example, in order to become entitled, the required length of contribution time on job is 20 weeks in US since year 2002 and 6 months in 22 in France since year 2004.

[3] In US, the UI benefits can be paid for a maximum of 26 weeks (since year 2002), and in France, it can be paid at maximum 23 months (since year 2004).

[4] In Fredriksson, P. and B. Holmlund (2001), they gave proof that UI should be higher than UA in optimal.

The main features of the model are as follows. There is a continuum of infinitely-lived risk-neutral workers and firms, with a common discount rate $r > 0$. The number of workers is normalized to 1. For sake of simplicity, we assume that all types workers have identical job destruction rates.[5]

The two types of workers, entitled and non entitled, we assume that they have the same productivity, thus they can be perfectly substituted. Non-entitled employed worker will obtain entitlement of unemployed insurance with probability σ per unit of time, equivalently, the required contribution time on the job is $1/\sigma$. And when worker becomes unemployed, he will lose his entitlement with probability d, that is, the UI spell is $1/d$. These two parameters can evaluate flow effect between the two group, for instance, if $d = 0$, there will be no non-entitled workers eventually and unemployed insurance will be paid permanently unless unemployed worker becomes re-employed. On the contrary, if $\sigma = 0$ there will be no entitled workers eventually. Additionally, unemployed insurance is denoted by b_e and unemployed assistance is b_n.

Like many literatures do, firms post vacancies and transitions into employment are endogenously determined by a Cobb-Douglas matching function $m(u, v) = mu^{\alpha}v^{1-\alpha}$?la Pissarides (2000). Therefore, we have matching rate $mq(\theta) = \frac{mu^{\alpha}v^{1-\alpha}}{v}$ for unfilled vacancies and $m\theta q(\theta) = \frac{mu^{\alpha}v^{1-\alpha}}{u}$ for the unemployed workers. And labor market tightness is given by $\theta = v/u$, where v and u are respectively the numbers of vacancies and unemployed workers. m captures the degree of mismatching between the two or matching efficiency. A lower level of m signifies higher degree of mismatching or equivalently lower matching efficiency. Finally, keeping vacant job is costly for each firm and the flow cost per unit of time is c.

2.2.1 Transition Dynamics and Unemployment in Steady State

Denote by L_e the number of employed workers with eligibility, L_n the number of employed workers without eligibility, u_e the number of unemployed workers with eligibility, and u_n the number of unemployed workers without eligibility.

The dynamic equation of entitled unemployed worker is

$$\dot{u}_e = \lambda L_e - du_e - m\theta q(\theta)u_e \tag{2.1}$$

There are λL_e entitled workers flowing into unemployment per unit of time, at the same time, there are du_e entitled unemployed workers losing eligibility and $m\theta q(\theta)u_e$

[5] In fact, they have different job destruction rates, job contracts of non-entitled workers are more temporary.

entitled unemployed workers becoming employed. Respectively, the dynamic equation of non-entitled unemployed worker is

$$\dot{u}_n = \lambda L_n + du_e - m\theta q(\theta)u_n \tag{2.2}$$

Another dynamic equation of entitled employed workers is

$$\dot{L}_e = -\lambda L_e + \sigma L_n + m\theta q(\theta)u_e \tag{2.3}$$

There are λL_e entitled workers becoming unemployed, σL_n non-entitled employed workers gaining eligibility, and $m\theta q(\theta)u_e$ entitled unemployed workers becoming employed. Another dynamic equation of non-entitled unemployed worker is

$$\dot{L}_n = -\lambda L_n - \sigma L_n + m\theta q(\theta)u_n \tag{2.4}$$

Assume that we have measure 1 of whole working population

$$u_n + L_n + u_e + L_e = 1 \tag{2.5}$$

The steady-state equilibrium number of workers in each state can obtained by imposing $\dot{u}_e = \dot{u}_n = \dot{n}_e = \dot{n}_n = 0$. We then have each dynamic variable's value by using equations (1), (2), (3), (4) and (5). And we can also obtain the following relationships

$$u_e = \frac{\lambda}{d + m\theta q(\theta)} L_e \tag{2.6}$$

and

$$u_n = \frac{\lambda + \sigma}{m\theta q(\theta)} L_n \tag{2.7}$$

These two equations give us the unemployment rate for each type of worker. Using (5), (6) and (7), we have

$$(1 + \frac{\lambda}{d + m\theta q(\theta)})L_e + (1 + \frac{\lambda + \sigma}{m\theta q(\theta)})L_n = 1 \tag{2.8}$$

2.2.2 Worker

For workers, we have four standard bellman equations below. The asset value to the employed workers who are entitled with eligibility of UI is

$$rV_{E,e} = w_e(1-t) + \lambda(V_{U,e} - V_{E,e}) \tag{2.9}$$

Each entitled employed worker obtains a flow profit of $w_e(1-t)$, where t is the taxation rate. And λ is probability that the job is destroyed per unit of time. The asset value of each employed worker who is not entitled is

$$rV_{E,n} = w_n(1-t) + \lambda(V_{U,n} - V_{E,n}) + \sigma(V_{E,e} - V_{E,n}) \tag{2.10}$$

Non-entitled employed worker has a flow income $w_n(1-t)$. Since UI eligibility can not obtained automatically, in average, non-entitled unemployed worker has probability σ of becoming eligible. The asset value of unemployed workers who are eligible is

$$rV_{U,e} = b_e + m\theta q(\theta)(V_{E,e} - V_{U,e}) + d(V_{U,n} - V_{U,e}) \tag{2.11}$$

Entitled unemployed worker get b_e from unemployed insurance, he matches with a vacancy at rate $m\theta q(\theta)$. What is more, each non-entitled worker has probability d of losing his eligibility since the entitlement is not permanent. Finally, the asset value of unemployed workers who are not entitled with UI is

$$rV_{U,n} = b_n + m\theta q(\theta)(V_{E,n} - V_{U,n}) \tag{2.12}$$

Non-entitled unemployed worker has a flow income b_n which is unemployed assistance. Equation (9)-(11) gives the rent of entitled workers being employed

$$V_{E,e} - V_{U,e} = \frac{w_e(1-t) - b_e}{r + \lambda + m\theta q(\theta)} + \frac{d}{r + \lambda + m\theta q(\theta)} \frac{b_e + [\frac{m\theta q(\theta)(1-t)}{r+\lambda+\sigma}](w_e - w_n)(1-t) - b_n}{r + m\theta q(\theta) + d - \lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}}$$

Similarly, equation (10)-(12) gives the rent of non-entitled workers being unemployed

$$V_{E,n} - V_{U,n} = \frac{w_n(1-t) - b_n}{r + \lambda + m\theta q(\theta)} + \frac{\sigma}{r + \lambda + m\theta q(\theta)} \frac{(w_e - w_n)(1-t) + \lambda\frac{b_e}{r+m\theta q(\theta)+d} - \lambda\frac{b_n}{r+m\theta q(\theta)+d}}{r + \lambda + \sigma - \lambda m\theta q(\theta)\frac{1}{r+m\theta q(\theta)+d}}$$

2.2.3 Firm

Now the objective function of firm becomes

$$\underset{L_e(s),L_n(s),V(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[A(L_e(s)+L_n(s))^{\gamma} - w_e(s)L_e(s) - w_nL_n(s) - cV(s)]ds \quad (2.13)$$

V is the number of vacancies unfilled. The dynamics of entitled as well as non-entitled employed workers are

$$\dot{L_e}(t) = mq(\theta(t))V(t)\frac{u_e(t)}{u_e(t)+u_n(t)} - \lambda L_e(t) + \sigma L_n(t) \quad (2.14)$$

and

$$\dot{L_n}(t) = mq(\theta(t))V(t)\frac{u_n(t)}{u_e(t)+u_n(t)} - \lambda L_n(t) - \sigma L_n(t) \quad (2.15)$$

The current value of Hamiltonian for the firm can be written as

$$\begin{aligned} \mathcal{H} = {} & A(L_e+L_n)^{\gamma} - w_eL_e - w_nL_n - cV \\ & + \phi_1(mq(\theta)V\frac{u_e}{u_e+u_n} - \lambda L_e + \sigma L_n) + \phi_2(mq(\theta)V\frac{u_n}{u_e+u_n} - \lambda L_n - \sigma L_n) \end{aligned} \quad (2.16)$$

If we only consider the steady state equilibrium, we have the following three first order conditions

$$\frac{\partial \mathcal{H}}{\partial V} = -c + \phi_1 mq(\theta)\frac{u_e}{u_e+u_n} + \phi_2 mq(\theta)\frac{u_n}{u_e+u_n} = 0 \quad (2.17)$$

$$\frac{\partial \mathcal{H}}{\partial L_e} = A\gamma(L_e+L_n)^{\gamma-1} - w_e - \phi_1\lambda = \phi_1 r \quad (2.18)$$

$$\frac{\partial \mathcal{H}}{\partial L_n} = A\gamma(L_e+L_n)^{\gamma-1} - w_n - \phi_2\lambda + \phi_1\sigma - \phi_2\sigma = \phi_2 r \quad (2.19)$$

Here the number of vacancies is the state variable and number of workers with different titles are control variables. Plug equation (18) and (19) into (17), we have the job creation condition on the labor demand side

$$\frac{c(r+\lambda)}{mq(\theta)} = (A\gamma(L_e+L_n)^{\gamma-1} - w_e)\frac{u_e}{u_e+u_n} + ((\frac{r+\lambda}{r+\lambda+\sigma})(A\gamma(L_e+L_n)^{\gamma-1} - w_n) + \frac{\sigma}{r+\lambda+\sigma}(A\gamma(L_e+L_n)^{\gamma-1} - w_e))\frac{u_n}{u_e+u_n} \tag{2.20}$$

Free entry condition implies that there is no extra profit from opening a new vacant job. So in the equilibrium, $V = 0$. In addition, we assume that the productivity of workers is identical no matter what is the status of entitlement of workers. Therefore for each firm, in terms of the productivity, they can be perfectly substituted.

2.3 Wage Determination by Unions

As we mentioned earlier, wages are proposed by unions in the first stage. Following the common practice in the literature, union chooses w_e and w_n to maximize the surplus or the rent of their members, anticipating the relationship between the wage demand for workers, w_e and w_n, and the labor market equilibrium conditions.[6]

The total number of union members is $n_e + n_n$ and $L_e + L_n$ of them are employed, then the expected welfare of a union member is given by

$$rL_eV_{E,e} + rL_nV_{E,n} + r(n_e - L_e)V_{U,e} + r(n_n - L_n)V_{U,n}$$

If the firm rejects the union's wage offer, then members become unemployed, entitled workers get their unemployment income $rV_{U,e}$ and non-entitled workers get their unemployment income $rV_{U,n}$. Therefore, the union's objective is to maximize the aggregate surplus or rent of its members given by

$$rL_eV_{E,e} + rL_nV_{E,n} + r(n_e - L_e)V_{U,e} + r(n_n - L_n)V_{U,n} - rn_eV_{U,e} - rn_nV_{U,n} = r(V_{E,e} - V_{U,e})L_e + r(V_{E,n} - V_{U,n})L_n \tag{2.21}$$

For simplification, I assume that each union does not discriminate the workers with different titles and set wage at the same level for all workers. That is $w_e = w_n = w$.

The subgame perfect equilibrium where the union proposes a wage at first and then the firm decides on how many workers it wants to hire by maximizing (21) subject to 2

[6]This set-up is also applied in Priya Ranjan (2013) in his paper.

constraints, one is equilibrium job creation condition which is derived from (20)

$$A\gamma(L_e + L_n)^{\gamma-1} = w + \frac{c(r+\lambda)}{mq(\theta)} \tag{2.22}$$

Another one is from the fact that the sum of employed and unemployed workers qual the whole working population which is normalized to 1

$$(1 + \frac{\lambda}{d + m\theta q(\theta)})L_e + (1 + \frac{\lambda+\sigma}{m\theta q(\theta)})L_n = 1 \tag{2.23}$$

The union's objective is to choose the right wage level w in order to maximize $r(V_{E,e} - V_{U,e})L_e + r(V_{E,n} - V_{U,n})L_n$ given the two constraints (22) and (23)

$$L = r(V_{E,e} - V_{U,e})L_e + r(V_{E,n} - V_{U,n})L_n + \psi[A\gamma(L_e + L_n)^{\gamma-1} - w - \frac{c(r+\lambda)}{mq(\theta)}] + \varphi[1 - (1 + \frac{\lambda}{d + m\theta q(\theta)})L_e - (1 + \frac{\lambda+\sigma}{m\theta q(\theta)})L_n]$$

The first order conditions are

$$\frac{\partial L}{\partial L_e} = r(V_{E,e} - V_{U,e}) - \psi A\gamma(1-\gamma)(L_e + L_n)^{\gamma-2} - \varphi(1 + \frac{\lambda}{d + m\theta q(\theta)}) = 0 \tag{2.24}$$

$$\frac{\partial L}{\partial L_n} = r(V_{E,n} - V_{U,n}) - \psi A\gamma(1-\gamma)(L_e + L_n)^{\gamma-2} - \varphi(1 + \frac{\lambda+\sigma}{m\theta q(\theta)}) = 0 \tag{2.25}$$

$$\frac{\partial L}{\partial w} = \frac{r}{r + \lambda + m\theta q(\theta)}(L_e + L_n)(1-t) - \psi = 0 \tag{2.26}$$

Plug equation (26) to (25), we have

$$\varphi = \frac{r(V_{E,n} - V_{U,n}) - \frac{r}{r+\lambda+m\theta q(\theta)}(1-t)A\gamma(1-\gamma)(L_e + L_n)^{\gamma-1}}{1 + \frac{\lambda+\sigma}{m\theta q(\theta)}} \tag{2.27}$$

Pluging (26) and (27) into (24) yields the following expression for wage

$$w = \frac{b_e - \frac{d(b_e-b_n)}{r+d+m\theta q(\theta)-\lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}} + \frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)}(-b_n + \frac{\sigma\lambda(b_e-b_n)}{(r+\lambda+\sigma)(r+d+m\theta q(\theta))-\lambda m\theta q(\theta)})}{(1-\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)})(1-t)} + A\gamma(1-\gamma)(L_e+L_n)^{\gamma-1} \quad (2.28)$$

And we also have one budget constraint which is

$$b_e w u_e + b_n w u_n = (w n_e + w n_n)t \quad (2.29)$$

This constraint means that the unemployment benefit and social security are covered by taxation. As we know the wage equation, we have the first equilibrium condition. We also have two constraints and the relative supply of entitled workers in the equilibrium $\frac{L_e}{L_n} = \frac{\sigma(d+m\theta q(\theta))}{\lambda d}$, so these five equations form our equilibrium conditions and we have five endogenous variables, L_e, $L_{n,}$, θ, w and t.

2.4 Individual Nash Bargaining

As surplus is shared according to a Nash bargain in which worker has bargaining power $\beta \in [0,1]$, we have the following "surplus-splitting" rule

$$(1-\beta)(V_E - V_U) = \beta(J - V) \quad (2.30)$$

For an entitled worker-job match, we have the surplus term

$$V_{E,e} - V_{U,e} = \frac{\beta}{1-\beta}J_e = \frac{\beta}{1-\beta}\frac{A\gamma(L_e+L_n)^{\gamma-1} - w_e}{r+\lambda} \quad (2.31)$$

Similarly, for non-entitled worker-job match, we have

$$V_{E,n} - V_{U,n} = \frac{\beta}{1-\beta}J_n = \frac{\beta}{1-\beta}\frac{A\gamma(L_e+L_n)^{\gamma-1} - w_n}{r+\lambda} \quad (2.32)$$

Finally, we have two wage equations, for entitled worker, in equilibrium we have

$$\frac{w_e(1-t-b_e)}{r+\lambda+m\theta q(\theta)}+\frac{d}{r+\lambda+m\theta q(\theta)}\frac{[b_e+\frac{m\theta q(\theta)(1-t)}{r+\lambda+\sigma}]w_e-[b_n+\frac{m\theta q(\theta)(1-t)}{r+\lambda+\sigma}]w_n}{r+m\theta q(\theta)+d-\lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}} = \frac{\beta}{1-\beta}\frac{A\gamma(L_e+L_n)^{\gamma-1}-w_e}{r+\lambda} \quad (2.33)$$

Similarly, for non-entitled worker, we have

$$\frac{w_n(1-t-b_n)}{r+\lambda+m\theta q(\theta)}+\frac{\sigma}{r+\lambda+m\theta q(\theta)}\frac{w_e(1-t+\lambda\frac{b_e}{r+m\theta q(\theta)+d})-w_n(1-t+\lambda\frac{b_n}{r+m\theta q(\theta)+d})}{r+\lambda+\sigma-\lambda m\theta q(\theta)\frac{1}{r+m\theta q(\theta)+d}} = \frac{\beta}{1-\beta}\frac{A\gamma(L_e+L_n)^{\gamma-1}-w_n+\frac{\sigma}{r+\lambda}(A\gamma(L_e+L_n)^{\gamma-1}-w_e)}{r+\lambda+\sigma} \quad (2.34)$$

Let us go back to the free entry condition, by combining equation (3), (6), (7) and (20), [7] we have

$$c = mq(\theta)[\frac{m\theta q(\theta)}{\lambda\frac{d}{\sigma}+d+m\theta q(\theta)}\frac{A\gamma(L_e+L_n)^{\gamma-1}-w_e}{r+\lambda} + \frac{\lambda\frac{d}{\sigma}+d}{\lambda\frac{d}{\sigma}+d+m\theta q(\theta)}\frac{A\gamma(L_e+L_n)^{\gamma-1}-w_n+\frac{\sigma}{r+\lambda}(A\gamma(L_e+L_n)^{\gamma-1}-w_e)}{r+\lambda+\sigma}] \quad (2.35)$$

The free entry condition and two wage equations link the wages with labor market tightness. Equations (33), (34), (35) gives us θ, w_e and w_n in equilibrium. In a stationary equilibrium, the aggregate variables must remain constant over time. This requires new entrants exactly replaces the employed workers who are hit by shock and exit. We will show unemployment dynamics in next section.

2.5 Numerical Illustration

Although our theoretical model can be fully characterized in the equilibrium, the effects of entitlement on labor market outcomes are potentially ambiguous. In order to learn the properties of the model, some specific restrictions on exogenous parameters are required. We therefore calibrate the model with US and France's labor market data respectively.

[7]Equation (3), (6) and (7) give us $\frac{u_e}{u_n+u_e}=\frac{m\theta q(\theta)}{\lambda\frac{d}{\sigma}+d+m\theta q(\theta)}$ and $\frac{u_n}{u_e+u_n}=\frac{\lambda\frac{d}{\sigma}+d}{\lambda\frac{d}{\sigma}+d+m\theta q(\theta)}$.

According to the data, 12% of workers are covered by the collective bargaining in the US and 95% of workers are covered by the collective bargaining in the France. What is more, OECD considers the French system as a largely decentralized system of collective bargaining, essentially regulated at firms and industry-levels.[8] Therefore, we calibrate our model where wage is set through collective bargaining using French data.

2.5.1 Calibration for US (2002:1-2007:12)

Since only 12% of workers are covered by collective bargaining in US, we calibrate the model where the wage is set by individual Nash bargaining. I choose one month as the length of a model period, and the reference period is 2002:1-2007:12 since new unemployment insurance rule in US was laid out in 2002, until 2007 this rule kept same.

In terms of the probability of gaining eligibility of UI, σ, and the probability of losing it, d, I use OECD data, since 2002, an individual must have worked 20 weeks to be eligible for UI and benefits can be paid for a maximum of 26 weeks. So $\sigma = 0.2$ and $d = 0.167$.

And as for unemployment insurance b_e, given that aggregate productivity is normalized to 1, I use statutory replacement rates in stead of b_e, it is 0.27 for each month. After eligibility is exhausted, there is no insurance payment anymore, but the Federal Government's Food Stamp program provides a cash equivalent benefit for food which can be seen as unemployment assistance, its amount is around 100 dollars per month whose value is about 0.025, only accounting for 9% of unemployment insurance.

The interest rate is set at 0.033 per month. As many literatures do, we specify a Cobb-Douglas matching function with constant return to scale, $m(u, v) = mu^{\alpha}v^{1-\alpha}$. For simplification, we set $\alpha = 0.5$. And we assume that Hosio's condition is satisfied, thus $\beta = 0.5$. [9]

About the matching efficiency, m, we also adopt its value from Pissarides (2007), in which it is deduced according to the job finding rate, and this value is 0.7. During this period, the job destruction rate is 0.038.

Last, the unemployment rate pin down the vacancy cost c, and it is quite close to the value of Camille (2010) in measuring the flow cost of maintaining a vacancy.

