Union, International Trade and Unemployment

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Abstract

We adopt Montagna and Nocco's (2013) unionization framework and introduce search frictions into homogeneous sector to study how the unions' bargaining power affects the unemployment rate before and after trade. When the unions' bargaining power increases, the minimum production threshold required to stay in the market decreases. It allows the entry of relatively less productively firms. The selection soften effect may be generated through the reduction in the toughness of competition via different labor demand elasticity of firms. Firms with higher productivity pay higher wages to labors. That is, raising unions' bargaining power do harm to the firms with higher productivity, and then it may leave the market space for firms with lower productivity. The number of entrant is decreasing and the number of surviving firms depends on the magnitude of unions' bargaining power. In autarky, we find out that when the unions' bargaining power is low enough, and increase in the bargaining power would cause the fall of aggregate unemployment rate. The effect of increasing in surviving firms outweighs the shrinking in average labor demand of firms. When the bargaining power is in the median level, the number of firms is still increasing but the average labor demand per firm decreases significantly. The later effect dominates the former; therefore, thus the total number of unemployed labors is increasing. When the bargaining power is high enough, then the unemployment rate increases in the bargaining power. After international trade is allowed, firms now could choose to serve domestic and foreign market or only producing for domestic market. Labor unions negotiate wages with distinct profit centers within a firm, that is, domestic and exporting departments. Labors in each department may earn different wages because of the variable price elasticity faced by different departments. We highlight the case that unions have asymmetric bargaining powers in two countries. Increasing in unions' bargaining power of one country always lowers the total number of employed labors in exporting sector, while the number of employed labors in domestic sector depends on the trade-off between the magnitude of trade openness and bargaining power, so does the unemployment rate.

Keywords: Unemployment, Union and Profit Center.

JEL Classification:

This study investigates the variations of unemployment under different labor market specifications between differentiated and homogeneous sectors before and after trade liberalization.

International trade links markets around the world together. The pros and cons of opening to trade have been discussed for decades. Advocators claim that consumers could buy greater varieties of goods at lower prices because of the competition effect. Besides, firms exporting goods to other countries or importing to domestic market need to afford extra trade costs such as tariffs and transportation costs, thus only firms producing products with better quality survive and consumers enjoy a higher quality of goods due to the selection effect (e.g., Melitz 2003, Melitz and Ottaviano 2008). However, opponents indicate that competition and selection effects would raise the involuntary unemployment rate directly because of the exit of firms. In fact, the problem of unemployment gathers public attention and becomes an essential issue for policy makers. Our research provides a new channel to investigate the changes in labor market, such as decreasing in bargaining power, affect unemployment rate of itself and trade partners.

Some stylized facts about the decentralized bargaining at department level must be addressed before our analyses. After the 2007-2008 financial crisis, within-firm pay inequality has become a focus of attention. However, past studies usually assume that a firm pays the same wage to its labors. Helpman et al. (2010) consider both firms' productivity and labors' heterogeneity; thereafter, the resulting wage is still firm-specific. In order to allow the different wage schemes within a firm, we introduce unions and wage bargaining at department level. It means that labors in different departments form department-specific unions to bargain wages with the head of the profit center. The details of profit center is addressed later. The wage is paid according to the union's bargaining power and the profitability of that department, which is usually related to the monopoly power. The report from OECD (2004) highlights the falling degree of centralization of collective bargaining. Even in countries with strong unions such as Germany and Australia (Visser 2016), the narrowed bargaining system implies that the bargaining occurs within companies or workplace level instead of a national-level or state-level. The wage differentials may be deteriorated by the fall of unions (ILO 2015).

In order to emphasize the wage differences between domestic department and exporting one, we introduce the concept of profit centers which is widely used in the cooperation management.[1] A profit center is a division within a corporation and considered as a separate business unit. The head of each profit center takes responsibility for its profit control—both revenue and cost control—regardless of other sections of a corporation. Considering the different characteristics between domestic and exporting markets, several profit centers may come into being within a firm to develop corresponding sale strategies and production decisions. In our model, there could be two profit centers within each differentiated firm. One is domestic department, and the other is exporting department if this firm chooses to export. Labors unite together to bargain wages with the heads of distinct profit centers. If there are two profit centers within a firm, unions signs different contracts relevant to distinct profit centers (Kamakura, 2006), and wage schemes in two departments may be different. That is, bargaining takes place at department level. Labors not employed in differentiated sector enter the homogeneous sector which is featured with search frictions and decentralized wage bargaining. Because of the search frctions, it means that some labors may be unemployed in the end.

A considerable amount of literature studies the effects of trade and unemployment. Search frictions, efficiency wages, fair wage preferences, and minimum wages are usually considered and specified in the framework when the unemployment is presented. Helpman and Itskhoki (2010) investigate the effects of labor market search frictions on wages, welfare, and the magnitude of unemployment. They build a model with asymmetric countries and find that the decreases in domestic search frictions would harm the foreign country's welfare. However, if the search frictions proportionally decrease in differentiated sectors in each country at the same time, they would benefit both countries. Relatively low search frictions do not guarantee the lower unemployment rate after opening to trade. Dinopoulos and Unel (2017) consider the occupational choice in the incomplete labor market featured with search frictions. Felbermayr et al. (2013) is an empirical paper and adopts search frictions and the Nash bargaining process to model the labor market. By introducing the concept of labor market spillover, they find that higher search frictions not only raise the domestic unemployment rate but also the foreign counterpart. Egger and Kreickemeier (2009) introduce fair wage preferences into Melitz model and show that the average profit of active firms, aggregate welfare, and the unemployment rate all

[1] Drucker (2002) mentioned that he created the term "profit center" around 1945.

increase after trade. Egger and Kreickemeier (2012) modify their previous paper and develop a model featuring two kinds of labors: one is worker, and the other is manager. Involuntary unemployment rate and the inequality between and within these two groups increase when trade costs fall. Egger et al. (2012) introduce minimum wages to explain the labor market imperfections. It demonstrates that a lift in minimum wages would harm domestic labors as well as foreign ones. The wage bargaining through unionization is a less-considered rent sharing mechanism given the international trade setting as Montagna and Nocco (2013) mention.

Considering those facts, we adopt the unionization framework by Montagna and Nocco (2013) and the search friction model developed by Helpman and Itskhoki (2010) to accommodate the unemployment and within-firm wage inequality. In Montagna and Nocco (2013), they extend the model with variable mark-ups in Melitz and Ottaviano (2008) to investigate the effects of unionization on intra-industry selection. Because of the existence of competitive homogeneous sector, unemployment is not derived in their model. So, we incorporate the concept of search frictions in the homogeneous sector to study the effects of bargaining power on unemployment rate.

The most important contribution of this study is that we consider the properties of different markets and investigate the changes of unemployment rate when the bargaining power of unions changes. In autarky, when the bargaining power of unions is low enough, an increase in bargaining power would raise up labor wage and price of goods at the same time, but do not hurt firms so much, therefore the unemployment rate decreases and number of firms increases. When the bargaining power is in median level, an increase in bargaining power would increase the unemployment rate despite of the number of firms still increases. If the bargaining power is high enough, then unemployment rate increases in bargaining power. After trade is allowed, the number of labors employed in exporting department is negatively related to the bargaining power, while the domestic employment depends on the magnitude of trade openness and bargaining power.

The remainder of this study is organized as follows. We construct an autarky model and investigate the equilibrium unemployment in the section 2. In section 3, we extend the model into two-country setting and observe how bargaining power affects the unemployment within and between the two countries. Finally, section 4 concludes the study.

1 Unionization and Unemployment Model in Autarky

The closed economy is populated with identical families, and each of them supplies L units of labor. We assume that there is a continuum of families and the mass is equal to 1.[2] There are two sectors in this study: one is the homogeneous product sector, and the other is horizontally differentiated sector (manufacturing sector). According to Montagna and Nocco (2013), labors in manufacturing sector bargain wages with firms through firm-specific unions. Firms determine the number of labors they need, and the rest of the labors look for jobs in the homogeneous sector with search frictions. Labors are thrown into unemployment if not employed by the competitive homogeneous-product sector or the monopolistic competitive differentiated sector.[3]

1.1 Preference

The utility function takes the following form as that in Melitz and Ottaviano (2008). The utility function of a typical individual within this representative family in country j is

$$U_j = q_0^c + \alpha \int_{i \in \Omega_j} q_j^c(i)\, di - \frac{\delta}{2} \int_{i \in \Omega_j} q_j^c(i)^2\, di - \frac{\eta}{2} \left(\int_{i \in \Omega_j} q_j^c(i)\, di \right)^2, \tag{1}$$

$q_j^c(i)$ is the individual c's consumption of variety $i \in \Omega_j$ in country j, and q_0^c is the consumption amount of homogeneous goods. Preference parameters α, δ and η are all positive. α and η reflect the consumer's inclination toward the differentiated goods relative to the homogeneous goods (higher α and lower η). If η is higher, it means that two kinds of goods are better substitutes for each other. δ measures the extent of love of variety.

The consumption of distinct differentiated goods may not be positive because of bounded marginal utility, and we assume that the consumption of homogeneous good is positive, that is $q_0^c > 0$. Set the price of homogeneous good as the numeraire and the budget constraint of a typical individual would be

[2] Dinopoulos and Unel (2017) and Helpman and Itskhoki (2010) also have this "big family" setting. Within family transfers enable us to sidestep the problems such as unemployment premium and the consumption of unemployed labors (zero income); the average income of any individual is the aggregate family income divided by the number of family members.

[3] Other types of employment configurations may be possible. Montagna and Nocco (2013) assume that every individual allocates his/her unit labor force between homogeneous and differentiated sectors, so every labor is hired by two sectors at the same time.

$$\text{s.t.} \int_{i \in \widetilde{\Omega}_j} p_j(i)\, q_j^c(i)\, di + q_0^c \leq I_j^c,$$

where $\widetilde{\Omega}_j \subset \Omega_j$ is the subset of varieties consumed, I_j^c is the income of a labor, and $p_j(i)$ is the price of variety i. The aggregate income of this representative family is $I_j = \overline{w}_j L_j^M + w_j^A X_j^A L_j^A$ where $L_j^M + L_j^A = L$, and X_j^A is the employment rate in homogeneous sector. L_j^M and $X_j^A L_j^A$ are the employment amount in the manufacturing sector and in the homogeneous sector. L_j^A is the number of labors search for jobs in the homogeneous sector, $\overline{w}_j$ and w_j^A are the corresponding expected wage rates, respectively.

Solving the maximization problem yields the inverse individual demand function. We transpose it and get the linear market demand system for the variety i:

$$q_{sj}(i) \equiv q_{sj}^c(i)\, L_j = \left[\frac{\alpha}{\delta + \eta N_j} - \frac{1}{\delta} p_{sj}(i) + \frac{\eta N_j \overline{p}_j}{\delta(\delta + \eta N_j)}\right] L_j, \tag{2}$$

$q_{sj}(i)$ is the aggregate demand of variety i coming from s country to j country, N_j is the measure of consumed varieties in $\widetilde{\Omega}_j$, $\overline{p}_j = (1/N) \int_{i \in \widetilde{\Omega}_j} p_j(i)\, di$ is the average price and we can derive for the price threshold that drives demand to 0:

$$p_j^{\max} = \frac{\alpha\delta + \eta N_j \overline{p}_j}{\delta + \eta N_j}. \tag{3}$$

The price ceiling could be the inverse indicator of "toughness of competition" because the price elasticity is not a constant. For a given price level $p_{sj}(i)$, the price elasticity of demand $\epsilon_{q,p}(i) = |\partial \log q_{sj}(i) / \partial \log p_{sj}(i)| = \left[\left(p_j^{\max}/p_{sj}(i)\right) - 1\right]^{-1}$ is large if N_j is high and $\overline{p}_j$ is small. For a given $p_j^{\max}$, $\epsilon_{q,p}(i)$ would increase if $p_{sj}(i)$ is high. Higher $\epsilon_{q,p}(i)$ implies the fierce competition in the market.

1.2 Production

Two sectors and one production factor are considered. Labor is the only production factor. In homogeneous sector, one unit of labor is needed for producing one unit of goods.

Before entering the manufacturing sector, *ex ante* identical firms have to invest F_E units of homogeneous goods to learn its productivity ϕ which is drawing from the Pareto distribution $G(\theta) = 1 - \left(\theta^{\min}\right)^{\kappa} / (\theta)^{\kappa}$ where $\kappa - 2 > 0$ and $\theta^{\min}$ is the minimum value of distribution. A type θ firm requires $(1/\theta)$ labors per unit output. In other words, if a firm hires l unit of labors, then it produces $q_j(\theta) = \theta l_j(\theta)$. The operating profit of a firm is thus $\pi_j(\theta) = [p_j(\theta) - w_j(\theta)/\theta]\, q_j(\theta)$, and $w_j(\theta)$ is the wage paid to labors in country j. Solving the maximization problem yields the price and quantity demand that satisfy the following relationship:

$$q_j(\theta) = \frac{L_j}{\delta}\left[p_j(\theta) - \frac{w_j(\theta)}{\theta}\right], \tag{4}$$

Combine equation (4) with production technology and then the labor demand is obtained as

$$l_j(\theta) = \frac{L_j}{\theta\delta}\left[p_j(\theta) - \frac{w_j(\theta)}{\theta}\right], \tag{5}$$

Given demand equation (2) and (4), we get the optimal price:

$$p_j(\theta) = \frac{1}{2}\left[\frac{w_j(\theta)}{\theta} + \frac{\alpha\delta + \eta N_j \bar{p}_j}{\delta + \eta N_j}\right], \tag{6}$$

Then the operation profit becomes

$$\pi_j(\theta) = \frac{L_j}{\delta}\left[p_j(\theta) - \frac{w_j(\theta)}{\theta}\right]^2, \tag{7}$$

We can rewrite the profit with labor demand (5) as:

$$\pi_j(\theta) = \frac{\delta}{L_j}\left[\theta l_j(\theta)\right]^2.$$

For the incumbent firms, $p_j^{\max} > p_j(\theta)$ implies that $p_j^{\max} > w_j(\theta)/\theta$. In the market with lower $p_j^{\max}$, only those firms with lower marginal costs could survive.

1.3 Labor Market

In the homogeneous sector, the labor market is characterized with search and matching friction, and the amount of employment is determined by a matching function. Without loss of generality, we assume that every homogeneous firm hire one labor. After the match process, firms and labors bargain over wages. In the manufacturing sector, labors form unions negotiate wages with the head of profit center, and the amount of employment is decided by the firm. This setting indicates the essential difference between two labor markets. Differentiated manufacturing sectors usually agglomerated in cities and homogeneous firms sprinkle around cities[4]. Labors in cities form unions to bargain wage

[4]This setting is common in urabn literatures, e.g. labors live in the countryside commute to central business district to find a job, work for the agricultural sector located outside of the city. See Behrens and Robert-Nicoud (2014).

with firms while peasants in rural area search for arable land and usually are self-employed [5]. After wage is decided, the unemployed enter homogeneous sector to find a job. Homogeneous firms need to pay searching cost to meet with a labor because of its scattered characteristic. The process of a labor searching for a job is summarized below:

Stage 1 *Labors in manufacturing sector form firm specific unions to bargain wage with firms and the employment decision is made by firms,*

Stage 2 *Labors not being hired in manufacturing sector enter into the homogeneous sector to find a job,*

Stage 3 *Through the matching process, the unemployment rate is determined.*

The coverage of collective bargaining is limited within departments of a firm in our model, and the wage schemes are department-specific.

1.3.1 Matching Process in Homogeneous Sector

When a homogeneous firm matches with a labor, one unit of homogeneous output is produced, and the price is normalized to 1. Labors find jobs in the homogeneous sector if they are not hired by the manufacturing firms. The total amount of labor supply L_j^A in the homogeneous sector depends on the employment amount L_j^M in the manufacturing sector, that is, $L_j^A = L_j - L_j^M$.

The matching function of the homogeneous sector is given by a Cobb-Douglas form and the number of successful matches is $H_j^A = m_j^A \left(V_j^A\right)^{\gamma} \left(L_j^A\right)^{1-\gamma}$, where $\gamma \in (0,1)$. There are V_j^A amount of job vacancies in the homogeneous sector, L_j^A number of labors searching for jobs, and H_j^A output of homogeneous goods. The matching efficiency m_j^A could be a country-specific parameter. The probability of a labor finding a job is $x_j^A \equiv H_j^A/L_j^A = m_j^A \left(V_j^A/L_j^A\right)^{\gamma}$, and the probability of a vacancy is filled (a firm finding a labor) is $H_j^A/V_j^A = \left(m_j^A\right)^{\frac{1}{\gamma}} \left(x_j^A\right)^{-\frac{1-\gamma}{\gamma}}$. x_j^A is also the measure of labor market tightness.