[8]See OECD employment outlook (2004) for example, and read "Wage Bargaining and Compensation Practices in France: An Overview" by O.Barrat et al.

[9]This is also used by C.Pissarides (2007) in his paper "The unemployment volatility puzzle, is wage stickiness the answer?".

2.5.1.1 Counterfactual Simulation

We do a counterfactual simulation before doing sensitivity analysis, and we try to see what would be the unemployment rate, wage, and welfare if U.S. adopts the collective bargaining wage setting scheme. Comparing with the economy where the wage is negotiated through individual Nash bargaining, the wage that worker can get becomes higher, and the unemployment becomes higher too since higher wage pushes up the unemployment rate. But in terms of the welfare, it becomes lower. Moreover, there is a polarization arising, for employed workers, their wages are raised, but there are more unemployed workers when the wage is set according to collective bargaining. Therefore, the inequality between employed and unemployed workers is raised when collective bargaining presents.

2.5.2 Calibration for France (2005:1-2007:12)

As for the probability of gaining eligibility of UI σ and the probability of losing it d, we use OECD data as well, since 2004, an individual must have worked 6 months in 22 to be eligible for UI and benefits can be paid for a maximum of 23 months. So $\sigma = 0.167$ and $d = 0.043$.

And as for unemployment insurance b_e, I use statutory replacement rates. Unlike U.S. labor market in which b_e can be simply obtained by using replacement rate since unemployment assistance is not included in the data, all the replacement ratio data of French labor market only give us the mean value which includes unemployment insurance as well as unemployment assistance. To avoid such problem, I use the average wage, unemployment insurance and unemployment assistance directly in order to compute each ratio, and we have $b_e = 0.55$ and $b_n = 0.17$.

There are many literatures which investigate the choice of the elasticity of match with respect to unemployment, for France, Burda and Wyplosz (1994) estimate a parameter close to 0.5, and for simplicity I set it to 0.5 as well which is identical to that of US.

We do not have direct information referring to job finding rate, we only have the proportion of unemployed workers staying unemployed more than one year p. So $1 - p$ of unemployed workers can find a job in a year. As job arrives with a poisson process, therefore job finding rate f in each quarter is $-lnp/4$ and it equals 0.07.

For job destruction rate, it is hard to find direct information too. We have number of unemployed workers u, number of employed workers n and job finding rate f in each period. According to the unemployment dynamics, the unemployed at time $t+1$ should be the sum of rest of unemployed at end of t and employed who flow into unemployed at t.

$$u_{t+1} = u_t(1 - f_t) + n_t\lambda_t$$

Then the average job destruction rate is 0.0067. And the matching quality m is deduced so as to match the aggregate unemployment rate , job finding rate and labor market tightness according to $u = \frac{\lambda}{\lambda + m\theta q(\theta)}$, giving that the sample mean for labor market tightness $\theta = 0.115$ in 2004-2007. This gives that $m = 0.2$.

The vacancy cost is chosen to match the unemployment rate, which gives that $c = 1.5$. This is very close to the result from Bentolila and Cahuc (2011).[10]

2.5.2.1 Counterfactual Simulation

Here I also make a counterfactual simulation. What is different is that now we try to see what would be the unemployment rate, wage, and welfare if France adopts the individual Nash bargaining. We find that if France sets wages according to individual Nash bargaining, the polarization will arise, the inequality between entitled and non-entitled workers becomes larger. In terms of unemployment rate, it becomes lower too. And as for the welfare, when the wage is set according to the individual Nash bargaining, welfare is higher than that when the wage is set by the union collectively.

By doing counterfactual simulations, we find that when the wage is set by the union, the unemployment is lower, the wage is higher and welfare is higher than that when the wage is set through individual Nash bargaining. In terms of efficiency, set wage according to the individual Nash bargaining is more efficient. The union has incentive to improve the workers' welfare by posting higher wage, unfortunately, this will make firm reduce domestic hires, enlarging the inequality between employed and unemployed workers.

2.5.3 Effectiveness of the Policy-Sensitivity Analysis

In the following analysis, we want to see how the two-tier compensation policies, which are captured by the four parameters respectively σ, d, b_e and b_n, affect the unemployment trends. When the wage is set through collective bargaining, the objective of union is to maximize the total rents. The ways of improving total rents are twofold: the first one is intensively improving rent of each worker, for example by increasing the wage level, but this will raise the number of unemployed population which inversely has negative

[10] In their paper, the calibrated vacancy cost is one half of the quarter production.

impact on total rents; the second one is extensively expanding employed population, but this will decrease the wage and rent for each individual worker.

2.5.3.1 Impact of an Increase in Entitlement Probability (σ becomes higher)

In the case of individual Nash bargaining, higher probability of gaining eligibility makes it easier for workers to flow into eligible state, equivalently more workers will earn wages paid to entitled workers which is higher than that paid to non-entitled workers, therefore the unemployment rate becomes higher.

On the contrary, in the case of collective bargaining, union posts a wage at first, then firm decides how many workers it hires. When σ becomes higher, more workers are entitled with unemployment insurance, hence$V_{E,e} - V_{U,e}$ decreases and $V_{E,n} - V_{U,n}$ increases. What is more, since we have $V_{E,n} - V_{U,n} > V_{E,e} - V_{U,e}$ given that workers with different titles have the identical wages, now the union puts more weights on $V_{E,e} - V_{U,e}$ which is smaller. Therefore intensively, increasing σ simply has downward pressure on the total rent of employed workers. As higher wage amplifies this negative impact, the union has incentive to post lower wage w to reduce the marginal negative effect of σ on total rents,[11]increasing the total hirings, this improves the total rents, drives down the unemployment. Consequently, when σ increases, the effect of extensively increasing employment on raising total rent dominates the effect of intensively increasing the wage of employed workers. Figure 1 shows us the unemployment and wage trends when σ changes.

2.5.3.2 Impact of an Increase in Probability of Losing Eligibility (d becomes higher)

In the case of individual Nash bargaining, when the probability of losing eligibility becomes higher, more workers flow into ineligible state and more workers will earn wages paid to non-entitled workers which is lower than that paid to entitled workers, unemployment becomes lower. For entitled workers, it is easier for them to lose eligibility, therefore their outside option values become lower, their wages are decreased. For non-entitled workers, their outside option values are relatively higher, so the wages are raised.

And in the case of collective bargaining, when d increases, $V_{E,e} - V_{U,e}$ increases and $V_{E,n} - V_{U,n}$ decreases, and there is a higher proportion of unemployed workers becoming non-entitled, for the same reasoning, union puts more weights on the term which is decreasing, thus it has incentive to posts lower wages to reduce the negative effect on total

[11]Both $V_{E,e} - V_{U,e}$ and $V_{E,n} - V_{U,n}$ decreases with the wage rate w.

rent, increasing the total hirings, and this drives down the unemployment. Therefore, when d increases, the effect of extensively increasing employment on raising total rent also dominates the effect of intensively increasing the wage of employed workers. Figure 2 shows us the unemployment and wage trends when d changes.

2.5.3.3 Impact of an Increase in UI (b_e becomes higher)

When the wage is set through individual Nash bargaining, higher unemployment insurance raises the outside option value of entitled workers and allows them to have higher wage. For non-entitled workers, however, their outside option value decreases relatively, so their wages decrease. In terms of unemployment, higher unemployment insurance increases the cost of hiring workers, thus the unemployment rate goes up.

In case of collective bargaining, when b_e is higher, $V_{E,e} - V_{U,e}$ decreases and $V_{E,n} - V_{U,n}$ increases, since $V_{E,n} - V_{U,n} > V_{E,e} - V_{U,e}$, the union has incentive to post higher wages to reinforce the positive effect of b_e on rents. This will eventually raise the unemployment rate. Therefore, when b_e becomes higher, the effect of intensively increasing the wage on raising total rent dominates the effect of extensively increasing the number of employed workers. Figure 3 shows us the unemployment and wage trends when b_e changes.

2.5.3.4 Impact of an Increase in UA (b_n becomes higher)

For all workers, including entitled and non-entitled, they have better outside options now. In the case of individual Nash bargaining, this pushes up the wage of each type of workers, thus the unemployment rate becomes higher.

But in the case of collective bargaining, when b_n becomes higher, both $V_{E,e} - V_{U,e}$ and $V_{E,n} - V_{U,n}$ decreases, the union has incentive to post lower wage to reduce the negative effect of b_n on rents. This will reduce the unemployment. Consequently, the effect of extensively increasing employment on raising total rent dominates the effect of intensively increasing the wage of employed workers. Figure 4 shows us the unemployment and wage trends when b_n changes.

And we also investigate how the change in policies affect workers' wages and unemployment quantitatively using the U.S. labor market data. We can see how they vary when the required contribution time to gain eligibility decreases, UI duration after becoming unemployed decreases, unemployment insurance and unemployment assistance increase. And we put the results in the Appendix. From the results, we find that the impacts of two-tier compensation policies are more significant when the wage is negotiated through collective bargaining in stead of individual Nash bargaining.

2.6 Extension

In this section, we try to extend the model to the case when the union puts different weights on the different group of workers. In previous sections, we conduct our analysis based on the assumption that union puts identical weight on each type of workers. However, in the real world, union may have different preferences toward different groups. For example, the union members are voted by the workers. Therefore, when they make decisions and try to post a wage, they should take into account of the proportion of each group. Now the objective of the union is to maximize

$$(2-k)r(V_{E,e}-V_{U,e})L_e + kr(V_{E,n}-V_{U,n})L_n \tag{2.36}$$

$0 < k < 2$, when $k = 1$, union puts the same weights on the rent of each type of workers. And when $k < 1$, union puts more weights on entitled workers. We put the computation process in the Appendix. As before, we can obtain the wage equation

$$\begin{aligned}&[(1-t)*(2-k-\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))k}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)})-(2-k)(b_e-\frac{d(b_e-b_n)}{r+d+m\theta q(\theta)-\lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}})\\&+\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))k}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)}(-b_n+\frac{\sigma\lambda(b_e-b_n)}{(r+\lambda+\sigma)(r+d+m\theta q(\theta))-\lambda m\theta q(\theta)})]w\\&-(1-\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)})(1-t)A\gamma(1-\gamma)(L_e+L_n)^{\gamma-2}[(2-k)L_e+kL_n]=0\end{aligned} \tag{2.37}$$

We also do a simple simulation exercise. From the Figure 5 and 6, we can see that when k is larger than 1, union puts more weights on the non-entitled workers. Because non-entitled workers have greater rent than entitled workers, union has incentive to raise the wage to reinforce this impact, increasing unemployment rate.

2.7 Conclusion

In this paper, I re-analyze the two-tier unemployment compensation reforming taking into account of the role of wage-setting schemes. We construct the standard unemployment search models where wages are negotiated respectively through individual Nash bargaining and collective bargaining. The former one is applied prevalently in the U.S. and the later one is applied widely in the European countries like in France, Sweden and Germany.

Based on the theoretical model, we calibrate the model where the wage is negotiated through individual Nash bargaining using the U.S. labor market data and calibrate the model where the wage is negotiated collectively using the French labor market data. We at first do a counterfactual simulation for each country, assuming that they adopt different wage-setting schemes. That is, U.S. adopts the collective bargaining wage-setting scheme and France adopts the individual Nash bargaining wage-setting scheme. We find that in both countries, comparing to the economy where the wage is negotiated through the individual Nash bargaining, when the wage is negotiated collectively, the unemployment rate is higher, wage level is higher, and both workers' welfare and social surplus are lower. Therefore, from the perspective of efficiency, setting wage through individual Nash bargaining is more efficient.

Then we mainly analyze the impact of two-tier unemployment compensation reforming on unemployment and wage level. We find that reducing the contribution time of gaining eligibility or increasing the unemployment assistance reduces the unemployment rate when the wage is set collectively but raises the unemployment rate when the wage is set through individual Nash bargaining. In addition, reducing the unemployment insurance duration or increasing replacement rate raises the unemployment rate no matter how the wage is set.

Last, we extend the model to where the union put different weights on different group of workers. By doing simulation exercise, we find that when union puts more weight on the non-entitled workers' surplus, both the unemployment rate and the wage become higher.

Table 2.1: Counterfactual Results for US

	w	u	Workers' Welfare	Social Surplus
Individual Nash Bargaining	0.59, 0.55	0.056	161.1	285
Collective Bargaining	0.61	0.095	155.6	281.2

Table 2.2: Counterfactual Results for France

	w	u	Welfare	Social Surplus
Individual Nash Bargaining	0.58, 0.4	0.064	163.4	281.5
Collective Bargaining	0.61	0.085	162.5	280

Chapter 3

Exposure to the New Wave of Offshoring, Unemployment and Welfare

3.1 Introduction

Globalization is normally defined as international trade at first and as offshoring at second which is the relocation of production processes abroad which shifts jobs of home country abroad. A major driving force behind offshoring is the difference in factor prices(see e.g. Nunnenkamp, 2004;Kohler, 2002). Firms that engage in offshoring activities can be seen as efficiency seekers as they take advantage of less costly resources. This potential cost advantage is fundamental in explaining offshoring decisions.

In the past decades, there are mainly two waves of offshoring. The first is characterized by material offshoring, predominantly in labor intensive industries such as consumer electronics, textiles and apparels, footwear and leather goods.[1] Production has been simply relocated from developed countries to low cost countries. The second wave is characterized by service relocation which is facilitated by the improvement in communication technology. The OECD (2007 b) reports that between 1995 and 2000, the outsourcing by the service sector have shown the strongest growth in OECD countries. Figure (a) shows this trend. "Now offshoring has become a wide phenomenon that involves all sectors [2]".

[1]See Bottini, Ernst and Luebker (2007), Dossani and Kenney (2004),Girma and Gorg (2003).
[2]See Bottini, Ernst and Luebker (2007).

People agree that home country can benefit from offshoring activity because of low cost advantage, but at the same time they are concerned by its impact on domestic job security. Whether offshoring will delocate domestic jobs abroad has become a hot political issue today. From the OECD report[3], however, we can observe from the table 1 that from mid 1990s to early 2000s, apart from Japan, Slovakia and the Czech Republic, all the other OECD countries have the net job creation. Additionally, the unemployment rate falls during this period in most of the OECD countries.

At the same time, the outsourcing scale of the traditional manufacturing sector in almost all OECD countries keeps growing. We can observe this trend from figure (a) as well for some selected countries.

In this paper, we attempt to bridge these facts and to investigate whether the impact of service relocation on domestic unemployment can be negative and what does it depend on, how the offshoring activity in the manufacturing sector is affected and what are the consequences for global welfare as well as inequality. To answer these questions, we construct a simple two sector model and integrate the Pissarides search model of unemployment with the Grossman and Rossi-Hansberg(2008) task trade model.

Grossman and Rossi-Hansberg argue that the production of good requires the completion of a group of tasks. Their model investigates how offshoring activity affects the wage rate of high skilled as well as low skilled workers. They decompose the impact of offshoring into three components: the productivity effect which comes from the cost savings, the relative price effect and the labor-supply effect which derives from the reabsorption of workers who formerly performed tasks that are now carried out abroad. As for the productivity effect, Grossman and Rossi-Hansberg (2008) show that it is negligible when offshoring scale is very small since there are not enough cost-savings caused by inframarginal tasks, but it can be large when the offshoring volume is positive and the cost schedule for trading tasks rises steeply, this is equivalent to the condition that the marginal task-specific offshoring cost for trading tasks is large. And if this condition is satisfied, the aggregate positive effect due to the productivity effect could outweigh the aggregate negative effect due to the relative price as well as the labor-supply effect.

Here we allow the offshoring activity to happen in both two sectors, the manufacturing sector and the service sector. We show that the increasing offshoring extent in the service sector due to the technology progress leads to lower domestic unemployment if the marginal task-specific offshoring cost for trading tasks is large enough, in which condition the positive effect of offshoring dominates the negative one. Reducing unemployment consequently makes the firm in the manufacturing sector offshore more because the

[3]See OECD (2007), "Preliminary results", in *Offshoring and Employment: Trends and Impacts*, OECD publishing

cost of hiring domestic workers becomes higher. And the increasing offshoring extent in the manufacturing sector will make the cost saving effect become greater too. If the marginal task-specific offshoring cost for trading tasks is also large enough in the manufacturing sector, the expanding offshoring extent can in turn help create even more jobs . Therefore the offshoring technology progress in the service sector may indirectly have a positive impact on the manufacturing sector's offshoring activity.

In addition to showing the analytical results, we also undertake a calibration exercise. We calibrate the model by using parameters of the Belgium who has very high degree of openness. Our simulation result predicts that the progress of offshoring technology in the service sector, starting from the present level, would reduce the domestic unemployment and raise the offshoring scale in the manufacturing sector provided that the marginal task-specific offshoring cost for trading tasks is sufficiently large.

Next, we also try to shed light on the welfare analysis. When offshoring becomes possible, we at first verify that the decentralized equilibrium is social optimum when Hosios condition holds, and under this condition the social welfare is higher than that in the closed economy when tasks are offshorable. Therefore we can conclude that the trade protection policy will actually make society worse off. We then show that when worker's share of surplus increases, the relative cost of hiring domestic workers becomes higher, so the domestic firm will change the composition of labor hires in the way of increasing the proportion of foreign hires. Consequently when the worker's bargaining power is higher than the matching elasticity, in the equilibrium, domestic firms perform tasks abroad with higher proportion than the social optimum.

Based on these analysis, we propose a simple efficient policy instrument which can make equilibrium optimal. That is, when the worker's bargaining power is higher than the matching elasticity, the government can correct the inefficiency by subsidizing the domestic firms on hiring domestic workers and the optimal subsidy level increases with the market tightness as well as the difference between the worker's bargaining power and the matching elasticity. What is more, if we concern the budget balance of the government and assume that the subsidy comes from the taxation of the whole working population, we find that the optimal subsidy increases with the market tightness too. We then simulate the optimal subsidy by using the labor market parameters of Belgium and show that if there is a progress of offshoring technology in the service sector, the optimal subsidy increases when the marginal task-specific offshoring cost for trading tasks is sufficiently large. On the contrary, the optimal subsidy decreases when the marginal task-specific offshoring cost for trading tasks is relatively small. In the end, we do a counterfactual exercise to compare the optimal subsidy in the open economy with that in the closed economy. We find that if the task-specific offshoring cost function is flat,the optimal subsidy level is always lower in the open economy than that in the closed economy. However, if it is convex enough, the optimal subsidy level can be higher than that in the open economy provided that the technology progress in the service sector can make unemployment be even lower than that in the closed economy.

At last,in order to study the impact of offshoring activity on the unemployment of the low wage country, the global inequality and the global welfare, we simplify the model and extend it to a two country framework. The firm in the high wage country (northern country) offshores tasks to the low wage country (southern country). So the southern workers can choose to work in the national or multinational firm. We find that the more southern workers that northern firm hires, the higher market tightness will be in the south. Additionally, as for the global issues, we show that the global welfare goes up with the offshoring scale and the wage inequality between two countries can increase with the offshoring scale.

To sum up, this paper contributes from three aspects. First we investigate the impact of the service's offshoring boom on the domestic labor hires and show how this impact can be positive. Second we show the possibility that the increasing offshoring scale in the traditional manufacturing sector can be partly due to the indirect impact exerted by the service offshoring. Third we discuss the impact of the offshoring activity on the low wage country's unemployment, global inequality and the global welfare.

3.1.1 Literature Review

Nowadays there has been a big of interest in analyzing responses of employment to globalization. On the theoretical side, it is Carl Davidson and Steven Matusz (2004) firstly introduce search frictions of labor market into trade models. The main concern of their research is how job search efficiency, job destruction rate and the frequency of job turnover affect comparative advantage. Felbermayr et al. (2011) integrates search unemployment with Meltiz (2003) firm heterogeneity model to study the effect of reducing trade cost on unemployment, decreases in trade costs raise the average productivity of domestic firms, this would reduce the effective cost of posting vacancies, thus domestic unemployment will be reduced. Helpman and Itskhoki (2010) also investigate the impact of trade liberalization on the unemployment by using an imperfectly competitive framework with heterogenous firms, they show that increasing trade openness reduces the unemployment if its relative labor market frictions in the differentiated sector are high. If we focus on the impact of offshoring activity, Mitra and Ranjan (2010) is the first paper to study the impact of offshoring activity on domestic unemployment. They demonstrate that if intersectoral mobility is allowed, when one sector offshores, economy-wide unemployment will decrease and wage will increase because of productivity effect. The main assumption in their paper is that there exists complementarity between foreign and domestic workers, this assumption will simply strengthen the unemployment reducing effect. In contrast to their assumption, this present paper assume that domestic and foreign workers can be perfectly substituted, then there is a net replacement effect which plays a negative role on the domestic job creation. Moreover, we allow all sectors can potentially offshore, then the indirect impact of the offshoring activity in one sector on another can become the driving force of job creation too. In our framework, this indirect impact works through affecting the cost of hiring domestic workers.

In addition to the theoretical literatures, on the empirical side, there are many literatures studying the impact of offshoring on the employment. Amiti and Wei (2004) examine the job effects of service offshoring for the United States and the UK, they find that offshoring is likely to change the employment composition but unlikely to change the aggregate level of employment. In addition, they make similar conclusion for the UK and find that offshoring services has no negative net effect on employment. Van Welsum and Reif (2006), using data for 14 OECD countries over the period 1996-2003, show that net offshoring in services is not associated with a significant decline in employment. Based on the Eurostat data for 64 countries over 1992-2004, Head et al. (2007) use a gravity model to estimate the impact of offshoring in the service sectors on domestic job destruction. They conclude that local workers are not at risk of displacement because the cost of delivery is significantly high, and they finally predict that if the price gap keep getting smaller, local workers could be hurt.

At last, referring to the studies on the income inequality due to the globalization, the authors fail to build common agreements. Wood and Ridao-Cano(1999) argue that the trade may lead to higher global inequality due to the divergence in growth rates across countries. Poor countries will specialize in products that use high growth factor in production while rich countries specialize in products that use the high growth factor in production. Dollar and Kraay (2002) argue that the countries engaging in greater global economic integration experience higher growth rate, so globalization will actually reduce global income inequality. Ghose (2000) analyzes data and show that the trade liberalization reduces the worldwide inequality.

Finally, it is worth mentioning the welfare issue. Zhou and Zeng (2012)investigate this issue using a model of two countries and one sector of increasing returns to scale. They find that falling cost of offshoring benefits the high-wage country but hurts the low-wage one. The explanation is that rising wage in the low-wage country pushes capital and firms out which hurts local workers by increasing the local price index. However, Fujita and Thisse (2006) and Robert-Nicoud (2008) show that decreasing offshoring cost benefits foreign workers but hurts local workers based on the assumption that no firms move from the low-wage country to the high-wage country.

The rest of the paper proceeds as follows. In section 2 we construct the basic ingredients of the model and solve for the autarky equilibrium. Section 3 solve for the offshoring equilibriums, we make some comparative static analysis and show in which condition the progress of offshoring technology in the service sector can lead to domestic job creation and exert positive impact effect on the manufacturing sector's offshoring activity. In section 4 we calibrate the model by using the parameters of Belgium and predict the employment trend numerically. Section 5 discusses the social planner's problem and propose an efficient policy instrument in case that the equilibrium is inefficient and also simulate the optimal policy for Belgium. Section 6 analyze the two country's case and investigate how does the offshoring activity have impact on the unemployment of the low wage country ,global wage inequality and the global welfare. Finally section 7 concludes.

3.2 Model

3.2.1 Set up

In each economy, all consumers have the same life time utility function

$$\int_{t=0}^{\infty} C_t e^{-rt} dt \tag{3.1}$$

C is consumption, r is discount rate which is considered to be identical in each period, and t is time index. In this economy, home country produces one consumption good C, C can be seen as the final good or the composite good, and it is produced using two intermediate goods X and Y . X is produced in the service sector X and Y is produced in the manufacturing sector Y.

Assume that the production function has Cobb-Douglas form

$$C = \frac{X^{\rho} Y^{1-\rho}}{\rho^{\rho}(1-\rho)^{1-\rho}} \tag{3.2}$$

We have $0 < \rho < 1$.We let p_x and p_y represent the prices of intermediates X and Y, and p_c represent the price of final good C. In perfect competition market, the marginal productivity of each intermediate input equals to its price, respectively we have two price equations

$$p_c \frac{\partial C}{\partial X} = p_c \frac{\rho X^{\rho-1} Y^{1-\rho}}{\rho^\rho (1-\rho)^{1-\rho}} = p_x \tag{3.3}$$

$$p_c \frac{\partial C}{\partial Y} = p_c \frac{(1-\rho) X^{\rho} Y^{-\rho}}{\rho^\rho (1-\rho)^{1-\rho}} = p_y \tag{3.4}$$

Combining two equations above, we have the relative price of intermediate Y

$$\frac{p_y}{p_x} = \frac{1-\rho}{\rho} \frac{X}{Y} \tag{3.5}$$

Assume the final good C is tradeable. The price of C is assumed to be taken as given and is normalized to 1 for simplicity. Then we have

$$p_x^\rho p_y^{1-\rho} = 1 \tag{3.6}$$

Combining (3.5) and (3.6), we have two price equations

$$p_x = (\frac{1-\rho}{\rho} \frac{X}{Y})^{\rho-1} \tag{3.7}$$

$$p_y = (\frac{1-\rho}{\rho} \frac{X}{Y})^{\rho} \tag{3.8}$$

3.2.2 Production and Firm's Profit Maximization Problem

Production of intermediate X involves l_x workers in the service sector X according to

$$X = A_1 l_x^\gamma \tag{3.9}$$

A_1 is the technology or the aggregate productivity of producing X in the service sector. $0 < \gamma < 1$ indicates that the marginal output of production decreases as the number of labor performing in the production increases[4]. Similarly, production of intermediate Y involves l_y workers according to

$$Y = A_0 l_y^\gamma \tag{3.10}$$

[4]OECD(1999) estimates that most of OECD countries correspond to the range from 0.6 to 0.72.

As workers can move freely across sectors, if we want to investigate the fluctuation of the unemployment, we only need to compute one sector's optimization problem. In the closed economy, the present discounted value of the firm's profit at time t in the manufacturing sector Y is given by

$$\underset{l_y(s),V_y(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[p_y(s)Y(s) - w_y(s)l_y(s) - c_y V_y(s)]ds \tag{3.11}$$

$p_y(s)Y(s)$ is the value of production at time s, $w_y(s)l_y(s)$ is the total wage paid to workers and $c_y V_y$ is the cost of vacancies where c_y is the unit vacancy cost. When job is unfilled, there is an additive cost for the firm since it has to pay some fixed costs, for example, when machines are not operated by workers, firm has to pay maintenance fees. Define $\theta_Y = \frac{V_y}{U_y}$ as the appropriate measure of the labor market tightness where V_y is the number of vacancies posted by firms in the manufacturing sector Y and respectively U_y is the number of unemployed workers who are searching for the jobs in the manufacturing sector. What is more, we define a formal and standard constant returns to scale matching function as

$$M(V_y, U_y) = mV_y^{1-\phi}U_y^{\phi} \tag{3.12}$$

m is the matching quality or matching efficiency. The rate at which vacant jobs are filled is $q(\theta_Y) = \frac{mV_y^{1-\phi}U_y^{\phi}}{V_y}$ and respectively the rate at which unemployed workers become employed is $\theta_Y q(\theta_Y) = \frac{mV_y^{1-\phi}U_y^{\phi}}{U_y}$. $q'()$ is assumed to be negative by the properties of the matching technology [5]. The job can be destroyed by an idiosyncratic shock with probability δ. Then dynamics of employment for a firm in the manufacturing sector Y is

$$\dot{l_y(t)} = q(\theta_Y(t))V_Y(t) - \delta l_y(t) \tag{3.13}$$

The firm maximizes (1.5) subject to (3.13), taking the worker's wage $w_y(s)$ and the price of intermediate Y $p_y(s)$ as given. After simplification, we have one wage equation in the manufacturing sector Y

$$w_y = p_y\frac{\partial Y}{\partial l_y} - \frac{(r+\delta)c_y}{q(\theta_Y)} = p_y A_0 \gamma l_y^{\gamma-1} - \frac{(r+\delta)c_y}{q(\theta_Y)} \tag{3.14}$$

This is the job creation condition, corresponding to a marginal condition for the demand for labor. The term $p_y\frac{\partial Y}{\partial l_y}$ is the marginal product of an additive worker in the manufacturing sector Y and the term $\frac{(r+\delta)c_y}{q(\theta_Y)}$ captures the expected value of the firm's hiring

[5] See Pissarides (2000).

cost caused by matching frictions in the labor market. Hiring a worker, firm not only has to pay worker's wage, but also has to pay the search cost when the vacancy is not filled by worker. In our model, this equation determines equilibrium employment l_y as a function of w_y,θ_Y and p_y.

3.2.3 Wage determination and equilibrium condition

Worker's wage is determined between firm and worker through individual Nash bargaining process. Employed workers get a wage of w_y, unemployed workers get b which can be viewed as opportunity cost of being unemployed.

Denote $V_{E,Y}$ the asset value of an employed worker in the manufacturing sector Y and $V_{U,Y}$ the asset value of an unemployed worker. The asset values are given as

$$rV_{E,Y} = w_y + \delta(V_{U,Y} - V_{E,Y}) \tag{3.15}$$

$$rV_{U,Y} = b + m\theta_Y q(\theta_Y)(V_{E,Y} - V_{U,Y}) \tag{3.16}$$

The benefit of being employed equals the present wage plus the expected change in the value from being employed to unemployed. Similarly, the benefit of being unemployed equals the opportunity cost b plus the expected benefit from getting out of unemployment which is given by $m\theta_Y q(\theta_Y)(V_{E,Y} - V_{U,Y})$. By combining the two equations, the surplus for an unemployed worker from getting a job can be given by

$$V_{E,Y} - V_{U,Y} = \frac{w_y - b}{r + \delta + m\theta_Y q(\theta_Y)} \tag{3.17}$$

In addition, the surplus for a firm from an occupied job in the manufacturing sector Y J_Y equals the shadow value λ. Since wage is determined through Nash Bargaining process where the bargaining weights are respectively given by η and $1-\eta$ for the worker and the firm , we have the following wage bargaining equation[6]

$$\frac{\eta}{1-\eta} = \frac{V_{E,Y} - V_{U,Y}}{J_Y} \tag{3.18}$$

Formally $J_Y = \lambda = \frac{c_y}{q(\theta_Y)}$ when entry is free, therefore we indirectly have the difference between employed and unemployed worker $V_{E,Y} - V_{U,Y} = \frac{\eta}{1-\eta}\frac{c_y}{q(\theta_Y)}$, equalize this with equation (17), we have another wage in the manufacturing sector

[6]This is derived from first-order maximization condition of $max(V_{E,Y} - V_{U,Y})^{\eta}(J_Y - V)^{1-\eta}$.

$$w_y = b + \frac{\eta c_y}{1-\eta}(m\theta_Y + \frac{r+\delta}{q(\theta_Y)}) \tag{3.19}$$

This is on the supply side. Equation (19) shows that labor market tightness enters wage equation through Nash bargaining, a higher tightness leads to higher wage rate. And given this labor demand curve (14) and labor supply curve (19), we can characterize our decentralized equilibrium in the manufacturing sector Y[7]

$$p_y\frac{\partial Y}{\partial l_y} = b + \frac{\eta c_y}{1-\eta}m\theta_Y + \frac{c_y}{1-\eta}\frac{r+\delta}{q(\theta_Y)} \tag{3.20}$$

Clearly, the labor market tightness depends on the value of the marginal product of each labor. Higher value of the marginal product leads to more job creations.

3.2.4 Occupation Choice and Price Determination

In the equilibrium, the welfare of unemployed worker in the manufacturing sector Y is

$$rV_{U,Y} = b + m\theta_Y q(\theta_Y)(V_{E,Y} - V_{U,Y}) = b + \frac{\eta}{1-\eta}mc_y\theta_Y \tag{3.21}$$

In the steady state, the welfare of unemployed workers should be identical across sectors since mobility across sectors is allowed and they can search job in either sector, the labor mobility condition $V_{U,Y} = V_{U,X}$ implies

$$c_y\theta_Y = c_x\theta_X \tag{3.22}$$

The market tightness for each sector is inversely proportional to the cost of posting a new job vacancy. For the sake of simplicity, we assume that vacancy cost is identical in both sectors, that is $c_x = c_y = c$, we then have $\theta_X = \theta_Y = \theta$ where θ is the tightness for the whole economy. According to two equilibrium conditions in both sectors, we will have the following equation

$$p_y\frac{\partial Y}{\partial l_Y} = p_x\frac{\partial X}{\partial l_X} \tag{3.23}$$

[8]

[7] In the sector X, the decentralized equilibrium condition is quite similar as $p_x\frac{\partial X}{\partial l_x} = b + \frac{\eta c_x}{1-\eta}m\theta_X + \frac{c_x}{1-\eta}\frac{r+\delta}{q(\theta_X)}$

[8] Two equilibrium conditions in two sectors give us this equalized relation.

That is, when there is no opportunity of arbitrage, the marginal product of each labor will be identical in both sectors in equilibrium. Then by using the equation above and the price equations,we get the equilibrium of working population in the manufacturing sector Y

$$N_Y = \frac{N}{(1+\frac{\rho}{1-\rho})} = N(1-\rho) \tag{3.24}$$

Apparently, the size of working population of the manufacturing sector Y increases with the weight of intermediate Y in producing final good.We also can compute the price value of each intermediate input in the equilibrium, the price value of intermediate Y is

$$p_y = (\frac{1-\rho}{\rho})^{\rho(1-\gamma)}(\frac{A_1}{A_0})^{\rho} \tag{3.25}$$

Finally, knowing the price value of each intermediate input and working population in each sector, we can simplify the previous equilibrium conditions as

$$(\frac{\rho}{1-\rho})^{(1-\gamma)(1-\rho)}(\frac{A_1}{A_0})^{\rho-1}A_1\gamma N^{\gamma-1}(1+\frac{1-\rho}{\rho})^{1-\gamma} = (b+\frac{\eta c}{1-\eta}m\theta+\frac{c}{1-\eta}\frac{r+\delta}{q(\theta)})(\frac{\theta q(\theta)}{\delta+\theta q(\theta)})^{1-\gamma} \tag{3.26}$$

Here there is only one endogenous variable which is to be determined, that is the market tightness of the whole economy.

3.3 Equilibrium with Offshoring Activity

3.3.1 Offshoring in one Sector

We at first look at the impact of one-sector offshoring activity on the domestic labor market, say the manufacturing sector Y. We borrow the basic set-up from Grossman and Rossi-Hansberg (2008), the home country can offshore tasks to countries with lower costs. There are continuum of Y-tasks. We index the Y-tasks by $i \in [0,1]$, and we require that in the manufacturing sector Y, if some tasks are moved to the foreign country, the firm uses the same amount of workers as the firm does on each of these tasks in the home country. That is, domestic workers and foreign workers can be perfectly substituted. Since Grossman and Rossi-Hansberg do not specify whether the offshoring is performed inside or outside of the domestic firm, as many other papers do, the home technology being transferred abroad can be seen as a multinational relationship in offshoring. For the sake of simplicity, we assume that the entire measure of tasks required per unit of labor (each worker) can be normalized to 1. And in order to proceed the production, all tasks $i \in [0,1]$ are required to be performed. For example, if firm needs l units of domestic labor input to perform each task i, then l is also the total amount of domestic labor input because $l = l \int_0^1 di$. In the framework, l is endogenous, that is, firm can determine optimally how much labor input it will use on each of task and indirectly determine how many workers it hires.

In order to capture the cost of offshoring each task, Grossman and Rossi-Hansberg (2008) introduces a specific term $\beta t(i) > 1$, β is a shift parameter which depends on the offshoring technology[9] and it is indifferent for all tasks that are offshored. $t(i)$ captures the specific cost for task with rank i, without loss of generality, the tasks are ranked from 0 to 1 and it becomes more difficult to offshore task with higher rank so that the function $t(i)$ is increasing in i and $t'(i) \geqq 0$. Additionally it should be noted that $t''()$ captures the convexity and the elasticity of the task-specific cost function with respect to the rank of task. If $t'() = 0$, the offshoring cost will be identical for all tasks.

When offshoring becomes possible, if firm decides to offshore their tasks abroad, they should pay the cost of hiring foreign workers. To focus on our analysis on the home labor market, we assume that there is no search friction in the foreign labor market and foreign wage rate w^* is taken as given. The firm of home country wants to perform the tasks $i \in [0, I]$ abroad, the marginal task I separates tasks $i \in [0, I]$ performed abroad from tasks $i \in [I, 1]$ performed in the home country.[10] Like Grossman and Rossi-Hansberg do, we assume that $t(i) \geq 1$ and $t(0) = 1$.

When firm offshores, now we assume that firm needs $\widetilde{l}$ units of labor input to perform each task. [11] Domestic labor performs tasks in the range $i \in [I, 1]$ and foreign labor performs tasks in the range $i \in [0, I]$, so it should hire $\widetilde{l} \int_I^1 di = \widetilde{l}(1 - I) = l_D$ domestic workers and $\widetilde{l} \int_0^I di = \widetilde{l}I = l_F$ foreign workers to proceed the production. The wages paid to the home workers in the manufacturing sector Y are $w_y \widetilde{l} \int_I^1 di = w l_D$ and the wages paid to the foreign workers are $w^* \widetilde{l} \int_0^I \beta t(i) di = w^*(l_F + l_D) \int_0^I \beta t(i) di$. w_y is the wage rate in the manufacturing sector of home country and respectively w^* is the wage rate of the foreign country. [12]

3.3.1.1 Firm producing Y

Now firm uses workers from both home and foreign countries, it hires l_D domestic workers and l_F foreign workers to produce intermediate input Y. l_D and l_F satisfy the following

[9] It depends on the outside trading environment, for instance, trade barriers and transportation costs.

[10] How much tasks firm offshores in home country I is determined optimally by the firm itself. To simplify our analysis, we assume in each sector , there is only one represented firm.

[11] It is not reasonable to believe $l = \widetilde{l}$, because of cost-saving effect, normally firm produces more than closed economy and so $l < \widetilde{l}$.

[12] For task $i \in [0, I]$, the cost of offshoring is $w^*(l_F + l_D)\beta t(i)$.

two conditions

$$(l_D + l_F)\int_0^I di = l_F \tag{3.27}$$

$$(l_D + l_F)(1 - I) = l_D \tag{3.28}$$

From either equation, we can obtain the relationship between the number of domestic workers

$$I = \frac{l_F}{l_D + l_F} \tag{3.29}$$

Now the objective function of firm becomes:

$$\underset{l_D(s),l_F(s),V_Y^D(s),V_Y^F(s)}{Max} \int_t^\infty e^{-r(s-t)}[p_y(s)Y(s) - w_y(s)l_D(s) - w^*(s)(l_F(s) + l_D(s))\int_0^I \beta t(i)di \\ - c^Y V_Y^D(s) - c^F V_Y^F(s)]ds \tag{3.30}$$

V_Y^D is the number of vacancies posted in the home country and respectively V_Y^F is the number of vacancies posted in the foreign country. As we assumed before, there is no search friction in the foreign labor market, thus the job filling probability is 1 and the vacancy cost c^F is 0. The dynamics of domestic as well as foreign employed workers in sector Y are

$$\dot{l_D}(t) = q(\theta_Y(t))V_Y^D(t) - \delta l_D(t) \tag{3.31}$$

$$\dot{l_F}(t) = V_Y^F(t) - \delta l_F(t) \tag{3.32}$$

The current value Hamiltonian for the firm can be written as

$$\mathcal{H} = p_y Y - w_y l_D - w^*(l_F + l_D)\int_0^I \beta t(i)di - cV_Y^D - c^F V_Y^F \\ + \zeta_1(q(\theta_Y)V_Y^D - \delta l_D) + \zeta_2(V_Y^F - \delta l_F) \tag{3.33}$$

If we only consider the steady state equilibrium, $\dot{\zeta_1} = 0$, we have the following four first order conditions

$$\frac{\partial \mathcal{H}}{\partial V_Y^F} = -c^F + \zeta_2 = -0 + \zeta_2 \tag{3.34}$$

$$\frac{\partial \mathcal{H}}{\partial V_Y^D} = -c + \zeta_1 q(\theta_Y(t)) = 0 \tag{3.35}$$

$$\frac{\partial \mathcal{H}}{\partial l_D} = p_y \frac{\partial Y}{\partial l_D} - w_y - w^* \int_0^I \beta t(i)di - w^*(l_F + l_D)\beta t(I)\frac{\partial I}{\partial l_D} - \zeta_1 \delta = \zeta_1 r \tag{3.36}$$

$$\frac{\partial \mathcal{H}}{\partial l_F} = p_y \frac{\partial Y}{\partial l_F} - w^* \int_0^I \beta t(i)di - w^*(l_F + l_D)\beta t(I)\frac{\partial I}{\partial l_F} = 0 \tag{3.37}$$

After simplifying equation (3.36), we have

$$w_y + \frac{(r+\delta)c}{q(\theta_Y)} = p_y \frac{\partial Y}{\partial l_D} - w^* \int_0^I \beta t(i)di - w^*(l_F + l_D)\beta t(I)\frac{\partial I}{\partial l_D} \tag{3.38}$$

From equation (38), we see that in the equilibrium, the marginal cost of hiring a home worker equals the marginal productivity of the worker plus the extra marginal benefit due to the offshoring activity. The extra marginal benefit is combined by two parts, the first part $-w^* \int_0^I \beta t(i)di < 0$ captures the marginal cost of hiring an additional unit of foreign labor.The second part

$-w^*(l_F + l_D)\beta t(I)\frac{\partial I}{\partial l_D} > 0$ captures the marginal cost-savings since hiring foreign labor is cheaper than hiring home labor. Combining these two terms, we have the net cost saving due to the offshoring activities $w^*\beta[t(I)I - \int_0^I t(i)di]$ and it is positive when $I > 0$. Taking the offshoring technology and the foreign wage as given, the cost saving increases with offshoring extent I.