Then we denote the cost of posting vacancies is ν_j^A units of homogeneous goods per labor in country j. After paying the entry cost ν_j^A, a firm matches with a labor with the probability $\left(m_j^A\right)^{\frac{1}{\gamma}} \left(x_j^A\right)^{-\frac{1-\gamma}{\gamma}}$

[5] For simplicity, we do not consider the entry fee of union and the transport cost within a country.

and not matched otherwise. In the following stage, they bargain over the unity surplus[6]. Assume the equal bargaining weight for both parties, firms get $\pi_{j0} = 1/2$ and pay $w_{j0} = 1/2$ to labors. The zero profit condition for a firm is $\left(m_j^A\right)^{\frac{1}{\gamma}} \left(x_j^A\right)^{-\frac{1-\gamma}{\gamma}} /2 = \nu_j^A$, and then we can get the equilibrium market tightness:

$$x_j^A = \left[\frac{\left(m_j^A\right)^{\frac{1}{\gamma}}}{2\nu_j^A}\right]^{\frac{\gamma}{1-\gamma}} < 1, \tag{8}$$

The parameters satisfy the condition $\left(m_j^A\right)^{\frac{1}{\gamma}} < 2\nu_j^A$ to ensure that the employment rate is smaller than 1. When the vacancy cost increases or matching efficiency decreases, the market tightness decreases. The number of labors employed in homogeneous sector is simply $H_j^A = x_j^A L_j^A$.

The expected income for a labor searching for a job in the homogeneous sector is:

$$\underline{\omega}_j = \frac{1}{2} x_j^A = \frac{1}{2}\left[\frac{\left(m_j^A\right)^{\frac{1}{\gamma}}}{2\nu_j^A}\right]^{\frac{\gamma}{1-\gamma}} < 1. \tag{9}$$

It increases in the matching efficiency and decreases in the vacancy cost. $\underline{\omega}_j$ is also the reservation wage for labors when they bargain with the heterogeneous firms.

Lemma 1 *Homogeneous sector reform (increases in matching efficiency or decreases in vacancy cost) increases the market tightness λ_j^A and expected wage $\underline{\omega}_j$.*

1.3.2 Union Bargaining in Manufacturing Sector

Following Montagna and Nocco (2013), labors form firm-specific unions and bargain wage with firms by Nash bargain game, subject to (6), (5) and (7).

$$\max_{w_j(\theta)} \Pi_j = \mu \log\left[V_j\left(w_j(\theta), l_j(\theta)\right)\right] + (1-\mu)\log\left[\pi_j\left(w_j(\theta), l_j(\theta)\right) - \pi_{j0}(\theta)\right], \tag{10}$$

where $\mu \in (0,1)$ is union's bargaining power, and $V_j\left(w_j(\theta), l_j(\theta)\right) = l_j(\theta)\left[w_j(\theta) - \underline{\omega}_j\right]$ is the total labor rent above the expected wage in the homogeneous sector. For simplicity, we set the firm's reservation profits $\pi_{j0}(\theta) = 0$. We may refer the endogenous determined $\underline{\omega}_j$ as reservation wage paid to labors in the manufacturing sector. By solving the bargaining game, the resulting wage rules is:

$$w_j(\theta) = \underline{\omega}_j + \frac{2\mu\theta}{2+\mu}\left[p_j(\theta) - \frac{\underline{\omega}_j}{\theta}\right]. \tag{11}$$

[6]Because the outside option in this stage is 0 for each party, the production surplus is the revenue from selling one unit of homogeneous goods which is equal to 1.

For active firms, equation (4) and (7) are non-negative, which means $p_j(\theta) \geq w_j(\theta)/\theta$, and we can infer that $p_j(\theta) > \underline{\omega}_j/\theta$. Then $w_j(\theta) > \underline{\omega}_j$ is trivial. The bargaining wage is correspondent with the firm's productivity and is higher than the expected wage in homogeneous sector.

1.4 Autarkic equilibrium

The country subscript is eliminated for simplicity in autarkic equilibrium. Before entering the market, a typical firm's expected payoff of is $\int_{\theta^d}^{\infty} \pi(\theta)\, dG(\theta) - F_E$. In equilibrium, the expected profit is driven to 0 because of free entry. The production threshold ϕ_d is uniquely determined and the marginal firm with the productivity ϕ_d also earns 0 profit. Combined with equation (7):

$$\pi\left(\theta^d\right) = 0 \Longleftrightarrow p\left(\theta^d\right) = \frac{w\left(\theta^d\right)}{\theta^d}, \tag{12}$$

$p\left(\theta^d\right)$ and $w_j\left(\theta^d\right)$ are the price and wage of marginal firm respectively. Entrants with $\theta \geq \theta^d$ stay in the market and earns non-negative profit. And $p\left(\theta^d\right) = \underline{\omega}/\theta^d$ is obtained by inserting (12) into (11) and then we get $w\left(\theta^d\right) = \underline{\omega}$, which means that the wage paid by the marginal firms equals to the expected wage in the homogeneous sector. In the next step we rewrite the performance variables we concern as functions of thresholds θ^d, the pricing rule $p(\theta)$, output level $q(\theta)$, labor demand $l(\theta)$, operating profit $\pi(\theta)$, and markup Δ_j (the difference between price and marginal cost) associated with productivity ϕ :

$$\begin{aligned}
p(\theta) &= \frac{\underline{\omega}}{4}\left(\frac{2-\mu}{\theta} + \frac{2+\mu}{\theta^d}\right),\ q(\theta) = \frac{(2-\mu)\,\underline{\omega}L}{4\delta}\left(\frac{1}{\theta^d} - \frac{1}{\theta}\right) \\
w(\theta) &= \underline{\omega}\left[1 + \frac{\mu}{2}\left(\frac{\theta}{\theta^d} - 1\right)\right],\ l(\theta) = \frac{q(\theta)}{\theta} = \frac{(2-\mu)\,\underline{\omega}L}{4\delta\theta}\left(\frac{1}{\theta^d} - \frac{1}{\theta}\right) \\
\pi(\theta) &= \frac{(2-\mu)^2 (\underline{\omega})^2 L}{16\delta}\left(\frac{1}{\theta^d} - \frac{1}{\theta}\right)^2,\ \Delta_j = \frac{(2-\mu)\,\underline{\omega}}{4}\left(\frac{1}{\theta^d} - \frac{1}{\theta}\right).
\end{aligned} \tag{13}$$

For a given bargaining power μ, firms with a higher θ charge lower price, sell more, and have larger operating profit despite the higher wages they pay. $\partial\epsilon_{q,p}(\theta)/\partial\theta < 0$ means that firms with higher productivity θ have stronger monopoly power in the product market. $\partial\epsilon_{l,w}(\theta)/\partial\theta < 0$ means that firms with higher productivity have lower labor demand elasticity. According to Montagna and Nocco (2013), unionization deteriorates the cost advantage of the firms by paying higher wages to their labors.

The elasticity of wage $w(\theta)$ with respect to bargaining power μ is $\epsilon_{w,\mu}(\theta) = \partial \log w(\theta) / \partial \log \mu = \mu\theta / \left[(2-\mu)\theta^d + \mu\theta\right]$. The firms with higher productivity are sensitive to the bargaining power changes, and they are willing to pay higer wages.