Equation (3.36) over (3.37) yields

$$w^*\beta t(I) = w_y + \frac{(r+\delta)c}{q(\theta_Y)} \tag{3.39}$$

By looking at this equation, we can see that for the marginal task I, it will be indifferent between hiring home worker and foreign worker. Clearly, the equilibrium amount of offshoring is determined where the cost of performing the borderline task abroad, which is $w^*\beta t(I)$, equals the cost of hiring home workers.

The endogenous variables here are labor market tightness θ_Y in the manufacturing sector Y and the offshoring extent I. To compute them, we need two equilibrium conditions.

After simplification, from equation (3.37) we have

$$w^* = \frac{p_y \frac{\partial Y}{\partial l_F}}{\beta[\int_0^I t(i)di + t(I)(1-I)]} \tag{3.40}$$

As foreign wage $w^*$is constant, this equation shows that offshoring extent I increases with the marginal productivity of each foreign worker.[13] We plug the equation (40) back into the first order (36), it gives us [14]

[15]

$$p_y \frac{\partial Y}{\partial l_D}[\frac{t(I)}{\int_0^I t(i)di + t(I)(1-I)}] = w_y + \frac{(r+\delta)c}{q(\theta_Y)} \tag{3.41}$$

Then we have two equilibrium conditions: (3.39) and (3.41) and two endogenous variables:labor market tightness in the manufacturing sector θ_Y and offshoring extent I. Denote the term $F(I) = [\frac{t(I)}{\int_0^I t(i)di+t(I)(1-I)}]$ and $F(I)$ captures the productivity effect which is greater than 1 once the cost function of offshoring is not flat. [16] And the productivity effect increases with the number of tasks offshored because $\frac{\partial F(I)}{\partial I}$ yields

$$\frac{\partial F(I)}{\partial I} = \frac{t^{'}(I)\int_0^I t(i)di}{[\int_0^I t(i)di + t(I)(1-I)]^2} > 0$$

Lemma 3.1. *Productivity effect increases with the extent of offshoring I if the offshoring cost is not flat $t'(i) \neq 0$.*

When the offshoring cost becomes more elastic to the offshoring extent I, $t'(I)$ becomes larger and indirectly leads to a greater marginal productivity effect $F'(I)$. As Grossman and Rossi-Hansberg show, around $I = 0$, the marginal productivity effect is close to 0, therefore the enhanced productivity is negligible. In case of flat offshoring cost, $t(i)$ is identical for all tasks belonging to $[0, 1]$, the productivity effect will disappear and the cost saving equals 0.

[13]The term $[\int_0^I t(i)di + t(I)(1-I)]$ increases with I, $\frac{\partial[\int_0^I t(i)di+t(I)(1-I)]}{\partial I} = t'(I)(1-I) > 0$

[14] Combining this with another wage equation of labor supply side which is identical with that of the closed economy and is determined by individual Nash bargaining, we have $p_y \frac{\partial Y}{\partial l_D}[1+\frac{t(I)I-\int_0^I t(i)di}{\int_0^I t(i)di+t(I)(1-I)}] = b + \frac{\eta c}{1-\eta}m\theta_Y + \frac{c}{1-\eta}\frac{r+\delta}{q(\theta_Y)}$.

[15]Since domestic workers and foreign workers can be perfectly substituted in terms of productivity, then their marginal products are identical, we thus have $p_y \frac{\partial Y}{\partial l_D} = p_y \frac{\partial Y}{\partial l_F}$.

[16]When the cost function $t()$ is convex, we have $t(I)I > \int_0^I t(i)di$.

3.3.1.2 Workers' Reallocation

As workers can move freely across sectors, in the equilibrium, the marginal productivity of worker is identical across sectors given the fact that the vacancy cost is identical across sectors

$$p_y \frac{\partial Y}{\partial l_D} F(I) = p_x \frac{\partial X}{\partial l_X} \tag{3.42}$$

After simplification, we have the relative supply of the working population when firm in the sector Y offshores

$$\frac{N_X}{N_Y} = \frac{\rho}{1-\rho} \frac{1}{(1-I)F(I)} \tag{3.43}$$

Proposition 3.2. *When only one sector exerts offshoring activities, Offshoring leads a net flow of workers from the sector with offshoring activities to the sector without offshoring activities.*

proof

$$(1-I)F(I) - 1 = (1-I)[\frac{t(I)}{\int_0^I t(i)di + t(I)(1-I)}] - 1 < 0 \tag{3.44}$$

Clearly, $(1-I)F(I) < 1$, comparing to the closed economy, more workers choose working in the sector without offshoring activity no matter what will be the economywide as well as sectoral unemployment evolvement. Now the number of workers in sector Y is

$$N_Y = \frac{N}{1 + \frac{\rho}{1-\rho}\frac{1}{F(I)(1-I)}} \tag{3.45}$$

3.3.1.3 Price of Each Intermediate Good

As for the price of intermediate input Y which can be offshored, now it becomes

$$p_y = (\frac{1-\rho}{\rho})^{\rho(1-\gamma)} (\frac{A_1}{A_0})^{\rho} (\frac{1}{F(I)})^{\gamma\rho} \tag{3.46}$$

Proposition 3.3. *Offshoring will reduce the price of intermediate input which is offshored and raise the price of intermediate input of the sector which is not offshored.*

Clearly, comparing to the closed economy, the price of input Y decreases with offshoring scale I since $F(I) > 1$. Firm now produces more due to enhanced productivities, this will push down the price of this intermediate input. On the contrary, the price of input which is not offshored will be raised because the relative demand for this intermediate input will be higher.

In conclusion, offshoring not only leads a productivity effect, but also a relative supply effect as well as a relative price effect.

3.3.1.4 Equilibrium with Offshoring

After knowing the equilibrium price of intermediate input Y and the size of working population in the manufacturing sector Y, we can re-characterize the equilibrium condition (39) as[17]

$$\left(\frac{1-\rho}{\rho}\right)^{\rho(1-\gamma)}\left(\frac{A_1}{A_0}\right)^{\rho}\underbrace{\left(\frac{1}{F(I)}\right)^{\gamma\rho}}_{relative-price}\gamma A_0 N^{\gamma-1}\Big[1+\frac{\rho}{1-\rho}\overbrace{\frac{1}{F(I)(1-I)}}^{relative-supply}\Big]^{1-\gamma}\underbrace{(1-I)^{1-\gamma}}_{replacement}\overbrace{F(I)}^{productivity}$$
$$=\Big[b+\frac{\eta c}{1-\eta}m\theta+\frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta)}\Big]\left(\frac{\theta q(\theta)}{\delta+\theta q(\theta)}\right)^{1-\gamma} \quad (3.47)$$

Here we specify each individual effect due to offshoring activities. They are respectively the relative price effect, the relative supply effect, the replacement effect and the productivity effect. The productivity effect and the relative supply effect are positive while the relative price effect and the replacement effect are negative. After simplifying this equation, we have

$$\left(\frac{1-\rho}{\rho}\right)^{\rho(1-\gamma)}\left(\frac{A_1}{A_0}\right)^{\rho}\gamma A_0 N^{\gamma-1}\Big[F(I)^{\frac{1-\gamma\rho}{1-\gamma}}(1-I)+\frac{\rho}{1-\rho}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}\Big]^{1-\gamma}$$
$$=\Big[b+\frac{\eta c}{1-\eta}m\theta+\frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta)}\Big]\left(\frac{\theta q(\theta)}{\delta+\theta q(\theta)}\right)^{1-\gamma} \quad (3.48)$$

The term in the bracket is the product of those four individual effects, we call it the aggregate effect. Larger aggregate effect implies higher market tightness.

Proposition 3.4. *If the aggregate effect* $F(I)^{\frac{1-\gamma\rho}{1-\gamma}}(1-I)+\frac{\rho}{1-\rho}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}$ *increases with the offshoring extent* I*, when the home firm offshores more, unemployment rate in the home country will decrease .*

If all tasks have identical task-specific offshoring cost, that is $t'(i) = 0$ for $i \in [0, 1]$, the cost-savings are null. In this case, the productivity effect disappears and offshoring more will simply raise the unemployment rate of the home country.

[17] In equilibrium, the labor market tightness as well as the unemployment are identical in two sectors, so we use θ instead of θ_Y to represent the tightness of the whole market.

Corollary 3.5. *If the task-specific offshoring cost is flat, unemployment in the home country will be higher when the home firm offshores more.*

The derivation of the aggregate effect with respect to the offshoring extent gives

$$\frac{\partial[F(I)^{\frac{1-\gamma\rho}{1-\gamma}}(1-I)+\frac{\rho}{1-\rho}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}]}{\partial I}=\frac{1-\gamma\rho}{1-\gamma}F^{'}(I)F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}(1-I) \\ +\frac{\rho\gamma}{1-\gamma}F^{'}(I)F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}-1}-F(I)^{\frac{1-\gamma\rho}{1-\gamma}} \tag{3.49}$$

Since $\frac{\partial F(I)}{\partial I}=\frac{t^{'}(I)\int_0^I t(i)di}{[\int_0^I t(i)di+t(I)(1-I)]^2}$, when the offshoring extent I is close to 0, $F^{'}(I)$ is close to 0 and the derivation is close to -1. On this condition, the aggregate effect decreases with the offshoring extent I. However, as argued in the Grossman and Rossi-Hansberg (2008), $F^{'}(I)$ could be large given two conditions, the first one is that there is a positive offshoring scale $I>0$ and the second one is that the cost schedule for trading tasks rises steeply. Equivalently it implies that if $t'(I)$ is sufficiently large, the aggregate effect can increase with the offshoring extent I. [18]

We illustrate the role of $t'(I)$ in determining the cost saving effect by the figure (a). As we showed before in the equation (38), the term $w^*\beta[t(I)I-\int_0^I t(i)di]$ captures the total cost savings when the home firm offshores tasks with rank $i\in[0,I]$ abroad . For each specific β, we will have different equilibrium extent of offshoring, steeper task-specific cost function implies lower offshoring scale I in the equilibrium. In the figure, $t(I')$ represents the steeper cost schedule. Its cost saving $[t(I')I'-\int_0^{I'} t(i)di]$ is represented by the area $A+C$. And similarly, the cost saving for the relatively flat cost schedule is represented by the area $B+C$. Therefore, $B-A$ captures the extra benefit from the higher degree of steepness. If this difference is sufficiently large, the extra benefit from higher degree of steepness can be large enough to make positive effect dominate the negative effect and simply create jobs.

3.3.2 Offshoring in Two Sectors

Then we focus on the two sectors' offshoring activities in order to see the impact of offshoring technology progress happening in the service sector. Assume firm in the

[18] In Grossman and Rossi-Hansberg (2008), they consider full employment and argue "The first bit of offshoring drives down the wages of domestic workers. This is because the fact that the productivity effect rests on the cost-savins for inframarginal tasks, and there are no such tasks when the complete production process is performed initially at home".

service sector X offshores task with index j. Now the relative supply of workers is given by

$$\frac{N_Y}{N_X} = \frac{1-\rho}{\rho}\frac{(1-I)F(I)}{(1-J)F(J)} \tag{3.50}$$

Like before, in order to capture the change in the unemployment rate of home country, we only need to analyze one sector's activity since the mobility across sectors allowed. Now the price of the intermediate input Y becomes

$$p_y = (\frac{1-\rho}{\rho})^{\rho(1-\gamma)}(\frac{A_1}{A_0})^{\rho}(\frac{F(J)}{F(I)})^{\gamma\rho} \tag{3.51}$$

Clearly, the price of intermediate input Y depends on the relative productivity effect $\frac{F(J)}{F(I)}$ because it can capture the change in the relative production which indirectly affects the relative price. For simplification, we assume that firms in both sectors offshore tasks to the countries with same wage rate w^*. β_I represents the non task-specific offshoring cost in the manufacturing sector and β_J represents the non task-specific offshoring cost in the service sector. At the cutoff, hiring domestic workers and foreign workers are indifferent, so we have two equations as follows

$$w^*\beta_I t(I) = b + \frac{\eta c}{1-\eta}m\theta_Y + \frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta_Y)} \tag{3.52}$$

$$w^*\beta_J t(J) = b + \frac{\eta c}{1-\eta}m\theta_X + \frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta_X)} \tag{3.53}$$

Since workers can move freely across sectors, we have $\theta_X = \theta_Y = \theta$. Combining equation (52) and (53), we obtain the relationship between the marginal task I and the marginal task J in the equilibrium

$$\beta_I t(I) = \beta_J t(J) \tag{3.54}$$

In case of the symmetric offshoring where the non task-specific offshoring costs are same in two sectors and the offshoring cost functions have the same form, [19]firms in two sectors offshore the same extent of tasks abroad in the equilibrium, $I = J$. And in addition to equation (52) and (53), another equilibrium condition that gives the relationship

[19] For instance, all tasks are moved to the same destination with same transportation fees.

between the market tightness and the offshoring extent is

$$(\frac{1-\rho}{\rho})^{\rho(1-\gamma)}(\frac{A_1}{A_0})^{\rho}\underbrace{(\frac{F(J)}{F(I)})^{\gamma\rho}}_{relative-price}\gamma A_0 N^{\gamma-1}[1+\frac{\rho}{1-\rho}\overbrace{\frac{F(J)(1-J)}{F(I)(1-I)}}^{relative-supply}]^{1-\gamma}\underbrace{(1-I)^{1-\gamma}}_{replacement}\overbrace{F(I)}^{productivity}$$
$$= [b+\frac{\eta c}{1-\eta}m\theta+\frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta)}](\frac{\theta q(\theta)}{\delta+\theta q(\theta)})^{1-\gamma} \quad (3.55)$$

Now we have three equations and three endogenous variables, they are the offshoring extent in each sector I ,J and the market tightness θ. As for the aggregate effect, by looking at equation (55) , we can see that offshoring in the service sector plays impact on it by changing the relative price effect as well as the relative supply effect.

When the offshoring technology makes progress in the service sector which means β_J decreases, then the firms in the service sector offshore more. If we consider its impact on the unemployment of home country, we can make the following conclusion.

Proposition 3.6. *When the offshoring technology makes progress in the service sector, if the aggregate effect* $(\frac{F(J)}{F(I)})^{\gamma\rho}[1+\frac{\rho}{1-\rho}\frac{F(J)(1-J)}{F(I)(1-I)}]^{1-\gamma}(1-I)^{1-\gamma}F(I)$ *increases, then the unemployment rate of home country decreases.*

We denote the aggregate effect of offshoring as $\Upsilon(I,J)$,when both sectors exert offshoring activities, it can be simplified into

$$\Upsilon(I,J) = F(J)^{\frac{\gamma\rho}{1-\gamma}}[F(I)^{\frac{1-\gamma\rho}{1-\gamma}}(1-I)+\frac{\rho}{1-\rho}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}F(J)(1-J)]$$

The derivation of $\Upsilon(I,J)$ with respect to I gives

$$\frac{\partial\Upsilon(I,J)}{\partial I} = \frac{1-\gamma\rho}{1-\gamma}F(J)^{\frac{\gamma\rho}{1-\gamma}}F(I)^{\frac{1-\gamma\rho}{1-\gamma}-1}F'(I)(1-I) - F(J)^{\frac{\gamma\rho}{1-\gamma}}F(I)^{\frac{1-\gamma\rho}{1-\gamma}}$$
$$+\frac{\rho}{1-\rho}\frac{\gamma(1-\rho)}{1-\gamma}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}-1}F'(I)F(J)^{\frac{\gamma\rho+1-\gamma}{1-\gamma}}(1-J) \quad (3.56)$$

and the derivation of $\Upsilon(I,J)$ with respect to J gives

$$\frac{\partial\Upsilon(I,J)}{\partial J} = \frac{\gamma\rho}{1-\gamma}F(J)^{\frac{\gamma\rho}{1-\gamma}-1}F(I)^{\frac{1-\gamma\rho}{1-\gamma}}F'(J)(1-I) - \frac{\rho}{1-\rho}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}F(J)^{\frac{1-\gamma+\gamma\rho}{1-\gamma}}$$
$$+\frac{\rho}{1-\rho}\frac{1-\gamma+\gamma\rho}{1-\gamma}F(I)^{\frac{\gamma(1-\rho)}{1-\gamma}}F'(J)F(J)^{\frac{\gamma\rho}{1-\gamma}}(1-J) \quad (3.57)$$

Similar to our previous analysis, if the marginal task-specific offshoring cost $t'(J)$ is small for task j , making $F'(J)$ small, and then $\frac{\partial \Upsilon(I,J)}{\partial J}$ will be negative. In this case, increasing the offshoring extent J in the service sector will reduce the aggregate effect and raise the domestic unemployment rate. On the contrary, if the marginal task-specific offshoring cost $t'(J)$ is sufficiently large for task j, $\frac{\partial \Upsilon(I,J)}{\partial J}$ is positive, then increasing the offshoring extent J in the service sector will increase the aggregate effect and reduce the domestic unemployment. Consequently, the progress of offshoring technology in the service sector which leads greater offshoring extent J can push the aggregate effect in either direction and make domestic unemployment become either higher or lower.

As for the indirect impact of the change in the service sector's offshoring technology on the manufacturing sector's offshoring activity. First let us consider the condition that in the manufacturing sector,in the initial equilibrium, the marginal task-specific offshoring cost $t'(I)$ is sufficiently large for task i. Under this condition, if $t'(J)$ is sufficiently large for task j as well in the initial equilibrium, the progress of offshoring technology in the service sector will raise the offshoring scale in the manufacturing sector through increasing the cost of hiring domestic workers. That is, the progress of offshoring technology in the service sector increases the aggregate effect and reduce the domestic unemployment rate. This makes hiring home workers become more costly and makes the firms in the manufacturing sector offshore more. This indirect effect will reinforce the dominance of the productivity effect in the manufacturing sector and in turn help create more domestic jobs. On the contrary, if $t'(J)$ is small for task j in the initial equilibrium, the progress of offshoring technology in the service sector will bring down the offshoring volume in the manufacturing sector to a smaller extent through reducing the cost of hiring domestic workers. For the same reasoning, this indirect effect will weaken the dominance of the productivity effect in the manufacturing sector and help destroy more domestic jobs. In both two cases, the indirect effect will amplify the impact of the offshoring technology progress in the service sector, either positively or negatively. Second we consider the condition where in the manufacturing sector, in the initial equilibrium, the marginal task-specific offshoring cost $t'(I)$ is not sufficiently large. Under this condition, the indirect effect will weaken the impact of the offshoring technology progress in the service sector on the domestic unemployment rate. The figure (b) shows us the role of the indirect effect in different conditions, the solid arrow represents the impact of offshoring technology progress in the service sector on the domestic unemployment rate and the dotted arrow represents the indirect effect ,coming from the change in the offshoring extent of the manufacturing sector, on the domestic unemployment rate.

3.3.3 Trade Balance

As we consider the steady state equilibrium, it is necessary to check whether trade is balanced since if the trade is not balanced, the government will change the interest rate to increase or decrease the capital account, hence the interest rate can not be constant. The final good will be consumed by home consumers as well as foreign consumers who will consume it by importing. The consumers include the firms and workers. Firms use their net profits to consume final good and workers use revenue to consume it, therefore the domestic consumption of final good equals

$$Consumption_{domestic} = p_y Y - w_y l_{D,Y} - w^*(l_{F,Y} + l_{D,Y}) \int_0^I \beta t(i) di - cV_Y^D - c^F V_Y^F + w_y l_{D,Y} + p_x X - w_x l_{D,X} - w^*(l_{F,X} + l_{D,X}) \int_0^J \beta t(j) dj - cV_X^D - c^F V_X^F + w_x l_{D,X} \quad (3.58)$$

$l_{D,Y}$ is the number of domestic employed workers in the manufacturing sector Y and $l_{D,X}$ is the number of domestic employed workers in the service sector X . The value of the net exports of final goods consumed by foreign consumers is the production of final good nets domestic comsumption and the sunk hiring cost

$$Exports = p_y Y - cV_Y^D - c^F V_Y^F + p_x X - cV_X^D - c^F V_X^F - Consumption_{domestic} = w^*(l_{F,Y} + l_{D,Y}) \int_0^I \beta t(i) di + w^*(l_{F,X} + l_{D,X}) \int_0^J \beta t(j) dj \quad (3.59)$$

That is, there is part of production being wasted in order to compensate the hiring cost. Since offshoring is a process of importing services, the value of the net imports equal the payment to foreign workers

$$Imports = w^*(l_{F,Y} + l_{D,Y}) \int_0^I \beta t(i) di + w^*(l_{F,X} + l_{D,X}) \int_0^J \beta t(j) dj \quad (3.60)$$

Clearly, the exports equal the imports and the trade is balanced.

3.4 Numerical Illustration

3.4.1 Calibration for Belgium

We choose Belgium as the target country for our calibration exercise as it is a country with higher degree of openness. We will provide details of the choice of parameter values and sources in the appendix. Below we will discuss the choice of some crucial parameters.

We take the month as the unit of time. The values of parameters are based on the observed data and literatures. The monthly rate of job destruction δ is chosen as 0.013 and the discount rate r is chosen as 0.008 based on the parameter values chosen in Van der Linden et al. (2001). As for the elasticity of matching function ϕ for the Belgium , the estimate of it in the empirical analysis of Petrongolo and Pissarides (2000)is 0.6. Therefore, the job finding rate can be given as $m\theta^{0.4}$. In Van der Linden et al (2001), the estimate of the labor market tightness in Belgium is 0.14 and hence the scale parameter m can be obtained indirectly by using job destruction rate δ and unemployment rate u according to $u = \frac{\delta}{\delta + m\theta^{0.4}}$. Then we obtain an estimate of $m = 0.34$. As for the worker's share of surplus, we choose $\eta = 0.77$ which is from Van der Linden et al (2001) as well. According to OECD report, the net replacement ratio $\frac{b}{w}$ is around 0.35 for Belgium.

Then we will see the parameters related to the production activity. We estimate the weight parameter ρ according to $\frac{p_Y Y}{p_X X} = \frac{1-\rho}{\rho}$ given the consumption of each intermediate inputs which can be found in OECD STAN input-output table, and the estimate is $\rho = 0.476$. We take the production function parameter γ from Bentolila and St. Paul (2003), what they estimate for Belgium is $\gamma = 0.64$. We do not have enough information of production technology, so for simplification, we normalize the technology of production in both sectors to 1, that is $A_0 = A_1 = 1$.

Finally, we consider the parameters related to the offshoring activity. As for the measure of the non task-specific cost of offshoring which captures the offshoring technology, we use the measure from Feenstra and Hanson (1999) and Greg Wright (2011) in which variation of offshoring is reflected in changes in the imports of intermediate inputs, they construct the direct measure of the offshoring extent as

$$Off_g = \frac{\sum_h [(intermediates\ purchased\ by\ g\ from\ h)(\frac{imports\ of\ intermediates\ in\ h}{domestic\ consumption\ of\ intermediates\ in\ h})]}{\sum_h (intermediates\ purchased\ by\ g\ from\ h)} \tag{3.61}$$

Off_g refers to the offshoring extent in the sector g. According to this measure, we can obtain the offshoring extents in the service sector as well as the manufacturing sector. For example, the offshoring extent in the manufacturing sector I is given as

$$I = \sum_{m \in M} Off_m \frac{intermediates\ comsumption\ of\ m}{intermediates\ comsumption\ in\ manufacturing\ sector} \tag{3.62}$$

Off_m is the offshoring extent in the sector m that belongs to the set of manufacturing sector M, the term $\frac{intermediates\ comsumption\ of\ m}{intermediates\ comsumption\ in\ manufacturing\ sector}$ refers to the weight of intermediates consumption in the sector m. In our model, the ratio of imported inputs to the total intermediate consumption is equivalent to the proportion of foreign hires, they are $I = \frac{l_{F,Y}}{l_{F,Y}+l_{D,Y}}$ and $J = \frac{l_{F,X}}{l_{F,X}+l_{D,X}}$.

We have five remaining parameters: c, w^*,τ, β_I and β_J to be determined. As we do not have direct information about the non task-specific offshoring cost for each sector, we have to compute them by using the economywide non task-specific cost of offshoring. In our model β represents it and it is equivalent to the iceberg cost of trade in other literatures , a commonly used value is around 1.5 (e.g. Melitz(2003),Felbermayr et al, 2011). We also can compute the economywide offshoring extent which is 0.305. For simplification, we assume that both sectors have the same task-specific offshoring cost function $t(.)$, so we can choose β_I and β_J according to the following relationship given offshoring extent in the manufacturing sector $I = 0.38$ and $J = 0.21$ in the service sector

$$\beta(1+0.305)^\tau = \beta_I(1+I)^\tau = \beta_J(1+J)^\tau \tag{3.63}$$

The relation above comes from the fact that for the marginal task, it will be indifferent between hiring workers in the manufacturing sector and hiring workers in the service sector. [20] At last, w^* and c are chosen to match the unemployment and the offshoring extent in the manufacturing sector.[21] We are going to try two different task-specific offshoring cost functions: the relatively flat one $t(i) = (1+i)^2$; the relatively steep one $t(i) = (1+i)^4$. For different task-specific cost functions, we obtain different values of w^* and c. [22]

3.4.2 Simulation Results

In our simulation exercises, for each specification of the task-specific cost function, we hold the calibrated values of c and w^* constant at their baseline values. Here we mainly concern the impact of the offshoring technology progress in the service sector on the domestic unemployment as well as on the offshoring extents of both service sector and manufacturing sector. The simulation results are shown in the figure (c) and figure (d).

Figure (c):Flat cost function $t(i) = (1+i)^2$ *and* $t(j) = (1+j)^2$

Figure (c) shows the results of comparative statics with respect to the offshoring technology (non task-specific offshoring cost) in the service sector when the task-specific cost

[20] For each marginal task, it is indifferent between hiring domestic workers and foreign workers. As domestic workers can move freely across sectors and the cost of hiring foreign workers is same for each sector,we can conclude that at the margin, it is indifferent between hiring workers in different sectors.

[21] We can also match the offshoring scale in the service sector.

[22] We do not know what exactly task-specific cost function looks like, so we just give two simple examples.

function has the form $t(.) = (1+.)^2$. It can be easily seen that a decrease in the non task-specific offshoring cost (the offshoring technology makes progress) in the service sector leads an increase in the unemployment as well as the offshoring extent in the service sector. As for the impact on the offshoring extent in the manufacturing sector, it makes firm in the manufacturing sector offshore less since hiring domestic workers becomes less costly now. Without this indirect effect,we can at first see that the unemployment would be higher because the offshoring scale in the manufacturing sector is assumed to be constant and non decreasing offshoring scale in the manufacturing sector does not help reduce unemployment.We can at second see that the offshoring extent would be lower in the service sector for each non task-specific offshoring cost level because the free mobility condition implies that the cost of offshoring for the marginal task is identical across sectors, without the indirect impact, the offshoring extent in the manufacturing sector is larger than that with the indirect impact, this makes the offshoring extent in the service sector for each level non task-specific offshoring cost be larger.

Figure (d): Steep cost function $t(i) = (1+i)^4$ and $t(j) = (1+j)^4$

Figure (d) shows the results when the cost function has the form $t(.) = (1+.)^4$ .We repeat the same exercise and can see that a decrease in the non task-specific offshoring cost in the service sector leads a decrease in unemployment, this makes hiring domestic workers become more costly, therefore it will enlarge the offshoring extent in the manufacturing sector. And the increasing offshoring scale in the manufacturing sector in turn reinforces the productivity effect and reduces the unemployment. Therefore, with the indirect impact, the unemployment would be even lower. And in terms of the offshoring scale for each non task-specific offshoring cost, same to our previous analysis, it would be lower than that without the indirect effect.

3.5 Welfare Analysis

3.5.1 Social Optimum vs. Equilibrium

Now we consider the social optimum condition. In case of offshoring in both sectors, the social planner now wishes to solve the following maximization problem

$$\underset{l_{D,X}(s),l_{F,X}(s),l_{D,Y}(s),l_{F,Y}(s),V_Y^D(s),V_Y^F(s),V_X^D(s),V_X^F(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[\frac{X^\rho Y^{1-\rho}}{\rho^\rho(1-\rho)^{1-\rho}}$$

$$+b(N-l_{D,X}(s)-l_{D,Y}(s))-w^*(l_{F,Y}(s)+l_{D,Y}(s))\int_0^I \beta_I t(i)di-w^*(l_{F,X}(s)+l_{D,X}(s))\int_0^J \beta_J t(j)dj$$

$$-cV_Y^D(s)-c^F V_Y^F(s)-cV_X^D(s)-c^F V_X^F(s)]ds \quad (3.64)$$

The social planner is subject to the identical matching constraints outlined in the decentralized economy, the evolution of unemployment that constrains social choices is the same as the one that contains firm's choice.

$$\dot{l_{D,X}}(t) = q(\theta_X(t))V_X^D(t) - \delta l_{D,X}(t) \tag{3.65}$$

$$\dot{l_{D,Y}}(t) = q(\theta_Y(t))V_Y^D(t) - \delta l_{D,Y}(t) \tag{3.66}$$

$$\dot{l_{F,X}}(t) = V_X^F(t) - \delta l_{F,X}(t) \tag{3.67}$$

$$\dot{l_{F,Y}}(t) = V_Y^F(t) - \delta l_{F,Y}(t) \tag{3.68}$$

The computation is put in the appendix. We find that the equilibrium coincides with the social optimum if the following condition is satisfied

$$(r + \delta + \phi m\theta q(\theta))\frac{c}{(1-\phi)q(\theta)} = \frac{\eta c}{1-\eta}m\theta + \frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta)} \tag{3.69}$$

Clearly,the Hosios condition is verified here, that is , when the elasticity of job matchings equals the labor's share of the surplus created by the job $\phi = \eta$, the decentralized equilibrium is social optimum. Therefore we can conclude that when offshoring becomes possible and the offshoring scale is greater than 0 in the equilibrium, the social welfare is greater than that in the economy where the offshoring activity is not forbidden. The trade protection policy actually makes society worse off no matter how evolves the domestic unemployment.

Proposition 3.7. *With offshoring activity, any decentralized equilibrium maximizes the social planner's problem provided that the Hosios condition holds $\phi = \eta$.*

When Hosios condition holds, the appropriability and congestion problems exactly balance each other. Then we try to see the role of the labor's share of the surplus in determining the market tightness and the offshoring scale, it is easier to analyze it under the condition of symmetric offshoring where both the task-specific offshoring cost function form and the non task-specific offshoring cost (offshoring technology) are identical across sectors. As workers can move freely across sectors, we simply need to analyze one sector's optimization problem, like before we choose the manufacturing sector as our target of analysis. The objective function of the firm in the manufacturing sector Y can be simplified into

$$\underset{l_{D,Y}(s),l_{F,Y}(s),V_Y^D(s),V_Y^F(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[p_y(s)Y(s)-(b+\frac{\eta c}{1-\eta}m\theta_Y+\frac{1}{1-\eta}\frac{(r+\delta)c}{q(\theta_Y)})l_{D,Y}(s)$$
$$-w^*(s)(l_{F,Y}(s)+l_{D,Y}(s))\int_0^I \beta t(i)di - c^Y V_Y^D(s) - c^F V_Y^F(s)]ds \quad (3.70)$$

Since $l_{D,Y}$ increases with θ_Y in case of symmetric offshoring , by using Topkis's Theorem, we can find that in equilibrium $\frac{\partial \theta_Y}{\partial \eta} < 0$. As workers move freely across sectors, we simply have[23]

$$\frac{\partial \theta}{\partial \eta} < 0 \quad (3.71)$$

As for the impact of worker's bargaining power on the offshoring extent in the equilibrium, we have the offshoring extent as $I = \frac{l_{F,Y}}{l_{F,Y}+l_{D,Y}}$. The differentiation of the offshoring extent with respect to the worker's bargaining power gives

$$\frac{\partial I(l_{D,Y}, l_{F,Y})}{\partial \eta} = \frac{\partial I}{\partial l_{D,Y}}\frac{\partial l_{D,Y}}{\partial \eta} + \frac{\partial I}{\partial l_{F,Y}}\frac{\partial l_{F,Y}}{\partial l_{D,Y}}\frac{\partial l_{D,Y}}{\partial \eta} = \frac{\frac{\partial l_{F,Y}}{\partial l_{D,Y}}l_{D,Y} - l_{F,Y}}{(l_{F,Y}+l_{D,Y})^2}(\frac{\partial l_{D,Y}}{\partial \eta}) \quad (3.72)$$

When the domestic worker's bargaining power increases, it becomes relatively more costly to hire domestic workers. Since domestic worker and foreign worker can be perfectly substituted, the increasing relative cost of hiring domestic workers makes firm hire more foreign workers to replace domestic workers,thus the sign $\frac{\partial l_{F,Y}}{\partial l_{D,Y}}$ should be negative. Consequently, when hiring domestic workers becomes more costly, firm changes the composition of labor hirings in the way of favoring cheaper foreign labor. When the worker's bargaining power is higher than the matching elasticity, the proportion of foreign hires in the equilibrium is higher than that in the social optimum. Social planner prefers to offshore less than in the equilibrium.

3.5.2 Policy Instrument

We propose a simple policy instrument which can make the equilibrium optimal. We assume that there is a subsidy on hiring domestic workers, hiring each unit of domestic worker is subsidized with t by the government . Here we also consider the case of symmetric offshoring. Then we can simulate the model with Belgium parameters and show the optimal subsidy level in case of non symmetric offshoring. Now the firm's

[23]In case of symmetric offshoring, we obtain $I = J$ and $\frac{l_{D,Y}}{l_{D,X}} = \frac{1-\rho}{\rho}$. As $l_D = l_{D,Y} + l_{D,X}$ $l_D$increases with $l_{D,Y}$. So we can conclude that both the number of domestic employed workers and the labor market tightness decrease with the worker's bargaining power.

objective in the manufacturing sector Y becomes

$$\underset{l_{D,Y}(s),l_{F,Y}(s),V_Y^D(s),V_Y^F(s)}{Max} \int_t^{\infty} e^{-r(s-t)}[p_y(s)Y(s) - (w_y(s) - t)l_{D,Y}(s) - w^*(s)(l_{F,Y}(s) + l_{D,Y}(s)) \int_0^I \beta t(i)di - c^Y V_Y^D(s) - c^F V_Y^F(s)]ds \quad (3.73)$$

The equilibrium condition for the marginal task I now becomes

$$w^*\beta t(I) = w_y - t + \frac{(r+\delta)c}{q(\theta)} \quad (3.74)$$

If we do not consider the budget balance of the government and equalize the equilibrium with the social optimum condition, we obtain the optimal level of subsidy

$$t = \frac{1}{1-b}(\frac{\eta}{1-\eta} - \frac{\phi}{1-\phi})c(m\theta + \frac{r+\delta}{q(\theta)}) \quad (3.75)$$

Clearly, if the worker's bargaining power is greater than the matching elasticity ϕ, the optimal subsidy is positive. Intuitively, if the cost of hiring domestic labor goes up, there will be less vacancies being posted in the domestic labor market. An increasing hiring subsidy can correct this inefficiency in the way of reducing the hiring cost. The optimal level of the subsidy increases both with the difference between the worker's bargaining power η and the matching elasticity ϕ and with the labor market tightness.[24]That is because larger difference between η and ϕ or greater labor market tightness makes the difference between equilibrium and social optimum become larger and this leads a greater distortion. Therefore, if the decreasing non task-specific offshoring cost leads to a decrease in domestic unemployment, the government should improve the subsidy level to achieve the social optimum.

If we concern the budget balance of the government, the subsidy should be compensated by other funds. We assume that it comes from the taxation of the whole working population and the taxation rate is given by T. Like before, if we equalize the equilibrium condition with the social optimal condition, we simply have the optimal level of subsidy

$$t = \frac{1}{1-b}(\frac{1}{1-T}\frac{\eta}{1-\eta} - \frac{\phi}{1-\phi})c(m\theta + \frac{r+\delta}{q(\theta)}) \quad (3.76)$$

Combining this with the wage equation, we will indirectly have the optimal subsidy rate

$$\frac{t}{w_y} = \frac{\frac{1}{1-b}(\frac{1}{1-T}\frac{\eta}{1-\eta} - \frac{\phi}{1-\phi})c(m\theta + \frac{r+\delta}{q(\theta)})}{\frac{1}{1-b}(\frac{1}{1-T}\frac{\eta}{1-\eta})c(m\theta + \frac{r+\delta}{q(\theta)})} = 1 - (1-T)\frac{\phi(1-\eta)}{\eta(1-\phi)} \quad (3.77)$$

[24]When the worker's bargaining power is smaller than the matching elasticity, the optimal subsidy becomes negative, in this case, government should tax the firm on hiring domestic workers.

When $\eta > \phi$, t is positive, there should be a subsidy for hiring domestic workers. Comparing the equation (75) with (76), we find that if we consider the budget balance, the scale of subsidy increases with the taxation rate T since higher level of taxation implies higher subsidy. The equation of budget balance gives

$$w_y T(1-u) + b w_y T u = (1-u)t \tag{3.78}$$

This equation gives us another relationship between the optimal subsidy rate $\frac{t}{w_y}$ and the taxation rate T. Combining equation (77) and (78), we have the optimal taxation rate

$$T = \frac{(1 - \frac{1-\eta}{\eta}\frac{\phi}{1-\phi})}{1 + \frac{u}{1-u}b - \frac{\phi(1-\eta)}{\eta(1-\phi)}} \tag{3.79}$$

Clearly, the sign of T is positive when worker's bargaining power is greater than the matching elasticity and the level of taxation rate decreases with the domestic unemployment

$$\frac{\partial T}{\partial u} < 0$$

According to equation (75) and (76), we can conclude that the optimal subsidy t in both cases, with and without concerning the budget balance, decreases with the domestic unemployment rate.

In addition to showing the analytical results, now we simulate the optimal subsidy for Belgium by using Belgium parameters. For simplification, we only show the case without considering the budget balance.[25] As we analyzed before, when the offshoring technology in the service sector makes progress, the domestic unemployment can be reduced if the marginal task-specific offshoring cost is large enough, in this case the optimal scale of subsidy should become larger. On the contrary, if the progress of the offshoring technology leads to an increase in domestic unemployment given that the marginal task-specific offshoring cost is relatively small, then the optimal scale of subsidy should become smaller.

Finally we do a counterfactual exercise to find the optimal subsidy scale in the closed economy when the worker's bargaining power is higher than the matching elasticity. Then we compare it with that in the open economy. The table below provides the numerical results under different regimes. The counterfactual result suggests that when the task-specific offshoring cost is relatively flat,implying small level of $t'()$, the optimal subsidy in the open economy is always lower than that in the closed economy as the unemployment rate in the closed economy is lower than that in the open economy. On

[25] As the analysis we showed above, the results are in the same pattern with and without considering the budget balance.

the contrary, when the task-specific offshoring cost becomes steeper,implying large level of $t'()$, the optimal subsidy scale in the open economy can be higher than that in the closed economy.

3.6 Offshoring in the Global Economy

3.6.1 Impact of Offshoring on Two Countries' Unemployment

We finally discuss the two country case where the foreign worker's wage is determined endogenously as well. The objective is to analyze the impact of offshoring activity on the home and foreign unemployment. we also discuss the global inequality and the welfare with simplified model in the end. We take the home country with higher wage level as the northern country and the foreign country with lower wage level as the southern country. Since we mainly focus on the two country's problem now, to simplify our analysis, we only consider the economywide offshoring activity instead of considering the offshoring activities of different sectors separately.