Pareto distribution is used and we can derive for the production threshold as:

$$\theta^d = \underline{\omega}^{\frac{2}{\kappa+2}} \left[\frac{(2-\mu)^2 \left(\theta^{\min}\right)^{\kappa} L}{8\delta(\kappa+1)(\kappa+2) F_E} \right]^{\frac{1}{\kappa+2}}, \tag{14}$$

and the average level of all relevant variables:

$$\begin{aligned} \overline{p} &= \frac{4\kappa+\mu+2}{4(\kappa+1)} \frac{\underline{\omega}}{\theta^d}, \overline{q} = \frac{(2-\mu)}{4\delta(\kappa+1)} \frac{\underline{\omega}}{\theta^d} L \\ \bar{l} &= \frac{\kappa(2-\mu)}{4\delta(\kappa+1)(\kappa+2)} \frac{\underline{\omega}}{\left(\theta^d\right)^2} L \qquad (15) \\ \overline{\pi} &= \frac{(2-\mu)^2}{8\delta(\kappa+1)(\kappa+2)} \left(\frac{\underline{\omega}}{\theta^d}\right)^2 L, \overline{\Delta} = \frac{(2-\mu)}{4(\kappa+1)} \frac{\underline{\omega}}{\theta^d}. \qquad (16) \end{aligned}$$

and the average cost of hiring a labor per firm is

$$\overline{VC} = \frac{(2-\mu)(\kappa+\mu) L}{4\delta(\kappa+1)(\kappa+2)} \left(\frac{\underline{\omega}}{\theta^d}\right)^2. \tag{17}$$

We can derive for the labor demand elasticity $\epsilon_{l,w}(\theta) = \left|\partial \log l_j(\theta) / \partial \log w_j(\theta)\right| = 2\theta^d / \left[(2-\mu)\left(\theta - \theta^d\right)\right] + \mu/(2-\mu)$. Firms with lower productivity are sensitive to the changes of wage. At the equilibrium, the price ceiling equals to the price of marginal firm, that is, $p^{\max} = p\left(\theta^d\right) = \underline{\omega}/\theta^d$. Insert $\overline{p}$ from (16) into (3) and the number of surviving firms in the market is[7]

$$N = \frac{4\delta(\kappa+1)}{\eta(2-\mu)\underline{\omega}} \left(\alpha\theta^d - \underline{\omega}\right), \tag{18}$$

and the number of entrants is $N^E = N\left(\theta^d\right)^{\kappa} / \left(\theta^{\min}\right)^{\kappa}$.

The total employment in manufacturing sector L^M is

$$L^M = N\bar{l} = \frac{\kappa L}{\eta(\kappa+2)\left(\theta^d\right)^2} \left(\alpha\theta^d - \underline{\omega}\right). \tag{19}$$

The total labor force in homogeneous sector is $L^A = L - L^M = L - N\bar{l}$, combined with (8) and (9) then we can calculate the unemployment as $\left(1 - x_j^A\right)\left(L - N\bar{l}\right)$, thus the unemployment rate is $\left(1 - x_j^A\right)\left(L - N\bar{l}\right)/L$ in this country.

[7] In order to ensure $N_j > 0$, we assume that the parameter of love of variety α is large enough, $\alpha > \underline{\omega}_j / \phi_{jj}^*$.

1.4.1 Comparative Statics

In this part, we investigate the impacts of the homogeneous sector reform and bargaining power. The homogeneous sector reform includes the improvement of matching efficiency m^A and the reduction in unit vacancy costs ν^A. The results are summarized below.

Lemma 2 *Homogeneous sector reform, an increase in search efficiency m^A or a decreases in vacancy cost ν^A:*

1. Increase the production threshold ϕ^d, average price $\overline{p}$, average production amount $\overline{q}$, average mark up $\overline{\Delta}$, average profit $\overline{\pi}$, and average labor demand per firm $\overline{l}$;

2. Decrease the number of firms N and the total number of employment in the manufacturing sector $N\overline{l}$.

Proof. Define $z = m^A$, $1/\nu^A$, by lemma 3.1, we know that the expected wage in homogeneous sector $\underline{\omega}$ is increasing in z, which means $\partial\underline{\omega}/\partial z > 0$, and the following results are immediately seen by investigating (16), (18), and (19).

$$\begin{aligned}
\frac{\partial \theta^d}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} &> 0, \ \frac{\partial \overline{p}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} > 0, \ \frac{\partial \overline{q}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} > 0 \\
\frac{\partial \overline{\pi}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} &> 0, \ \frac{\partial \overline{l}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} > 0, \ \frac{\partial \overline{\Delta}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} > 0 \\
\frac{\partial N}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} &< 0, \ \frac{\partial N\overline{l}}{\partial \underline{\omega}}\frac{\partial \underline{\omega}}{\partial z} < 0.
\end{aligned}$$

The homogeneous sector reform raises the expected wage paid to labors, which is served as the reservation wage for manufacturing labors. The higher the expected wage is, the higher the level of productivity is needed to survive in the market. The market becomes much more competitive. The firms that stay in the market on average produce more, hire more workers, and acquire higher profits. It means that magnitude of firms becomes larger, but the number of firms decreases and so does the amount of employment in the manufacturing sector.

Lemma 3 *An increase in the bargaining power of unions μ*

1. Reduce the cutoff θ^d, average production amount $\overline{q}$, average markup $\overline{\Delta}$, average profit $\overline{\pi}$, and *average labor demand $\bar{l}$,*

2. Increase the average price $\overline{p}$,

3. Increase the number of firm N if $2 - [(\kappa+2)/\alpha\kappa]^{\frac{\kappa+2}{2}} \Upsilon_A > \mu$,

4. Increase the total employment in manufacturing sector $N\bar{l}$ if $2 - (2/\alpha)^{\frac{\kappa+2}{2}} \Upsilon_A > \mu$.

where $\Upsilon_A = (1/2)^{\frac{\kappa}{2}} \left[\left(m^A\right)^{\frac{1}{\gamma}} / 2\nu^A \right]^{\frac{\kappa\gamma}{2(1-\gamma)}} \left[8\delta(\kappa+1)(\kappa+2) F_E / \left(L \left(\phi^{\min} \right)^{\kappa} \right) \right]^{\frac{1}{2}}$.

As in Montagna and Nocco (2013), the production threshold becomes lower when the bargaining power increases. It means that less efficient firms could enter the market because of the selection-soften effects. Productive firms pay more to their labors with respect to the bargaining power changes, that is $\epsilon_{w,\mu}(\theta) = \mu\theta / \left[(2-\mu)\theta^d + \mu\theta \right]$; furthermore, the margin is growing, that is $\partial\epsilon_{w,\mu}(\theta)/\partial\mu > 0$. For a given threshold θ^d, it harms firms with higher productivity more because of the higher wages. The rise in the bargaining power leaves room for relatively inefficient firms. The reduction in toughness of competition elevates the level of average price $\overline{p}$, but lowers average quantity $\overline{q}$, average markup $\overline{\Delta}$, and average profit $\overline{\pi}$. However, although the average number of labors hired is decreasing, the number of firms increases faster. Not only the variety in this market but also the total number of employed labors in manufacturing increases.

And the welfare measured by indirect utility function is ambiguous with respect to increases in bargaining power (shown in appendix).

Proposition 1 *If the unions' bargaining power μ is small enough ($2 - (2/\alpha)^{\frac{\kappa+2}{2}} \Upsilon_A > \mu$), an increase in the bargaining power μ would increase the amount of employment in the manufacturing sector, and thus decrease the unemployment rate in this country.*

Proof. By lemma 3.3, set

$$2 - \left(\frac{2}{\alpha}\right)^{\frac{\kappa+2}{2}} \Upsilon_A = \mu^a,\ 2 - \left(\frac{\kappa+2}{\alpha\kappa}\right)^{\frac{\kappa+2}{2}} \Upsilon_A = \mu^b, \tag{20}$$

and it is trivial to prove $\mu^b > \mu^a$, then we know that

1. If the bargaining power is low enough, then an increase in μ increases employment because the number of firms increases even though the labor demand per firm decreases.

$$\frac{\partial N\bar{l}}{\partial\mu} > 0 \text{ and } \frac{\partial N}{\partial\mu} > 0 \text{ if } \mu^a > \mu,$$

2. If the bargaining power is in median level, then an increase in μ decreases the amount of employment, but the number of firm increases.

$$\frac{\partial N\bar{l}}{\partial \mu} < 0 \text{ and } \frac{\partial N}{\partial \mu} > 0 \text{ if } \mu^a < \mu < \mu^b,$$

3. If the bargaining power is high enough, the total amount of employment decreases, and the number of firms decreases

$$\frac{\partial N\bar{l}}{\partial \mu} < 0 \text{ and } \frac{\partial N}{\partial \mu} < 0, \text{ if } \mu^b < \mu.$$

Considering the case $\mu^a < \mu^b < 1$, the results could be illustrated as the following graph.