Once offshoring activity becomes possible, some southern workers will work in the national firm (southern firm) and some work in the multinational firm(northern firm). Both the national firm and the multinational firm pay the same wage to the southern workers. Southern firm hires l_f southern workers, and the equilibrium condition gives

$$pA_f l_f^{\gamma-1}\gamma = w^* + \frac{(r+\delta)c_f}{q(\theta_f)} \tag{3.80}$$

Similarly, the firm in the north hires l_D northern workers and l_F southern workers, the equilibrium condition gives

$$pA_0(l_D + l_F)^{\gamma-1}\gamma F(I) + (1 - F(I))\frac{c_f(r+\delta)}{q(\theta_f)} = w + \frac{(r+\delta)c}{q(\theta)} \tag{3.81}$$

As before, the equilibrium amount of offshoring is determined where the costs of performing the borderline task abroad equals its cost at home, that is

$$w + \frac{(r+\delta)c}{q(\theta)} = \beta t(I)w^* + \frac{(r+\delta)c_f}{q(\theta_f)} \tag{3.82}$$

And at the cutoff, the extent of offshoring is

$$I = \frac{l_F}{l_F + l_D} \tag{3.83}$$

Finally, once we know the labor market tightness we can obtain the amount of labor employed in each country

$$l_f + l_F = n_f \frac{\theta_f q(\theta_f)}{\delta + \theta_f q(\theta_f)} \tag{3.84}$$

$$l_D = n_d \frac{\theta q(\theta)}{\delta + \theta q(\theta)} \tag{3.85}$$

The offshoring equilibrium in global economy is characterized by the 6 equations (80), (81), (82), (83) ,(84) and (85) which solve for the 6 endogenous variables: l_f, θ_f,l_F, I, θ and l_D. Combining equations (80) and (84), we have

$$l_F = n_f \frac{\theta_f q(\theta_f)}{\delta + \theta_f q(\theta_f)} - [\frac{(b + \frac{\eta_f c_f}{1-\eta_f} m_f \theta_f + \frac{c_f}{1-\eta_f}\frac{r+\delta}{q(\theta_f)})}{pA_f\gamma}]^{\frac{1}{\gamma-1}} \tag{3.86}$$

Apparently, the more southern workers that northern firm hires, the higher market tightness will be in the south. Then we undertake a simulation by using the parameters of Belgium again. As we do not concern the impact of labor market institutions, we simply assume all the labor market institutions are identical in two countries and they also have the same working population size, the same discount rate and job destruction rate. The only difference roots in the technology of production, we assume the marginal productivity of each worker in the South A_f equals half of that in the North, $A_f/A_0 = 0.5$. The simulation results are shown in the figure (f), from which we can see that offshoring technology progress reduces the unemployment in the south. As for the north, the unemployment can be reduced provided that the marginal task-specific offshoring cost is sufficiently large, this result is consistent with our previous analysis.

3.6.2 Global Inequality and Welfare

Then we consider the impact of offshoring activity on the global issues including the global wage inequality and the welfare. To obtain the analytical results, we simplify the model and assume that the vacancy cost is 0 in both countries. We make such simplification because with search frictions, wage increases with the market tightness, offshoring raising the market tightness is equivalent to raising the wage rate.However it is difficult to see the impact on the tightness directly, so we simply assume no friction and the change in the wage rate can reflect the impact of offshoring. Then we have the following simplified equilibrium conditions

$$pA_f l_f^{\gamma-1}\gamma = w^* \tag{3.87}$$

$$pA_0(l_D + l_F)^{\gamma-1}\gamma F(I) = w \tag{3.88}$$

$$w = \beta t(I) w^* \tag{3.89}$$

$$I = \frac{l_F}{l_F + l_D} \tag{3.90}$$

The offshoring equilibrium in global economy is characterized by the 4 equations (87), (88), (89), and (90) , which solve for the 4 endogenous variables: w, w^*, l_f(or l_F since $l_f + l_F$ is constant now) and I. If we combine these four equations, we will have the relation between the non task-specific offshoring cost β and the offshoring extent in the equilibrium as

$$\beta = \frac{A_0}{A_f}[\frac{l_f + l_F}{l_D}(1-I) - I]^{1-\gamma}\frac{1}{\int_0^I t(i)di + t(I)(1-I)} \tag{3.91}$$

Clearly, the offshoring scale I decreases with β as $\frac{\partial I}{\partial \beta} < 0$. What is different from the previous section is that the offshoring scale is bounded since the number of southern workers working in the national firm can not be negative, this implies that the offshoring scale can not be more than $\frac{l_f + l_F}{l_f + l_F + l_D}$.

We then mainly focus on analyzing the impact of the decrease in the non task-specific cost of offshoring on the global inequality as well as on the global welfare.As $\frac{\partial I}{\partial \beta} < 0$, all levels of the offshoring extent I in the range $[0, 1]$ can be obtained by changing β, thus in order to see the impact of β , we simply can see the impact of the offshoring extent.

3.6.2.1 Global Inequality

As for the impact of offshoring activity on global wage inequality $\frac{w}{w^*}$, we combine equation (87) and (88), then we have

$$\frac{w}{w^*} = \frac{A_0}{A_f}[\frac{l_f + l_F}{l_D}(1-I) - I]^{1-\gamma}F(I) \tag{3.92}$$

The derivation of it with respect to the offshoring extent I is

$$\frac{\partial \frac{w}{w^*}}{\partial I} = (1-\gamma)\frac{A_0}{A_f}[\frac{l_f + l_F}{l_D}(1-I) - I]^{-\gamma}F(I)(-\frac{l_f + l_F}{l_D} - 1) + \frac{A_0}{A_f}[\frac{l_f + l_F}{l_D}(1-I) - I]^{1-\gamma}F'(I) \tag{3.93}$$

When I is close to 0, this derivative is close to $-(1-\gamma)\frac{A_0}{A_f}(\frac{l_f+l_F}{l_D})^{-\gamma}(\frac{l_f+l_F}{l_D}+1)$, the wage inequality increases with the offshoring scale.When the offshoring scale increases, if the marginal task-specific offshoring cost for trading tasks $t'()$ is large enough, the derivative can be positive and thus the wage inequality can increase. This result is also quite consistent with our previous analysis. The productivity effect can be large enough to make the increase of wage in the north be larger than that in the south. The simple simulation result is shown in the figure (g).In the simulation exercise, we try two cost schedules, one is relatively flat and another one is relatively steep.We can see that with flat cost schedule, the wage inequality decreases with the offshoring extent. However, with steep cost schedule, the wage inequality can increase with the offshoring extent. We conclude our result in the proposition below.

Proposition 3.8. *When* $\frac{F'(I)}{F(I)} > (1-\gamma)\frac{l_f+l_F+l_D}{(l_f+l_F)(1-I)-l_D I}$, *the wage inequality between north and south is raised when the offshoring technology makes progress.*

3.6.2.2 Global Welfare

The global welfare is sum of the firms' profits and workers' wages

$$W = pA_0(l_F+l_D)^{\gamma} + pA_f l_f^{\gamma} - w^*(l_D+l_F)\int_0^I \beta t(i)di + w^* l_F \tag{3.94}$$

The derivation of the welfare with respect to the offshoring extent gives

$$\begin{aligned}\frac{\partial W}{\partial I} &= pA_0 l_D^{\gamma}\gamma(1-\gamma)(1-I)^{-\gamma-1}[1-(1-I)F(I)] + A_0(\frac{l_D}{1-I})^{\gamma}\gamma F'(I)(1-I) \\ &\quad + A_f(1-\gamma)(l_f+l_F-\frac{I}{1-I}l_D)^{\gamma-2}\gamma\frac{l_D^2 I}{(1-I)^3}\end{aligned} \tag{3.95}$$

Since $(1-I)F(I) < 1$,[26] the derivative is positive. Consequently we have $\frac{\partial W}{\partial I} > 0$ and indirectly have $\frac{\partial W}{\partial \beta} < 0$. The global welfare goes up when the offshoring technology makes progress. This is because both north and south gain from the productivity improvement. For the northern firm, its productivity is raised because of cost saving effect. For the southern firm, its productivity is raised because of the decreasing return to scale,the marginal product of each worker becomes greater.

Proposition 3.9. *When the offshoring technology makes progress, the global welfare goes up.*

[26] We have$(1-I)F(I) = \frac{t(I)(1-I)}{\int_0^I t(i)di + t(I)(1-I)} < 1$ for $I > 0$.

3.6.2.3 Worker's welfare

It is also interesting to look at the welfare of workers, we want to see whether the workers can benefit from the globalization. The welfare of total working population is

$$WW = \frac{w}{p} l_D + \frac{w^*}{p}(l_f + l_F) \tag{3.96}$$

Combining equations (87) and (88), we will have the worker's welfare in terms of the offshoring scale I

$$WW = A_f \gamma (l_f + l_F)(l_f + l_F - \frac{I}{1-I} l_D)^{\gamma - 1} + A_0 \gamma F(I)(1-I)^{1-\gamma} l_D^{\gamma} \tag{3.97}$$

The derivation of it with respect to the offshoring extent gives

$$\begin{aligned}\frac{\partial WW}{\partial I} &= (1-\gamma) A_f \gamma (l_f + l_F)(l_f + l_F - \frac{I}{1-I} l_D)^{\gamma-2} \frac{1}{(1-I)^2} l_D \\ &+ A_0 \gamma l_D^{\gamma} [(1-I)^{1-\gamma} F'(I) - (1-\gamma) F(I)(1-I)^{-\gamma}]\end{aligned} \tag{3.98}$$

When I is close to 0, the derivative can be simplified into

$$(1-\gamma) l_D [A_f \gamma (l_f + l_F)^{\gamma-1} - A_0 \gamma l_D^{\gamma-1}] \tag{3.99}$$

If $A_f l_D^{1-\gamma} > A_0 (l_f + l_F)^{1-\gamma}$, the sign of the derivative is positive, but this is in contradiction to the initial condition where $\frac{w}{w^*} > 1$, therefore when the offshoring volume is small, the workers' welfare falls with the extent of offshoring. When I is close to 0, the marginal benefit gained from the offshoring activity is close to the marginal productivity in the southern country, at the same time the marginal loss is close to the marginal productivity in the north, as the later one is greater than the former one, the workers' welfare falls.

To see whether the workers' welfare can increase, we at first see an extreme case where the cost schedule is flat, this implies that $F'(I) = 0$ and $F(I) = 1$. The derivation becomes

$$\frac{\partial WW}{\partial I} = (1-\gamma) A_f \gamma (l_f + l_F)(l_f + l_F - \frac{I}{1-I} l_D)^{\gamma-2} \frac{1}{(1-I)^2} l_D - A_0 \gamma l_D^{\gamma} (1-\gamma)(1-I)^{-\gamma} \tag{3.100}$$

So when

$$I > \frac{\frac{l_f + l_F}{l_D} - (\frac{A_f}{A_0} \frac{l_f + l_F}{l_D})^{\frac{1}{2-\gamma}}}{\frac{l_f + l_F}{l_D} + 1}, \tag{3.101}$$

the workers' welfare is improved by increasing offshoring volume. Since the number of south workers hired by the northern firm can not be more than the whole working population $l_f + l_F$, the northern firm offshores at most $\frac{l_f+l_F}{l_f+l_F+l_D}$, clearly there always exists a range in which the workers' welfare is improved, that is $I \in (\frac{\frac{l_f+l_F}{l_D} - (\frac{A_f}{A_0}\frac{l_f+l_F}{l_D})^{\frac{1}{2-\gamma}}}{\frac{l_f+l_F}{l_D}+1}, \frac{\frac{l_f+l_F}{l_D}}{\frac{l_f+l_F}{l_D}+1})$. In this case, though there is no productivity effect, the workers' welfare can increase.

Proposition 3.10. *When the task-specific offshoring cost is flat, if the offshoring scale belongs to the range* $(\frac{\frac{l_f+l_F}{l_D} - (\frac{A_f}{A_0}\frac{l_f+l_F}{l_D})^{\frac{1}{2-\gamma}}}{\frac{l_f+l_F}{l_D}+1}, \frac{\frac{l_f+l_F}{l_D}}{\frac{l_f+l_F}{l_D}+1})$*, the workers' welfare decreases with the non task-specific offshoring cost.*

Without the productivity effect, offshoring activity here simply changes the worker's marginal productivity due to the decreasing return to scale. When firm in the north hires more foreign workers, the marginal productivity of each worker falls and this drives down the wage level of north worker. At the same time, the wage level of south worker is raised because of the increasing marginal productivity. When the offshoring scale is very small, at the margin, the decrease of the workers'welfare in the north dominates the increase of welfare in the south. But when the offshoring extent is large enough, at the margin,the increase of the welfare in the south will dominate the decrease of the welfare in the north.

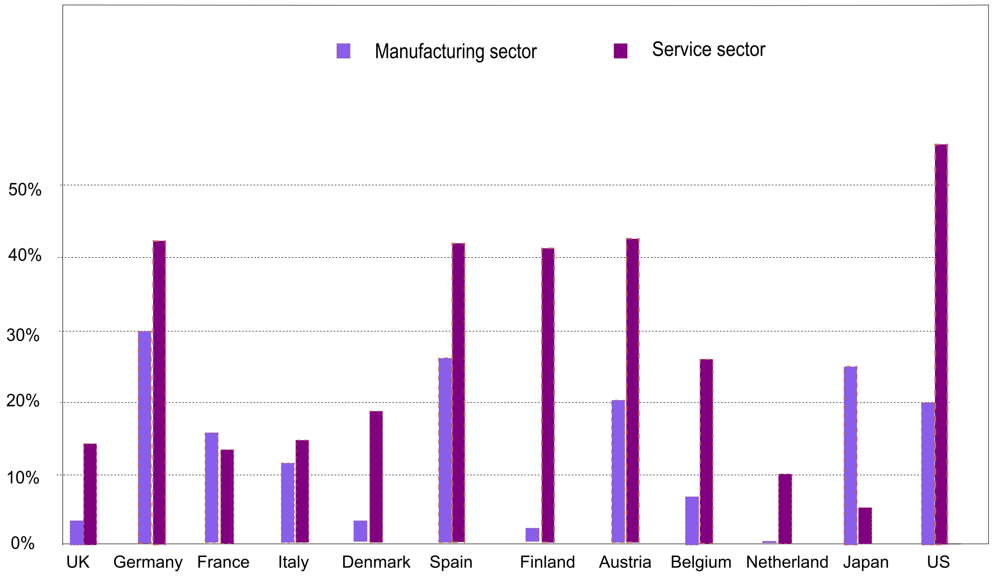
When the cost schedule becomes more steep, increasing offshoring scale will enforce the productivity effect and make it become a main driving force of raising the global welfare. The simulation result is put in the figure (h). We can clearly see from the exercise that when the offshoring scale is large enough, the global welfare will increase with it. And if the offshoring cost schedule becomes more steep, the enhancing productivity effect will strengthen the welfare improving trend.

3.7 Concluding Remarks

This paper studies the impact of offshoring boom in the service sector. It shows that when the marginal task-specific cost of offshoring for trading tasks is large enough, the technology progress of offshoring in the service sector will simply reduce domestic unemployment and indirectly make firm in the manufacturing sector offshore more because hiring domestic workers becomes more costly. This may in turn enhance the productivity effect of offshoring in the manufacturing sector and help create even more domestic jobs. Consequently, the offshoring scale in either sector not only increases with the offshoring technology progress in its own sector, but also it may increase with the technology progress in another sector due to the positive indirect impact. Based on the theoretical analysis, we calibrate the model by using the parameters of Belgium and the simulation result shows this possibility.

In terms of the social welfare, we at first verify that any equilibrium maximize social planner's problem provided that the Hosios condition holds . Then we show that when the worker's share of surplus becomes higher, firm will increase the proportion of foreign hires because the relative cost of hiring domestic workers becomes higher. Consequently we can conclude that when the worker's bargaining power is higher than the matching elasticity, social planner prefers offshoring less than in the equilibrium. In order to correct this inefficiency caused by the difference between the worker's share of surplus and the matching elasticity, we propose a policy instrument which can make equilibrium optimal, that is the subsidy of hiring domestic workers. And we simulate the optimal subsidy for Belgium and make a counterfactual exercise in order to compare the optimal policy in the open economy with that in the closed economy. We find at first that the optimal subsidy can either increase or decrease with the offshoring technology progress in the service sector. At second the optimal subsidy level is lower than that in the closed economy provided that the technology progress of offshoring in the service sector raises the domestic unemployment, but it can be higher than that in the closed economy provided that the progress reduces the unemployment.

Finally, we simplify the model and extend it to two country framework of offshoring. We show that the unemployment in the southern country decreases with the number of workers hired by the northern country,the global welfare increases with the offshoring technology and the global wage inequality can increase with the offshoring technology if the productivity effect is large enough to push up the workers' wage in the northern country and make the increase be greater than the wage increase in the south country.



(a) Growth of outsourcing abroad in selected OECD countries from 1995 to 2000

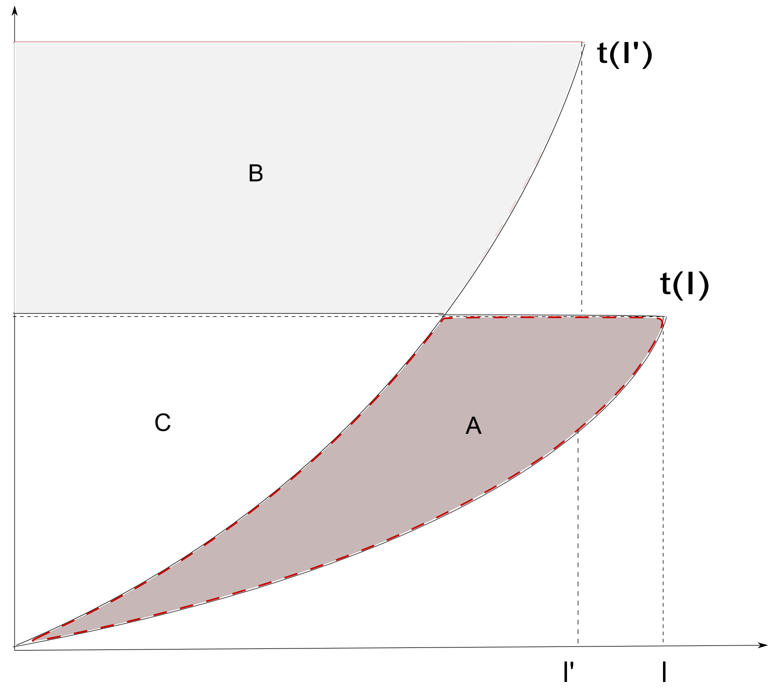
Country	E	U	Country	E	U	
Czech Republic	-5.2	75.8	United Kingdom	9.3	-36.7	
Japan	-2.5	53.5	United States	9.6	-9	
Slovak Republic	-2.2	45	France	9.9	-17.3	
Poland(2)	0.3	40	Italy	10.4	-16	
Germany	2.5	-0.3	Iceland	10.6	-36.6	
Turkey	2.7	6.7	Australia (1)	10.8	-30	
Greece	4.1	0.5	Portugal	11.7	-22	
Switzerland	5.3	-12.5	Finland	14.8	-39.2	
Swenden	5.9	-37.6	Netherlands	16.1	-42.5	
Denmark	5.9	-26.9	Canada	16.7	-24.3	
Austria	6.1	-15	New Zealand	18.7	-28	
Belgium	7.8	-17	Mexico	20.6	-35.1	
Hungary	8.3	-38	Spain	22.6	-36.5	
Norway	8.7	-20	Ireland	41.2	-62.4	%

TABLE 3.1: Trend in total employment and unemployment rate in the whole economy, 1995-2003
1. 1995-2001. 2. 1995-2002.

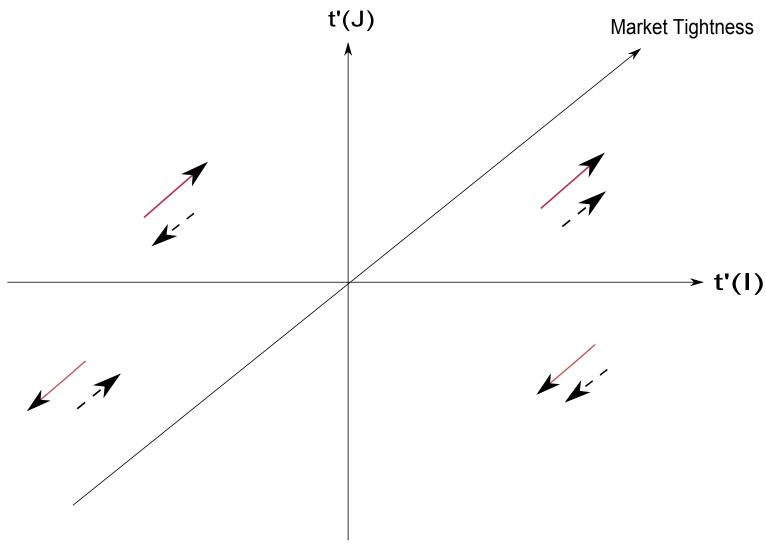
Source: OECD, STAN and LFS database.

TABLE 3.2

Optimal subsidy	$\beta_J = 1.8$	$\beta_J = 1.2$	$\beta_J = 0.6$	Closed Economy
$\tau = 2$	0.315	0.305	0.28	0.33
$\tau = 4$	0.311	0.314	0.324	0.314



(b) Cost Saving for Different Offshoring Cost Functions



(c) When Offshoring Technology Makes Progress in the Service sector, $t'(J)$ increases.