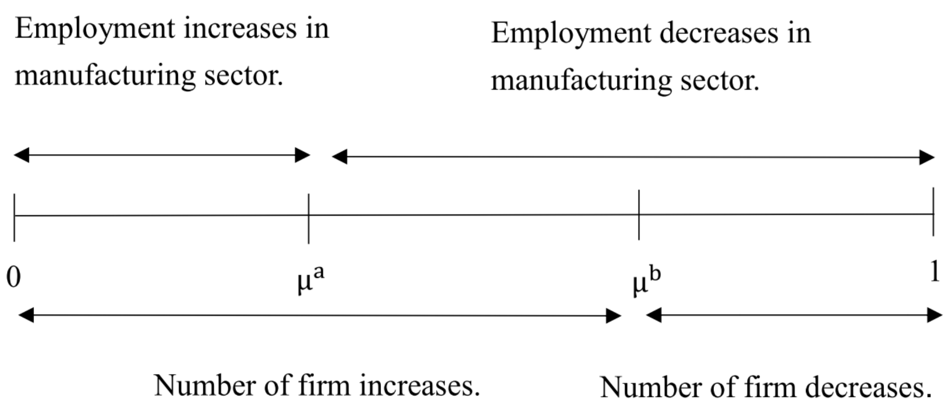

Figure 1: Change in bargaining power (Autarky)

The aggregate number of unemployed labors is $\left(1 - x^A\right)\left(L - N\bar{l}\right)$. Higher bargaining power do harm to the firms because they have to pay higher wages and the number of entrants (N^E) shrinks. However, it also alleviates the level of competition and allows the entry of firms with lower productivity. Despite the average labor demand $\bar{l}$ is decreasing, the number of firms is still increasing when the bargaining power is small enough ($\mu < \mu^a$). Hence the number of employed labors is increasing. Besides, the bargaining power μ would not affect the matching rate x^A in homogeneous sector, if the number of labors employed in the manufacturing sector increases, then unemployment rate decreases.

Finally we discuss the effects of the homogeneous sector reform on unemployment rate. The matching rate x^A in the homogeneous sector increases. By lemma 3.2, we know that the number of employed labors in the manufacturing sector $N\bar{l}$ also decreases, so the changes of total amount of unemployed labors $\left(1 - x^A\right)\left(L - N\bar{l}\right)$ is undetermined.

2 Unionization and Unemployment Model in the Open Economy

Trade liberalization links not only the goods markets but also the labor markets of different countries. In order to get further insight into the labor-market interdependencies, we extend our model into a two-country setting. Consider two countries j and s, with L_j and L_s as labor force in each country, respectively.

The two countries share the same preference, generating demand function as shown in equation (2), and the production technology. Homogeneous goods is freely traded. The expected wages in the homogeneous sectors of the two countries are still determined by the market tightness. Manufactured goods are costly traded, and $\tau_{js} > 1$ represents the ice-berg cost from j to s; hence the delivery cost of one unit of goods is $w_{js}(\theta)\,\tau_{js}/\theta$.

The production decision in this section is isomorphic as the autarkic case. Firms pay fixed cost F_E to learn its productivity. After they enter the market, firms decide whether to produce for the domestic market or not and whether for foreign market or not. Because of the trade cost, the two markets are segmented and the firms face distinct levels of competition and different monopoly powers. As equation (3), the price thresholds of two countries are:

$$p_j^{\max} = \frac{\alpha\delta + \eta N_j \overline{p}_j}{\delta + \eta N_j},\; p_s^{\max} = \frac{\alpha\delta + \eta N_s \overline{p}_s}{\delta + \eta N_s}, \tag{21}$$

where N_j and N_s are the number of surviving firms in the two markets (both domestic and importing firms) and $\overline{p}_j$ and $\overline{p}_s$ are the average prices across all goods selling in country j and s, respectively. $p_{jj}(\theta)$ is the domestic price in country j and $p_{js}(\theta)$ is the delivery price of a good produced in country j and sold to s country. If a firm decides to export, it has domestic and exporting departments—the two corresponding profit centers. The authorities of each profit center maximize the domestic profit $\pi_{jj}(\theta) = [p_{jj}(\theta) - w_{jj}(\theta)/\theta]\, q_{jj}(\theta)$ and profit from exports $\pi_{js}(\theta) = [p_{js}(\theta) - \tau_{js} w_{js}(\theta)/\theta]\, q_{js}(\theta)$ separately, of which $w_{jj}(\theta)$ and $w_{js}(\theta)$ are the wages paid to labors work for domestic department and exporting department, respectively. The maximization problems yield the relationship between price and quantity as shown in $q_{jj}(\theta) = (L_j/\delta)\,[p_{jj}(\theta) - w_{jj}(\theta)/\theta]$

and $q_{js}(\theta) = (L_s/\delta)[p_{js}(\theta) - \tau_{js} w_{js}(\theta)/\theta]$. The firm's labor demand for the two departments are

$$l_{jj}(\theta) = \frac{L_j}{\delta\theta}\left[p_{jj}(\theta) - \frac{w_{jj}(\theta)}{\theta}\right], \; l_{js}(\theta) = \frac{\tau_{js} L_s}{\delta\theta}\left[p_{js}(\theta) - \frac{\tau_{js} w_{js}(\theta)}{\theta}\right], \tag{22}$$

so we can rewrite the profit function as

$$\pi_{jj}(\theta) = \frac{\delta}{L_j}\left[\theta l_{jj}(\theta)\right]^2, \; \pi_{js}(\theta) = \frac{\delta}{L_s}\left[\frac{\theta}{\tau_{js}} l_{js}(\theta)\right]^2. \tag{23}$$

Only firms incur non-negative profit stay in the market.

2.1 Labor Markets

The homogeneous sectors of the two countries are embedded with search frictions. We allow for different matching efficiency parameters (m_j^A , m_s^A) and vacancy costs (v_j^A , v_s^A) in the two countries. The matching rate and expected wage may not be the same. The job searching process is the same as that in the autarky.

In the open economy, firms could choose to produce for the domestic market or foreign market. Domestic firms face Nash bargaining as shown in equation (10), which is subject to firm's profit function (23), and the resulting wages rule is

$$w_{jj}(\theta) = \underline{\omega}_j + \frac{2\mu_j \theta}{2+\mu_j}\left[p_{jj}(\theta) - \frac{\underline{\omega}_j}{\theta}\right]. \tag{24}$$

Firms exporting to other countries have two departments (two profit centers) because domestic and foreign markets are embedded with different levels of price elasticity, and pricing behavior depends on the market-specific elasticity. The head of the profit centers bargains the wage separately with firm-specific labor unions. The wages paid to labors in the domestic (exporting) department is $w_{jj}(\theta)$ ($w_{js}(\theta)$). The domestic wage scheme is the same as (24), and the head of exporting department solve the following Nash equilibrium problem with labor unions

$$\max_{w_{js}(\theta)} \Pi_{js} = \mu_j \log\left[l_{js}(\theta)\left(w_{js}(\theta) - \underline{\omega}_j\right)\right] + \left(1-\mu_j\right)\log\frac{\delta}{L_s}\left[\frac{\theta}{\tau_{js}} l_{js}(\theta)\right]^2,$$

and the relationship between the wage and price is

$$w_{js}(\theta) = \underline{\omega}_j + \frac{2\mu_j \theta}{2+\mu_j}\left[\frac{p_{js}(\theta)}{\tau_{js}} - \frac{\underline{\omega}_j}{\theta}\right]. \tag{25}$$

According to (25), $w_{js}(\theta) > \underline{\omega}_j$ is trivial. Montagna and Nocco (2013) prove that under symmetric setting, the wage paid by domestic department is higher within a firm because domestic department has stronger monopoly power (lower price elasticity, higher markup) and lower labor demand elasticity.