Appendix A

Appendix A: Chapter 1

A.1 Social Planner's Objective

A.1.1 Optimal $\underline{\alpha}$

Social planner's objective is to maximize the social welfare and it is given by

$$\underset{\underline{\alpha_s},u_s}{Max} \int_t^{\infty} e^{-r(s-t)}[(1-u_s)\int_0^{\underline{\alpha_s}} V_E(\alpha_s)f(\alpha_s)d\alpha + u_s V_U]ds$$

As we have the welfare of unemployed and employed workers as

$$V_U = \frac{h\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r(r+\delta+h\underline{\alpha})} = \frac{v\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r((r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha})} \tag{A.1}$$

and

$$V_E = \frac{(1+r)(w-\alpha)}{r+\delta} + \frac{\delta}{r+\delta}V_U \tag{A.2}$$

The dynamics of unemployment rate is

$$\dot{u_s} = \delta(1-u_s) - u_s\frac{v\underline{\alpha_s}}{1-\lambda(1-\underline{\alpha_s})} \tag{A.3}$$

We can now write down the Hamiltonian

$$\mathcal{H} = (1-u)\frac{1+r}{r+\delta}(w-\frac{1}{2}\underline{\alpha}) + [(1-u)\frac{\delta}{r+\delta}+u]\frac{v\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]} + \varphi[\delta(1-u) - u\frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha})]^2}] \tag{A.4}$$

We only focus on the steady state. Next, we can write down the FOC

$$\frac{\partial\mathcal{H}}{\partial\underline{\alpha}} = 0 \Longleftrightarrow -\frac{(1+r)}{2(r+\delta)}(1-u) + [(1-u)\frac{\delta}{r+\delta}+u]\frac{v(1+r)}{r}\frac{[-\frac{1}{2}\underline{\alpha}^2(\lambda(r+\delta)+v)+(1-\lambda)(r+\delta)(w-\underline{\alpha})]}{[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]^2} - \varphi u\frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha})]^2} = 0 \tag{A.5}$$

$$\frac{\partial\mathcal{H}}{\partial u} = 0 \Longleftrightarrow -\frac{1+r}{r+\delta}(w-\frac{1}{2}\underline{\alpha}) + \frac{r}{r+\delta}\frac{v\underline{\alpha}(1+r)(w-\frac{1}{2}\underline{\alpha})}{r[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]} + \varphi[-\delta - \frac{v\underline{\alpha}}{[1-\lambda(1-\underline{\alpha})]}] = \varphi r \tag{A.6}$$

Then we can obtain the φ

$$\varphi = \frac{-(1+r)(w-\frac{1}{2}\underline{\alpha})\frac{[1-\lambda(1-\underline{\alpha})]}{[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]}}{r+\delta+\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}} \tag{A.7}$$

Substituting into $\frac{\partial\mathcal{H}}{\partial\underline{\alpha}}$, and we get

$$\frac{\partial\mathcal{H}}{\partial\underline{\alpha}} = -\frac{(1+r)}{2(r+\delta)}(1-u) + [(1-u)\frac{\delta}{r+\delta}+u]\frac{v(1+r)}{r}\frac{[-\frac{1}{2}\underline{\alpha}^2(\lambda(r+\delta)+v)+(1-\lambda)(r+\delta)(w-\underline{\alpha})]}{[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]^2} + u\frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha})]^2}\frac{(1+r)(w-\frac{1}{2}\underline{\alpha})\frac{[1-\lambda(1-\underline{\alpha})]}{[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]}}{r+\delta+\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}} = 0 \tag{A.8}$$

This condition defines the socially optimal condition and we obtain optimal $\underline{\alpha}$. In the equilibrium $\underline{\alpha}$ is determined by the equation

$$\frac{v(\underline{\alpha}^E)^2}{1-\lambda(1-\underline{\alpha}^E)} + 2(r+\delta)\underline{\alpha}^E = 2(r+\delta)w$$

We plug equilibrium $\underline{\alpha}^E$ into the first order condition $\frac{\partial \mathcal{H}}{\partial \underline{\alpha}}$. If $\frac{\partial \mathcal{H}}{\partial \underline{\alpha}} = 0$, then we can conclude that the equilibrium is social optimum, if $\frac{\partial \mathcal{H}}{\partial \underline{\alpha}} > 0$, then social planner prefers higher $\underline{\alpha}$ than equilibrium, if $\frac{\partial \mathcal{H}}{\partial \underline{\alpha}} < 0$, then social planner prefers lower $\underline{\alpha}$ than equilibrium. Then the first order condition becomes

$$\begin{aligned}\frac{\partial \mathcal{H}}{\partial \underline{\alpha}}(\underline{\alpha} = \underline{\alpha}^E) = &-\frac{(1+r)}{2(r+\delta)}(1-u)\\ &-[(1-u)\frac{\delta}{r+\delta}+u]\frac{v(1+r)}{r}\frac{(r+\delta)\lambda\underline{\alpha}^E(\underline{\alpha}^E+2(w-\underline{\alpha}^E))}{2[(r+\delta)(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]^2}\\ &+u\frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha}^E)]}\frac{(1+r)(w-\frac{1}{2}\underline{\alpha}^E)\frac{1}{[(r+\delta)(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]}}{r+\delta+\frac{v\underline{\alpha}^E}{1-\lambda(1-\underline{\alpha}^E)}}\end{aligned} \tag{A.9}$$

The second term is negative, the sum of the first and third term is denoted by Φ

$$\Phi = -\frac{(1+r)}{2(r+\delta)}(1-u)+u\frac{v(1-\lambda)}{[1-\lambda(1-\underline{\alpha})]}\frac{(1+r)(w-\frac{1}{2}\underline{\alpha})\frac{1}{[(r+\delta)(1-\lambda(1-\underline{\alpha}))+v\underline{\alpha}]}}{r+\delta+\frac{v\underline{\alpha}}{1-\lambda(1-\underline{\alpha})}} \tag{A.10}$$

Since in the equilibrium we have

$$\frac{v(\underline{\alpha}^E)^2}{1-\lambda(1-\underline{\alpha}^E)}+2(r+\delta)\underline{\alpha}^E = 2(r+\delta)w \tag{A.11}$$

Indirectly we have

$$\frac{(w-\frac{1}{2}\underline{\alpha}^E)}{[(r+\delta)(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]} = \frac{\underline{\alpha}^E}{2(r+\delta)[(1-\lambda(1-\underline{\alpha}^E))]} \tag{A.12}$$

What is more, the unemployment rate in the steady state is

$$u = \frac{\delta[1-\lambda(1-\underline{\alpha})]}{\delta[1-\lambda(1-\underline{\alpha})]+(1-\delta)v\underline{\alpha}} \tag{A.13}$$

Then Φ can be simplified into

$$\begin{aligned}\Phi = &-\frac{(1+r)}{2(r+\delta)}\frac{(1-\delta)v\underline{\alpha}^E}{[\delta(1-\lambda(1-\underline{\alpha}^E))+(1-\delta)v\underline{\alpha}^E]}\\ &+u\frac{v(1-\lambda)(1+r)}{[(r+\delta)(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]}\frac{\underline{\alpha}^E}{2(r+\delta)[1-\lambda(1-\underline{\alpha}^E)]}\\ = &-\frac{(1+r)}{2(r+\delta)}\frac{v\underline{\alpha}^E}{[\delta(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]}\frac{[r(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E+\delta\lambda\underline{\alpha}^E]}{[(r+\delta)(1-\lambda(1-\underline{\alpha}^E))+v\underline{\alpha}^E]}\end{aligned} \tag{A.14}$$

Therefore, we have

$$\frac{\partial \Omega}{\partial \underline{\alpha}}(\underline{\alpha} = \underline{\alpha}^E) < 0$$

What is more, we can observe from equation (43) that the second order derivative is negative, therefore we can conclude that social planner prefers that workers are more selective than that in the equilibrium.

Appendix B

Appendix B: Chapter 2

B.1 Impact of Two-tier Unemployment Compensation Policies

B.1.1 Sensitivity Analysis

B.1.2 Different Weights on Different Groups

Anticipating the relationship between the wage demand for workers, and the labor market equilibrium, union chooses w to maximize the ex ante welfare of its members $(2-k)r(V_{E,e}-V_{U,e})L_e + kr(V_{E,n}-V_{U,n})L_n$. The rent of entitled employed workers and non-entitled employed workers are given respectively as

$$V_{E,e}-V_{U,e} = \frac{w(1-t)-b_e}{r+\lambda+m\theta q(\theta)} + \frac{d}{r+\lambda+m\theta q(\theta)} \frac{(b_e-b_n)}{(r+d+m\theta q(\theta))-\lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}} \tag{B.1}$$

$$V_{E,n}-V_{U,n} = \frac{w(1-t)-b_n}{r+\lambda+m\theta q(\theta)} + \frac{\sigma}{r+\lambda+m\theta q(\theta)} \frac{\frac{\lambda}{r+d+m\theta q(\theta)}(b_e-b_n)}{(r+\lambda+\sigma)-\lambda m\theta q(\theta)\frac{1}{r+d+m\theta q(\theta)}} \tag{B.2}$$

And we have 2 constraints, one is equilibrium job creation condition

$$A\gamma(L_e+L_n)^{\gamma-1} = w + \frac{c(r+\lambda)}{mq(\theta)} \tag{B.3}$$

Another one is from the fact that the sum of employed and unemployed workers qual the whole working population which is normalized to 1

$$(1+\frac{\lambda}{d+m\theta q(\theta)})L_e + (1+\frac{\lambda+\sigma}{m\theta q(\theta)})L_n = 1 \tag{B.4}$$

The union's objective is to choose the right wage level w in order to maximize $(2-k)r(V_{E,e}-V_{U,e})L_e + kr(V_{E,n}-V_{U,n})L_n$ given the two constraints (22) and (23)

$$L = (2-k)r(V_{E,e}-V_{U,e})L_e + kr(V_{E,n}-V_{U,n})L_n + \psi[A\gamma(L_e+L_n)^{\gamma-1} - w - \frac{c(r+\lambda)}{mq(\theta)}]$$
$$+\varphi[1-(1+\frac{\lambda}{d+m\theta q(\theta)})L_e - (1+\frac{\lambda+\sigma}{m\theta q(\theta)})L_n]$$

The first order conditions are

$$\frac{\partial L}{\partial L_e} = (2-k)r(V_{E,e}-V_{U,e}) - \psi A\gamma(1-\gamma)(L_e+L_n)^{\gamma-2} - \varphi(1+\frac{\lambda}{d+m\theta q(\theta)}) = 0 \tag{B.5}$$

$$\frac{\partial L}{\partial L_n} = kr(V_{E,n} - V_{U,n}) - \psi A\gamma(1-\gamma)(L_e + L_n)^{\gamma-2} - \varphi(1 + \frac{\lambda+\sigma}{m\theta q(\theta)}) = 0 \tag{B.6}$$

$$\frac{\partial L}{\partial w} = \frac{r}{r+\lambda+m\theta q(\theta)}((2-k)L_e + kL_n)(1-t) - \psi = 0 \tag{B.7}$$

Plug equation (44) to (43), we have

$$\varphi = \frac{r(V_{E,n} - V_{U,n}) - \frac{r}{r+\lambda+m\theta q(\theta)}(1-t)A\gamma(1-\gamma)(L_e+L_n)^{\gamma-2}[(2-k)L_e + kL_n]}{1 + \frac{\lambda+\sigma}{m\theta q(\theta)}} \tag{B.8}$$

Pluging (44) and (45) into (42) yields the following expression for wage

$$\begin{aligned}
&[(1-t)*(2-k-\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))k}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)})-(2-k)(b_e-\frac{d(b_e-b_n)}{r+d+m\theta q(\theta)-\lambda m\theta q(\theta)\frac{1}{r+\lambda+\sigma}}) \\
&+\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))k}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)}(-b_n+\frac{\sigma\lambda(b_e-b_n)}{(r+\lambda+\sigma)(r+d+m\theta q(\theta))-\lambda m\theta q(\theta)})]w \\
&-(1-\frac{m\theta q(\theta)(\lambda+d+m\theta q(\theta))}{(d+m\theta q(\theta))(m\theta q(\theta)+\lambda+\sigma)})*(1-t)A\gamma(1-\gamma)(L_e+L_n)^{\gamma-2}[(2-k)L_e+kL_n] = 0
\end{aligned} \tag{B.9}$$

And we also have one budget constraint which is

$$b_e w u_e + b_n w u_n = (wn_e + wn_n)t \tag{B.10}$$

This constraint means that the unemployment benefit and social security are covered by taxation. As we know the wage equation, we have the first equilibrium condition. We also have two constraints and the relative supply of entitled workers in the equilibrium $\frac{L_e}{L_n} = \frac{\sigma(d+m\theta q(\theta))}{\lambda d}$, so these five equations form our equilibrium conditions and we have five endogenous variables, L_e, $L_{n,}$, θ, w and t.

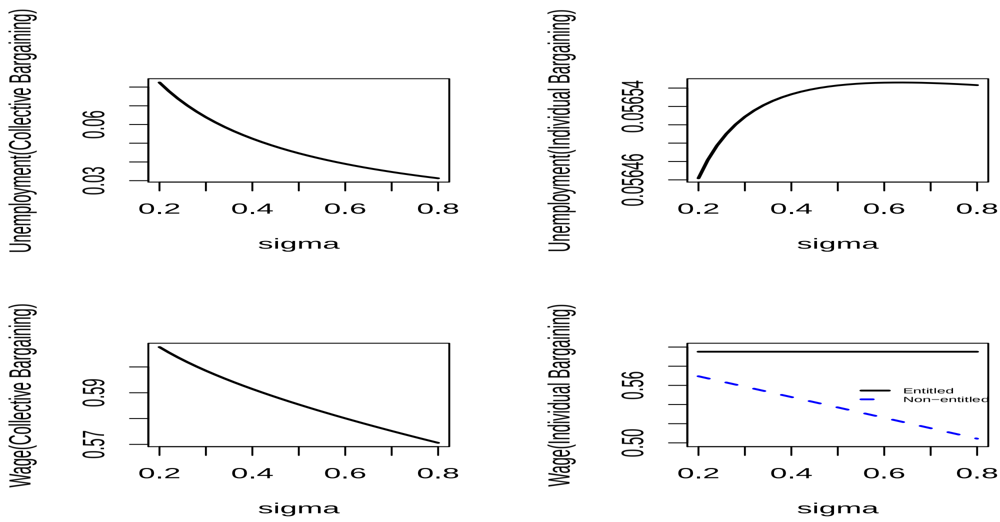


FIGURE B.1: Impact of σ

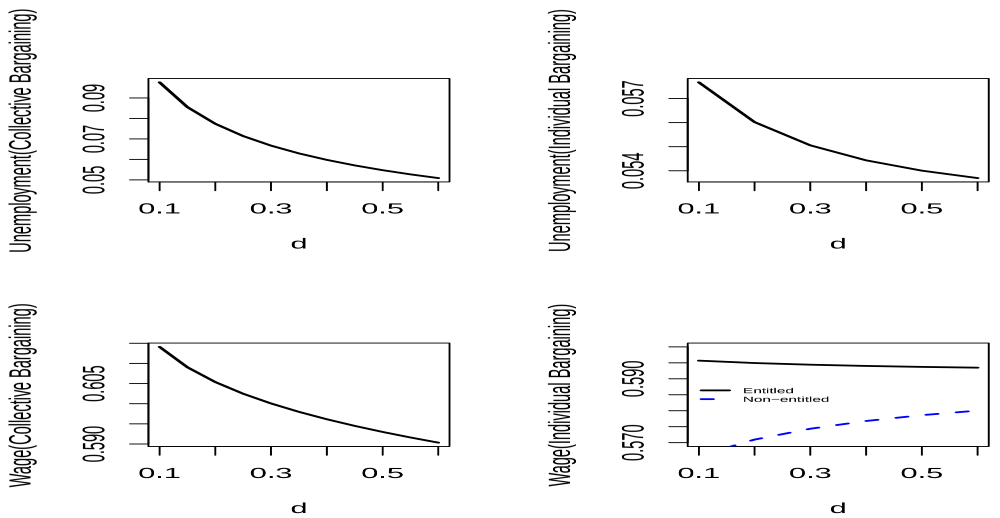


FIGURE B.2: Impacts of d.

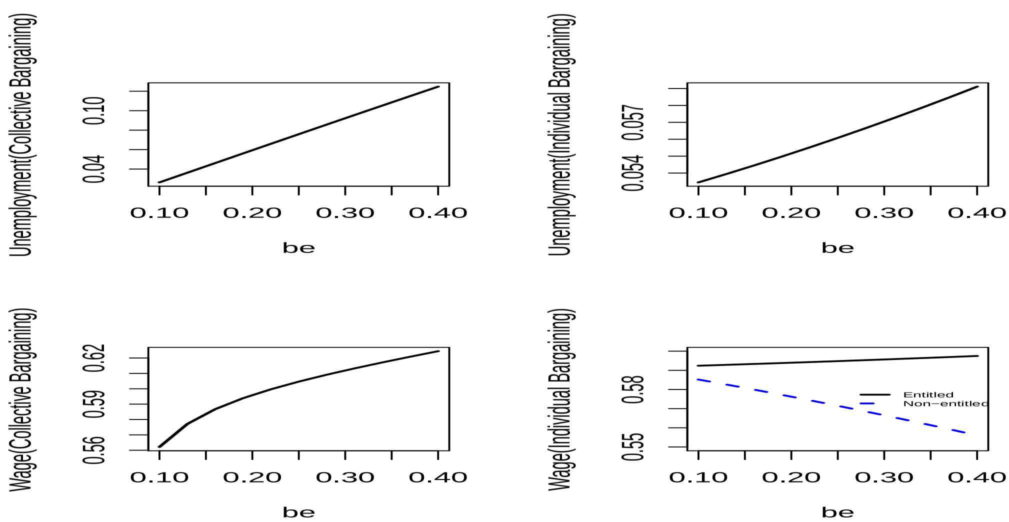


FIGURE B.3: Impacts of b_e.

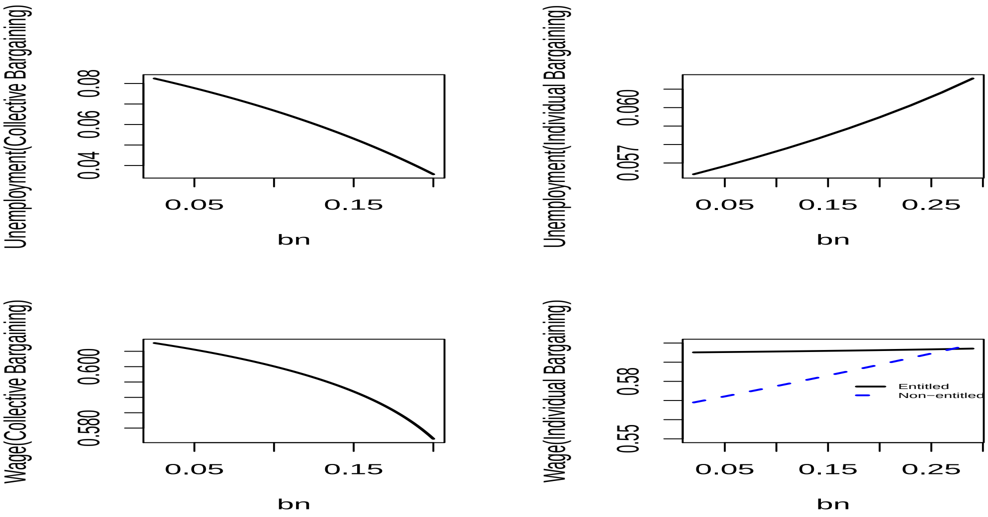


FIGURE B.4: Impacts of b_n.

TABLE B.1: A 10% rise in σ (%)

	w	u	u_e	u_n
Collective Bargaining	-0.34	-5.54	-3.26	-10.4
Individal Bargaining	-0.006, -0.4	0.035	0.37	-1.05

TABLE B.2: A 10% rise in d (%)

	w	u	u_e	u_n
Collective Bargaining	-0.2	-3.26	-5.1	0.67
Individal Bargaining	-0.02, 0.133	-0.4	-2.62	6.65

TABLE B.3: A 10% rise in b_e (%)

	w	u	u_e	u_n
Collective Bargaining	0.63	10.73	6.7	19.3
Individal Bargaining	0.08, -0.47	0.93	0.7	1.69

TABLE B.4: A 10% rise in b_n (%)

	w	u	u_e	u_n
Collective Bargaining	-0.033	-0.54	-0.355	-0.95
Individal Bargaining	0.0023, 0.046	0.065	0.048	0.12

Appendix C

Appendix C: Chapter 3

C.1 Social Optimum

The current value Hamiltonian for the firm can be written as

$$\mathcal{H} = \frac{X^{\rho}Y^{1-\rho}}{\rho^{\rho}(1-\rho)^{1-\rho}} + b(N - l_{D,X} - l_{D,Y}) - w^{*}(l_{F,Y} + l_{D,Y})\int_{0}^{I}\beta_{I}t(i)di - w^{*}(l_{F,X} + l_{D,X})\int_{0}^{J}\beta_{J}t(j)dj$$
$$- cV_{Y}^{D} - c^{F}V_{Y}^{F} - cV_{X}^{D} - c^{F}V_{X}^{F} + \mu_{1}(q(\theta_{X})V_{X}^{D} - \delta l_{D,X}) + \mu_{2}(q(\theta_{Y})V_{Y}^{D} - \delta l_{D,Y})$$
$$\mu_{3}(V_{X}^{F} - \delta l_{F,X}) + \mu_{4}(V_{Y}^{F} - \delta l_{F,Y}) \quad \text{(C.1)}$$

If we only consider the steady state, we have the following eight first order conditions

$$\frac{\partial\mathcal{H}}{\partial V_{Y}^{F}} = -c^{F} + \mu_{4} = -0 + \mu_{4} \quad \text{(C.2)}$$

$$\frac{\partial\mathcal{H}}{\partial V_{Y}^{D}} = -c + \mu_{2}[q'(\theta_{Y})\frac{\partial\theta_{Y}}{\partial V_{Y}^{D}}V_{Y}^{D} + q(\theta_{Y})] = 0 \quad \text{(C.3)}$$

$$\frac{\partial\mathcal{H}}{\partial l_{D,Y}} = (\frac{1-\rho}{\rho})^{\rho}(\frac{X}{Y})^{\rho} - b - w^{*}\int_{0}^{I}\beta_{I}t(i)di - w^{*}(l_{F,Y} + l_{D,Y})\beta_{I}t(I)\frac{\partial I}{\partial l_{D,Y}} +$$
$$\mu_{2}[q'(\theta_{Y})\frac{\partial\theta_{Y}}{\partial l_{D,Y}}V_{Y}^{D}] - \mu_{2}\delta = \mu_{2}r \quad \text{(C.4)}$$

$$\frac{\partial\mathcal{H}}{\partial l_{F,Y}} = (\frac{1-\rho}{\rho})^{\rho}(\frac{X}{Y})^{\rho} - w^{*}\int_{0}^{I}\beta_{I}t(i)di - w^{*}(l_{F,Y} + l_{D,Y})\beta_{I}t(I)\frac{\partial I}{\partial l_{F,Y}} = \mu_{4} \quad \text{(C.5)}$$

$$\frac{\partial \mathcal{H}}{\partial V_X^F} = -c^F + \mu_3 = -0 + \mu_3 \tag{C.6}$$

$$\frac{\partial \mathcal{H}}{\partial V_X^D} = -c + \mu_1[q'(\theta_X)\frac{\partial \theta_X}{\partial V_X^D}V_X^D + q(\theta_X)] = 0 \tag{C.7}$$

$$\frac{\partial \mathcal{H}}{\partial l_{D,X}} = (\frac{\rho}{1-\rho})^{1-\rho}(\frac{X}{Y})^{\rho-1} - b - w^* \int_0^J \beta_J t(j)dj - w^*(l_{F,X} + l_{D,X})\beta_J t(J)\frac{\partial J}{\partial l_{D,X}} + \mu_1[q'(\theta_X)\frac{\partial \theta_X}{\partial l_{D,X}}V_X^D] - \mu_1\delta = \mu_1 r \tag{C.8}$$

$$\frac{\partial \mathcal{H}}{\partial l_{F,X}} = (\frac{\rho}{1-\rho})^{1-\rho}(\frac{X}{Y})^{\rho-1} - w^* \int_0^J \beta_J t(j)dj - w^*(l_{F,X} + l_{D,X})\beta_J t(J)\frac{\partial J}{\partial l_{F,X}} = \mu_3 \tag{C.9}$$

After simplification, we have several social optimum conditions as

$$(\frac{1-\rho}{\rho})^{\rho}(\frac{X}{Y})^{\rho}F(I) = b + (r + \delta + \phi m\theta_Y q(\theta_Y))\frac{c}{(1-\phi)q(\theta_Y)} \tag{C.10}$$

$$w^*\beta_I t(I) = b + (r + \delta + \phi m\theta_Y q(\theta_Y))\frac{c}{(1-\phi)q(\theta_Y)} \tag{C.11}$$

And in the service sector, we have the same equilibrium conditions, so we do not write them here. Since social planner, in deciding how many vacancies to post and how extent to offshore, does take into account the effect of his choices on workers who can move freely , social optimum condition can be simplified into

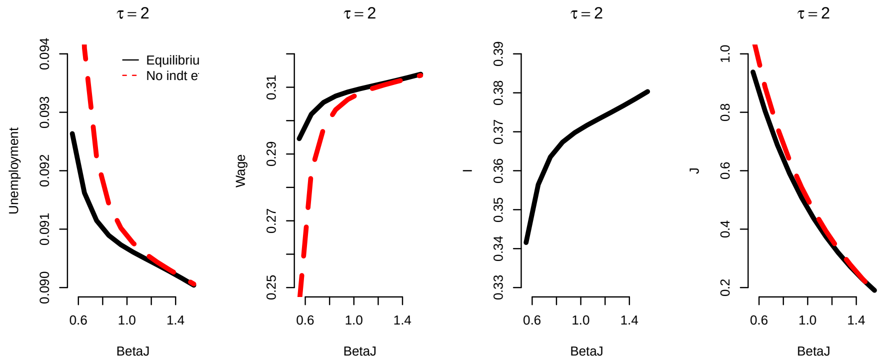
$$(\frac{1-\rho}{\rho})^{\rho(1-\gamma)}(\frac{A_1}{A_0})^{\rho}(\frac{F(J)}{F(I)})^{\gamma\rho}[1 + \frac{\rho}{1-\rho}\frac{F(J)(1-J)}{F(I)(1-I)}]^{1-\gamma}(1-I)^{1-\gamma}F(I) = b + (r + \delta + \phi m\theta q(\theta))\frac{c}{(1-\phi)q(\theta)} \tag{C.12}$$

$$w^*\beta_I t(I) = b + (r + \delta + \phi m\theta q(\theta))\frac{c}{(1-\phi)q(\theta)} \tag{C.13}$$

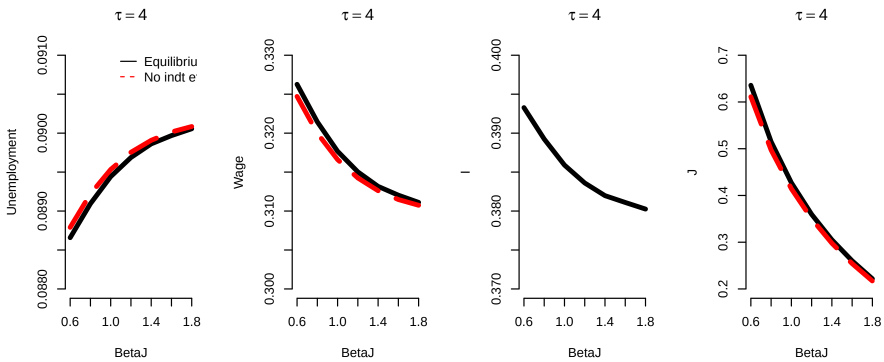
$$\beta_I t(I) = \beta_J t(J) \tag{C.14}$$

Table C.1: Calibration Parameter Values for Belgium

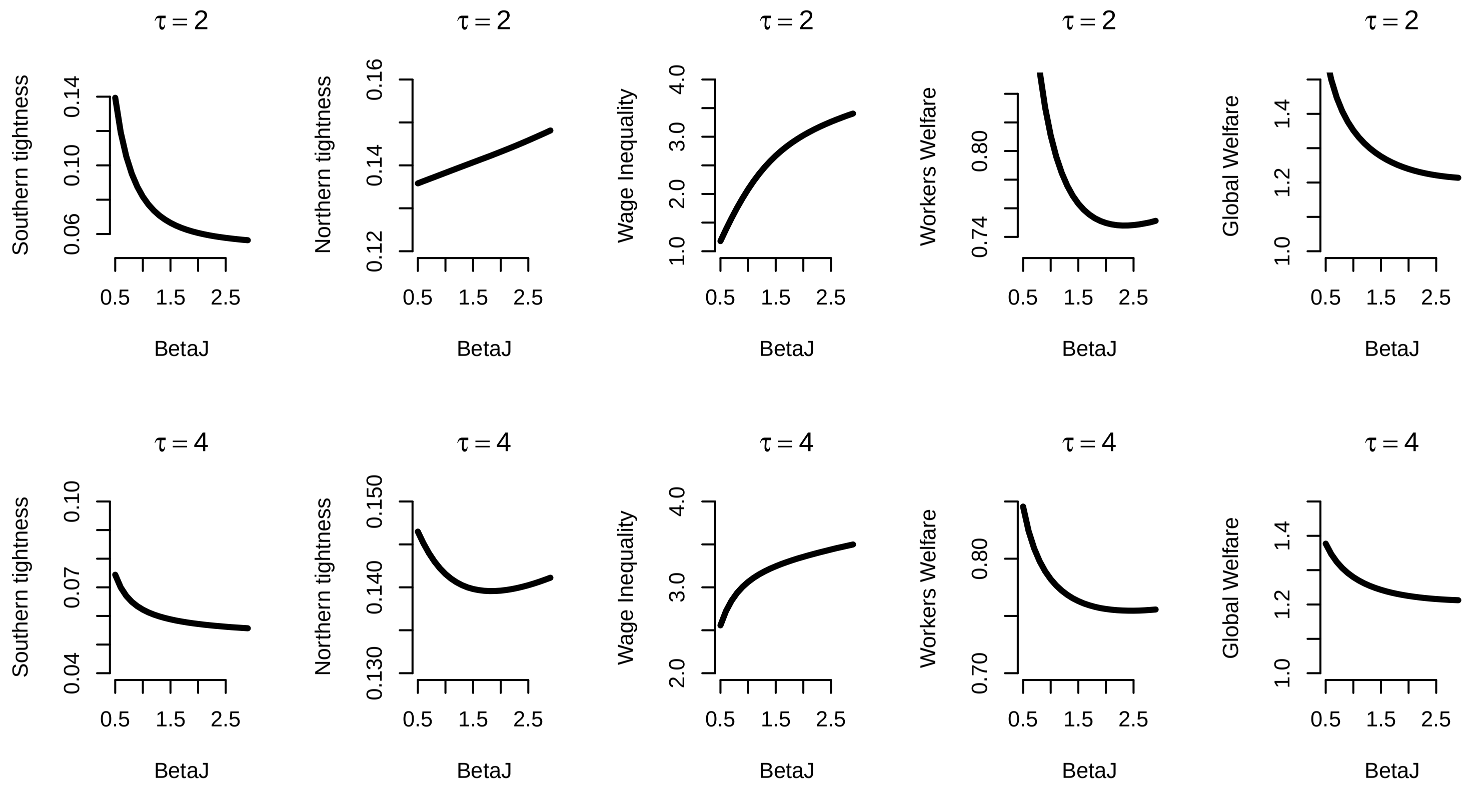
Parameter	Interpretation	Value	Source
	Normalized Parameters		
P	Aggregate price level	1	
$A_0 = A_1$	Aggregate productivity parameter	1	
N	Size of labor force	1	
	External parameter estimates and parameters matched to moments in the data		
r	Monthly discount rate	0.008	Van der Linden et al. (2001)
ϕ	Elasticity of matching function	0.4	Van der Linden et al. (2001)
δ	Job worker seperation rate	0.013	Van der Linden et al. (2001)
b	Unemployment benefit	0.35	OECD (1999)
θ	Labor market tightness	0.14	Van der Linden et al. (2001)
m	Scale parameter of matching function	0.35	Obtained from $u = \frac{\delta}{\delta + m\theta^{0.4}}$ and θ
η	Bargaining power of workers	0.77	Van der Linden et al. (2001)
γ	Production function parameter	0.64	Benlolila and St.Paul (2003)
β_I	Non-task-specific offshoring cost in manufacturing sector	1.5	Felbermayr et al (2011)
β_J	Non-task-specific offshoring cost in service sector	Free	to match $\beta_I(1+I)^\tau = \beta_J(1+J)^\tau$
ρ	Weight parameter	0.476	Estimate by using OECD $I-O$ data
c	Vacancy cost	Free	to match $u = 0.09$, $I = 0.38$
w^*	Foreign wage	Free	to match $u = 0.09$, $I = 0.38$



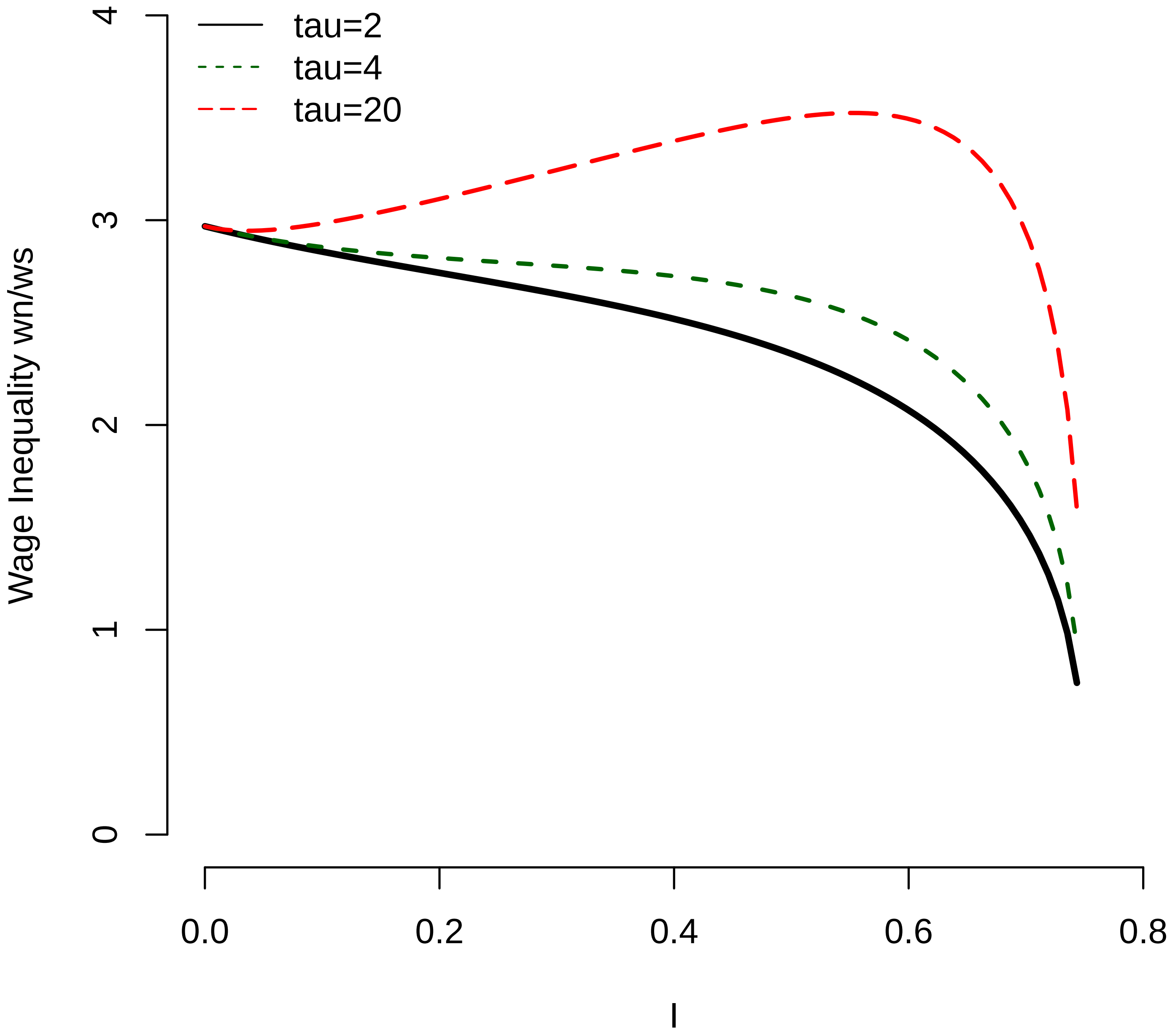
(a) Flat cost function $t(i) = (1 + i)^2$



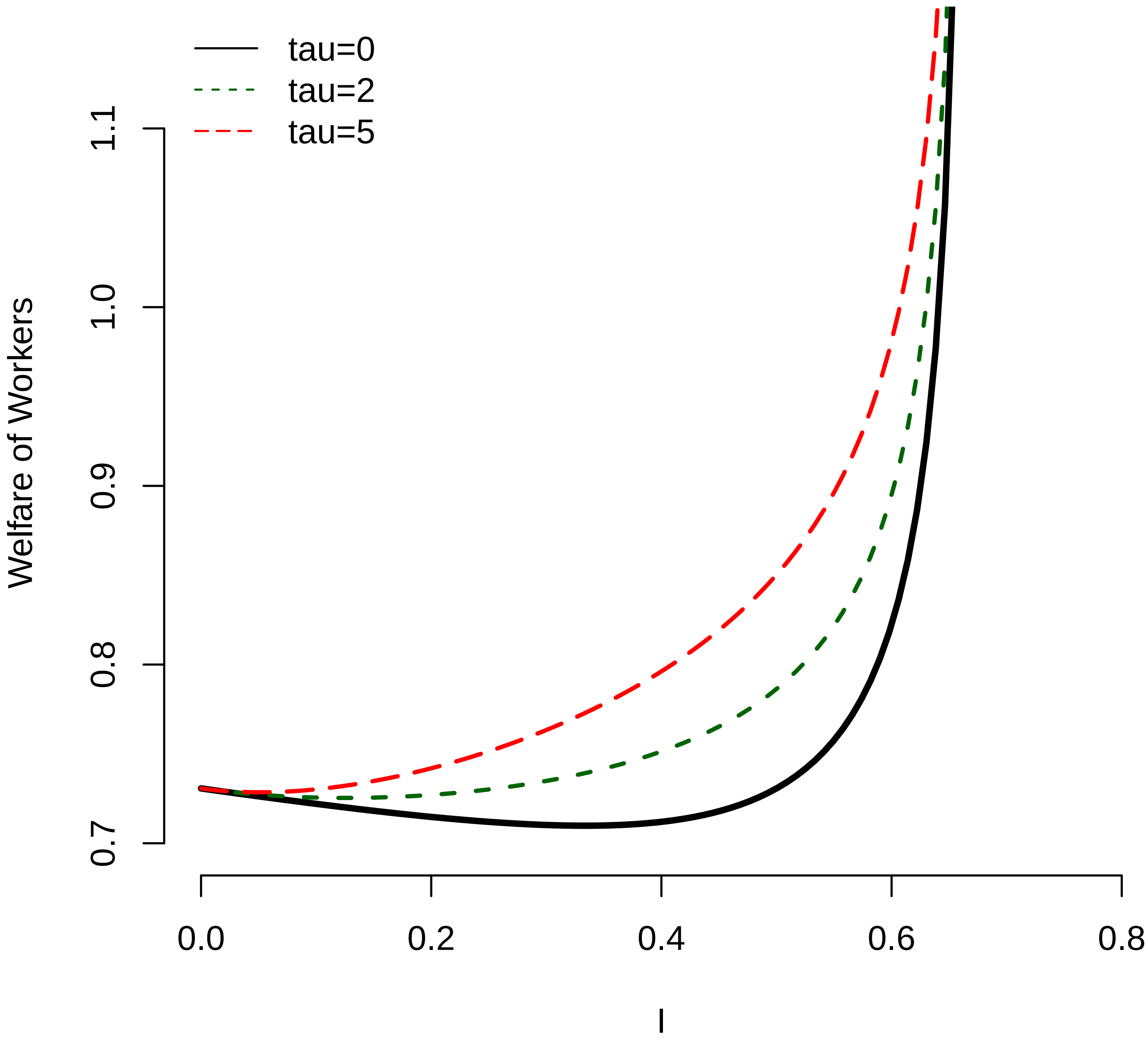
(b) Steep cost function $t(i) = (1 + i)^4$



(c) Offshoring in the Global Economy



(d) Wage Inequality


tau=0
tau=2
tau=5
Welfare of Workers
0.7
0.8
0.9
1.0
1.1
0.0
0.2
0.4
0.6
0.8
l

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