2.2 The Two-Country Equilibrium

The domestic production threshold θ_j^d and exporting cutoff θ_j^x are uniquely determined by zero profit conditions. Only firms with non-negative profit stay in the market:

$$\begin{aligned}
\pi_{jj}\left(\theta_j^d\right) &= 0 \Longleftrightarrow p_{jj}\left(\theta_j^d\right) = \frac{w_j\left(\theta_j^d\right)}{\theta_j^d} = \frac{\underline{\omega}_j}{\theta_j^d}, \\
\pi_{js}\left(\theta_j^x\right) &= 0 \Longleftrightarrow p_{js}\left(\theta_j^x\right) = \frac{\tau_{js} w_j\left(\theta_j^x\right)}{\theta_j^x} = \tau_{js}\frac{\underline{\omega}_j}{\theta_j^x}.
\end{aligned}$$

The second equality on the right-hand side is from $w_j\left(\theta_j^d\right) = w_j\left(\theta_j^x\right) = \underline{\omega}_j$. All relevant performance variables could be written as the functions of thresholds. The price rule, output level, and labor demand are listed below:

$$\begin{aligned}
p_{jj}(\theta) &= \frac{\underline{\omega}_j}{4}\left(\frac{2-\mu_j}{\theta} + \frac{2+\mu_j}{\theta_j^d}\right), \; p_{js}(\theta) = \frac{\underline{\omega}_j \tau_{js}}{4}\left(\frac{2-\mu_j}{\theta} + \frac{2+\mu_j}{\theta_j^x}\right), \\
q_{jj}(\theta) &= \frac{\left(2-\mu_j\right)\underline{\omega}_j L_j}{4\delta}\left(\frac{1}{\theta_j^d} - \frac{1}{\theta}\right), \; q_{js}(\theta) = \frac{\left(2-\mu_j\right)\underline{\omega}_j L_s \tau_{js}}{4\delta}\left(\frac{1}{\theta_j^x} - \frac{1}{\theta}\right), \\
l_{jj}(\theta) &= \frac{\left(2-\mu_j\right)\underline{\omega}_j L_j}{4\delta\theta}\left(\frac{1}{\theta_j^d} - \frac{1}{\theta}\right), \; l_{js}(\theta) = \frac{\left(2-\mu_j\right)\underline{\omega}_j L_s \left(\tau_{js}\right)^2}{4\delta\theta}\left(\frac{1}{\theta_j^x} - \frac{1}{\theta}\right), \qquad (26)
\end{aligned}$$

where the mark up of two markets are $\Delta_{jj} = p_{jj}(\phi) - w_{jj}(\phi)/\phi$ and $\Delta_{js} = p_{js}(\phi) - \tau_{js} w_{js}(\phi)/\phi$, and the maximized profit levels are

$$\pi_{jj}(\theta) = \frac{\left(2-\mu_j\right)^2 \left(\underline{\omega}_j\right)^2 L_j}{16\delta}\left(\frac{1}{\theta_j^d} - \frac{1}{\theta}\right)^2, \pi_{js}(\theta) = \frac{\left(2-\mu_j\right)^2 \left(\underline{\omega}_j \tau_{js}\right)^2 L_s}{16\delta}\left(\frac{1}{\theta_j^x} - \frac{1}{\theta}\right)^2. \qquad (27)$$

Using (26) to replace prices in (24) and (25), the wages are

$$w_{jj}(\theta) = \underline{\omega}_j\left[1 + \frac{\mu_j}{2}\left(\frac{\theta}{\theta_j^d} - 1\right)\right], \; w_{js}(\theta) = \underline{\omega}_j\left[1 + \frac{\mu_j}{2}\left(\frac{\theta}{\theta_j^x} - 1\right)\right]. \qquad (28)$$

The free entry condition characterizes the equilibrium thresholds; the expected profit is driven to 0:

$$\int_{\theta_j^d}^{\infty} \pi_{jj}(\theta)\, dG(\theta) + \int_{\theta_j^x}^{\infty} \pi_{js}(\theta)\, dG(\theta) = F_E, \qquad (29)$$

and the price ceiling conditions imply $p_{jj}\left(\theta_j^d\right) = p_{sj}\left(\theta_s^x\right)$, so we know that

$$\theta_s^x = \tau_{sj}\frac{\underline{\omega}_s}{\underline{\omega}_j}\theta_j^d. \tag{30}$$

Combined with (29) and (30), it yields the production thresholds[8]

$$\begin{aligned}
\theta_j^d &= \underline{\omega}_j\left\{\frac{\left(\theta^{\min}\right)^{\kappa} L_j\left(2-\mu_j\right)^2\left(2-\mu_s\right)^2\left[1-\left(\tau_{js}\right)^{-\kappa}\left(\tau_{sj}\right)^{-\kappa}\right]}{8\delta\left(\kappa+1\right)\left(\kappa+2\right)F_E\left[\left(2-\mu_s\right)^2\left(\underline{\omega}_j\right)^{\kappa}-\left(2-\mu_j\right)^2\left(\underline{\omega}_s\right)^{\kappa}\left(\tau_{js}\right)^{-\kappa}\right]}\right\}^{\frac{1}{\kappa+2}}, \\
\theta_j^x &= \tau_{js}\underline{\omega}_j\left\{\frac{\left(\theta^{\min}\right)^{\kappa} L_s\left(2-\mu_j\right)^2\left(2-\mu_s\right)^2\left[1-\left(\tau_{js}\right)^{-\kappa}\left(\tau_{sj}\right)^{-\kappa}\right]}{8\delta\left(\kappa+1\right)\left(\kappa+2\right)F_E\left[\left(2-\mu_j\right)^2\left(\underline{\omega}_s\right)^{\kappa}-\left(2-\mu_s\right)^2\left(\underline{\omega}_j\right)^{\kappa}\left(\tau_{sj}\right)^{-\kappa}\right]}\right\}^{\frac{1}{\kappa+2}}.
\end{aligned} \tag{31}$$

In order to ensure that $\theta_j^d > \theta^{\min}$, and that $\theta_j^x > \theta^{\min}$, the following conditions are sufficient.

Condition 1 $\left(2-\mu_s\right)^2\left(\underline{\omega}_j\right)^{\kappa} > \left(2-\mu_j\right)^2\left(\underline{\omega}_s\right)^{\kappa}\left(\tau_{js}\right)^{-\kappa}$, $\left(2-\mu_j\right)^2\left(\underline{\omega}_s\right)^{\kappa} > \left(2-\mu_s\right)^2\left(\underline{\omega}_j\right)^{\kappa}\left(\tau_{sj}\right)^{-\kappa}$.

The average variables could be written as functions of threshold ϕ_j^d,

$$\begin{aligned}
\overline{p}_{jj} &= \frac{\underline{\omega}_j}{4\theta_j^d}\frac{4\kappa+\mu_j+2}{\kappa+1}, \overline{p}_{js} = \frac{\tau_{js}\underline{\omega}_j}{4\theta_j^x}\frac{4\kappa+\mu_j+2}{\kappa+1}, \\
\bar{l}_{jj} &= \frac{\kappa\left(2-\mu_j\right)\underline{\omega}_j}{4\delta\left(\kappa+1\right)\left(\kappa+2\right)\left(\theta_j^d\right)^2}L_j, \bar{l}_{js} = \frac{\kappa\left(2-\mu_j\right)\underline{\omega}_j\left(\tau_{js}\right)^2}{4\delta\left(\kappa+1\right)\left(\kappa+2\right)\left(\theta_j^x\right)^2}L_s.
\end{aligned} \tag{32}$$

In the next step we calculate the number of entrants N_j^E in country j. The number of surviving domestic firms in country j is $N_{jj} = N_j^E\left(\theta^{\min}\right)^{\kappa}/\left(\theta_j^d\right)^{\kappa}$ and the number of importing firms from s to j is $N_{sj} = N_s^E\left(\theta^{\min}\right)^{\kappa}/\left(\theta_s^x\right)^{\kappa}$. The total number of firms selling in country j is $N_j = N_{jj} + N_{sj}$. By the same token, $N_s = N_{ss} + N_{js} = N_s^E\left(\theta^{\min}\right)^{\kappa}/\left(\theta_s^d\right)^{\kappa} + N_j^E\left(\theta^{\min}\right)^{\kappa}/\left(\theta_j^x\right)^{\kappa}$. The average price in country j and s are given by

$$\begin{aligned}
\overline{p}_j &= \frac{1}{N_j}\left(N_{jj}\overline{p}_{jj} + N_{sj}\overline{p}_{sj}\right), \\
&= \frac{\underline{\omega}_j\left[N_j^E\left(4\kappa+\mu_j+2\right)+N_s^E\left(4\kappa+\mu_s+2\right)\left(\frac{\underline{\omega}_j}{\tau_{sj}\underline{\omega}_s}\right)^{\kappa}\right]}{4\left(\kappa+1\right)\left[N_j^E+N_s^E\left(\frac{\underline{\omega}_j}{\tau_{sj}\underline{\omega}_s}\right)^{\kappa}\right]\theta_j^d}, \\
\overline{p}_s &= \frac{1}{N_s}\left(N_{ss}\overline{p}_{ss} + N_{js}\overline{p}_{js}\right) \\
&= \frac{\underline{\omega}_s\left[N_j^E\left(4\kappa+\mu_j+2\right)\left(\frac{\underline{\omega}_s}{\tau_{js}\underline{\omega}_j}\right)^{\kappa}+N_s^E\left(4\kappa+\mu_s+2\right)\right]}{4\left(\kappa+1\right)\left[N_j^E\left(\frac{\underline{\omega}_s}{\tau_{js}\underline{\omega}_j}\right)^{\kappa}+N_s^E\right]\theta_s^x}.
\end{aligned} \tag{33}$$

[8] Substitute s for j, and then get the foreign thresholds.

Insert the average price into the choke prices and combine it with zero profit conditions,

$$p_j^{\max} = \frac{\alpha\delta + \eta N_j \overline{p}_j}{\delta + \eta N_j} = \frac{\underline{\omega}_j}{\theta_j^d}, \; p_s^{\max} = \frac{\alpha\delta + \eta N_s \overline{p}_s}{\delta + \eta N_s} = \tau\frac{\underline{\omega}_j}{\theta_j^x} = \frac{\underline{\omega}_s}{\theta_s^d}.$$

We can derive for the number of entrants,

$$\begin{aligned} N_j^E &= \frac{4\delta(\kappa+1)}{\eta(2-\mu_j)(1-\phi^2)\left(\theta^{\min}\right)^{\kappa}\underline{\omega}_j}\left[\left(\alpha\phi_{jj}^* - \underline{\omega}_j\right)\left(\theta_j^d\right)^{\kappa} - \phi\left(\alpha\theta_s^d - \underline{\omega}_s\right)\left(\theta_s^d\right)^{\kappa}\left(\frac{\underline{\omega}_j}{\underline{\omega}_s}\right)^{\kappa+1}\right], \\ N_s^E &= \frac{4\delta(\kappa+1)}{\eta(2-\mu_s)(1-\phi^2)\left(\theta^{\min}\right)^{\kappa}\underline{\omega}_s}\left[\left(\alpha\phi_{ss}^* - \underline{\omega}_s\right)\left(\theta_s^d\right)^{\kappa} - \phi\left(\alpha\theta_j^d - \underline{\omega}_j\right)\left(\theta_j^d\right)^{\kappa}\left(\frac{\underline{\omega}_s}{\underline{\omega}_j}\right)^{\kappa+1}\right]. \end{aligned} \tag{34}$$

$N_j^E > 0$ implies that $\theta_s^x > \theta_s^d$; and $N_s^E > 0$ implies that $\theta_j^x > \theta_j^d$. The positive number of entrants ensures that only more productive firms export as described in Melitz (2003).

Before we discuss the properties of equilibrium, we list the results of comparative statics of domestic production thresholds θ_j^d, exporting cutoff θ_j^x, the number of entrants N_j^E and N_s^E, and the average demands of labor $\bar{l}_{jj}$ and $\bar{l}_{js}$ on bargaining power μ_j or μ_s as follows.

Lemma 4 *If the unions' bargaining power μ_j or μ_s increases:*

1. $\partial\theta_j^d/\partial\mu_j < 0$, $\partial\theta_j^x/\partial\mu_j > 0$,
2. $\partial\theta_j^d/\partial\mu_s > 0$, $\partial\theta_j^x/\partial\mu_s < 0$,
3. $\partial N_j^E/\partial\mu_j < 0$ *and* $\partial N_s^E > \partial\mu_j$[9],
4. $\partial\bar{l}_{js}/\partial\mu_j < 0$,
5. $\partial\bar{l}_{jj}/\partial\mu_s < 0$, $\partial\bar{l}_{js}/\partial\mu_s > 0$.

The increases in bargaining power μ_j generate selection-soften effects in domestic market and selection-toughen effects for exporting firms because wages paid to labors increase more for efficient firms. Hence it allows the lower productivity firms to stay in domestic market and the minimum exporting threshold θ_j^x increases .The rise in bargaining power μ_s means that the domestic firms in country j face a stronger competition from another country. The production threshold θ_j^d then increases. However, because the competition in market s decreases, so the exporting threshold θ_j^x also decreases. The mass of entrants in country j decreases while the number of entrants in country s increases. An increase in μ_j decreases the average labor demand in exporting department $\bar{l}_{js}$. An

[9] Subsitite s for j, and then get the corresponding results.

increase in other country's bargaining power μ_s decreases average domestic labor demand $\bar{l}_{jj}$ and increases the average exporting labor demand $\bar{l}_{js}$.

2.2.1 Symmetric Equilibrium

The two countries are symmetric in terms of bargaining power, population, and trade cost—$\mu_j = \mu_s = \mu$, $L_j = L_s = L$, $\tau_{sj} = \tau_{js} = \tau$ and set $\phi \equiv (\tau)^{-\kappa} \in (0, 1)$. The symmetric homogeneous sector implies that the equilibrium expected wages are the same. That is, $\underline{\omega}_j = \underline{\omega}_s = \underline{\omega}$. The equilibrium domestic threshold θ_j^d reduces to

$$\theta_j^d = (\underline{\omega})^{\frac{2}{\kappa+2}} \left[\frac{(2-\mu)^2 (1+\phi) \left(\theta^{\min}\right)^{\kappa} L}{8\delta (\kappa+1)(\kappa+2) F_E} \right]^{\frac{1}{\kappa+2}}.$$

and the exporting threshold is simply $\theta_j^x = \tau \theta_j^d$. Comparing with the autarky threshold (14), we can easily investigate that the domestic production threshold θ_j^d becomes larger after trade. It means that opening to trade induces tougher competition. By equation (28) we know that firms pay lower export-wage $w_{js}(\theta)$ than domestic-wages $w_{jj}(\theta)$ within a firm engaging in exporting. Besides, with equations (13) and (17) we also discover that domestic-wage $w_{jj}(\theta)$ and average variable cost $\overline{VC}$ of hiring a labor per firm in domestic sector becomes lower than autarky for a surviving firm.

Imposing symmetry on (34) and rewriting the number of firms as

$$N_j^E = \frac{4\delta(\kappa+1)}{\eta(2-\mu)(1+\phi)\left(\theta^{\min}\right)^{\kappa} \underline{\omega}} \left(\alpha\theta_j^d - \underline{\omega}\right) \left(\theta_j^d\right)^{\kappa},$$

and we get the number of domestic firms N_{jj} as

$$N_{jj} = N_j^E \frac{\left(\theta^{\min}\right)^{\kappa}}{\left(\theta_j^d\right)^{\kappa}} = \frac{4\delta(\kappa+1)}{\eta(2-\mu)(1+\phi)\underline{\omega}} \left(\alpha\theta_j^d - \underline{\omega}\right). \tag{35}$$

the average labor demand as

$$\bar{l}_{jj} = \frac{\kappa(2-\mu)\underline{\omega}}{4\delta(\kappa+1)(\kappa+2)\left(\theta_j^d\right)^2} L, \tag{36}$$

Combined with (35) and (36), the number of labors employed in the domestic department is

$$N_{jj}\bar{l}_{jj} = N_j^E \frac{\left(\theta^{\min}\right)^{\kappa}}{\left(\theta_j^d\right)^{\kappa}} \frac{\kappa(2-\mu)\underline{\omega}}{4\delta(\kappa+1)(\kappa+2)\left(\theta_j^d\right)^2} L.$$

Proposition 2 *When the two countries are symmetric, the bargaining power μ increases,*

(1) the total number of employed labors in the exporting department decreases;

(2) if the bargaining power of unions μ is small enough, the number of employed labors in the manufacturing sector and the number of firms increase;

(3) if the bargaining power of unions μ is in median level, the number of unemployed labors increases despite of the increased number of firms;

(4) the number of unemployed labors increases and the number of firms decreases when the bargaining power μ is large enough.

Proof. (1) By lemma 3.4, we know that the average number of employed labors and the number of entrants in the exporting sector decreases in the bargaining power, combining with an increase in exporting production threshold. It means the number of surviving exporting firms decreases and we know that the total number of employed labors in exporting sector declines in the bargaining power μ.

(2) Set

$$2-\left(\frac{2}{\alpha}\right)^{\frac{\kappa+2}{2}}\Upsilon_o=\mu_o^a,\ 2-\left(\frac{\kappa+2}{\alpha\kappa}\right)^{\frac{\kappa+2}{2}}\Upsilon_A=\mu_o^b, \tag{37}$$

where $\Upsilon_o=(1/2)^{\frac{\kappa}{2}}\left[\left(m^A\right)^{\frac{1}{\gamma}}/\left(2\nu^A\right)\right]^{\frac{\kappa\gamma}{2(1-\gamma)}}\left[8\delta\left(\kappa+1\right)\left(\kappa+2\right)F_E\left(\underline{\omega}\right)^{\kappa}/\left(\left(1+\phi\right)\left(\theta^{\min}\right)^{\kappa}L\right)\right]^{\frac{1}{2}}$.
Differentiate the total employment of domestic department $N_{jj}\bar{l}_{jj}$ with respect to μ, and then we get

$$\frac{\partial N_{jj}\bar{l}_{jj}}{\partial\mu}>0,\text{ if }\mu_o^a>\mu,$$

(3), (4). When the bargaining power is in median level $\mu_o^a<\mu<\mu_o^b$, then we know that,

$$\frac{\partial N_{jj}\bar{l}_{jj}}{\partial\mu}<0\text{ and }\frac{\partial N_{jj}}{\partial\mu}>0.$$

And if μ is large enough $\mu_o^a<\mu_o^b<\mu$, we obtain

$$\frac{\partial N_{jj}\bar{l}_{jj}}{\partial\mu}<0\text{ and }\frac{\partial N_{jj}}{\partial\mu}<0.$$

The amount of the unemployment is

$$\left(L-L_j^M\right)\left(1-x_j^A\right)=\left(L-N_{jj}\bar{l}_{jj}-N_{js}\bar{l}_{js}\right)\left(1-x_j^A\right).$$

L_j^M is the total amount of employment in the manufacturing sector. Because the total amount of employment in the exporting department $N_{js}\bar{l}_{js}$ decreases, thus we only have to investigate the changes of employment in the domestic department $N_{jj}\bar{l}_{jj}$. If the amount of employment decreases, then the unemployment rate increases in country j. We use the following graph to demonstrate the results (considering the case $\mu_o^a < \mu_o^b < 1$).

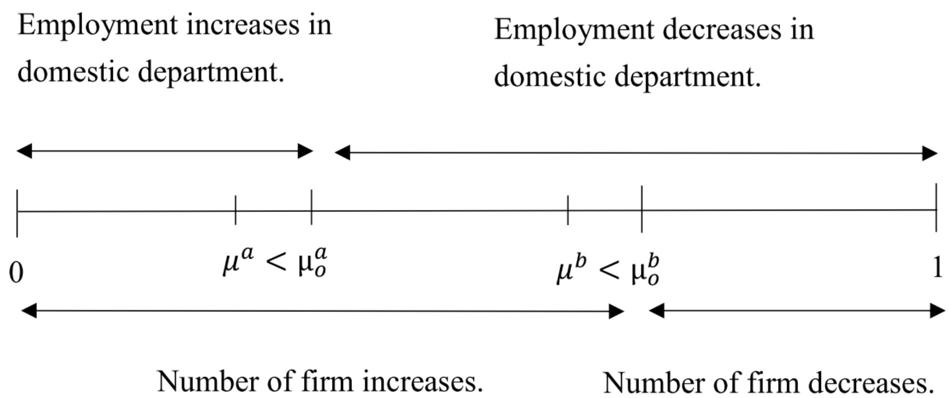

Figure 2: Change in bargaining power (Symmetric countries)

And the change of homogeneous sector reform is the same as that in the autarky.

2.2.2 Asymmetric Equilibrium

In this part, we loosen the restriction so that labor unions could have different bargaining powers in the two countries. That is, $\mu_j \neq \mu_s$. In order to simplify the results of analyses, all other variables are the same as those in the previous part. The thresholds reduce to

$$\begin{aligned} \theta_j^d &= \left(\underline{\omega}_j\right)^{\frac{2}{\kappa+2}} \left\{ \frac{\left(2-\mu_j\right)^2 \left(2-\mu_s\right)^2 \left(1-\phi^2\right) \left(\theta^{\min}\right)^{\kappa} L}{\left[\left(2-\mu_s\right)^2 - \left(2-\mu_j\right)^2 \phi\right] 8\delta\left(\kappa+1\right)\left(\kappa+2\right) F_E} \right\}^{\frac{1}{\kappa+2}}, \\ \theta_j^x &= \phi^{-\frac{1}{\kappa}} \left(\underline{\omega}_j\right)^{\frac{2}{\kappa+2}} \left\{ \frac{\left(2-\mu_j\right)^2 \left(2-\mu_s\right)^2 \left(1-\phi^2\right) \left(\theta^{\min}\right)^{\kappa} L}{\left[\left(2-\mu_j\right)^2 - \left(2-\mu_s\right)^2 \phi\right] 8\delta\left(\kappa+1\right)\left(\kappa+2\right) F_E} \right\}^{\frac{1}{\kappa+2}}, \end{aligned} \tag{38}$$

and the number of entrants are

$$\begin{aligned} N_j^E &= \frac{4\delta\left(\kappa+1\right)}{\eta\left(2-\mu_j\right)\left(1-\phi^2\right)\left(\theta^{\min}\right)^{\kappa} \underline{\omega}} \left[\left(\alpha\theta_j^d - \underline{\omega}\right)\left(\theta_j^d\right)^{\kappa} - \phi\left(\alpha\theta_s^d - \underline{\omega}\right)\left(\theta_s^d\right)^{\kappa}\right], \\ N_s^E &= \frac{4\delta\left(\kappa+1\right)}{\eta\left(2-\mu_s\right)\left(1-\phi^2\right)\left(\theta^{\min}\right)^{\kappa} \underline{\omega}} \left[\left(\alpha\theta_s^d - \underline{\omega}\right)\left(\theta_s^d\right)^{\kappa} - \phi\left(\alpha\theta_j^d - \underline{\omega}\right)\left(\theta_j^d\right)^{\kappa}\right]. \end{aligned} \tag{39}$$

The number of domestic surviving firms is

$$N_{jj} = \frac{4\delta\left(\kappa+1\right)}{\eta\left(2-\mu_j\right)\left(1-\phi^2\right)\underline{\omega}}\left[\left(\alpha\theta_j^d-\underline{\omega}\right)-\rho\left(\alpha\theta_s^d-\underline{\omega}\right)\left(\frac{\theta_s^d}{\theta_j^d}\right)^{\kappa}\right]. \tag{40}$$

given $\kappa > 2$.

Proposition 3 *In the asymmetric bargaining power setting,*

(1) when both trade openness ϕ and the bargaining power μ_j are small enough, then the number of employed labors $N_{jj}\bar{l}_{jj}$ increases in bargaining power μ_j;

(2) when trade openness ϕ is large enough, the number of firms N_{jj} decreases and the average number of employed $\bar{l}_{jj}$ increases in bargaining power μ_j.

Proof. (1) When $\phi \to 0$, the scenario reduces to the autarky case, hence proposition 3.1 is immediately applicable.

(2) Define

$$\widetilde{\phi} \equiv \frac{\kappa}{\kappa+2}\frac{\left(2-\mu_s\right)^2}{\left(2-\mu_j\right)^2},$$

When $\phi > \widetilde{\phi}$, we get

$$\frac{\partial \bar{l}_{jj}}{\partial \mu_j} > 0 \text{ and } \frac{\partial N_{jj}}{\partial \mu_j} < 0.$$

When the bargaining power μ_j increases, the number of labors hired in the exporting department decreases. If the trade openness ϕ is large enough, the average number of labors hired in the domestic department increases while the number of firms decreases. The change of unemployment rate is undetermined, thus we plot several figures to illustrate the results[10].

[10] $\mu_s = 0.4$, $\kappa = 2.5$, $\omega = 0.45$, $L_j = 200$, $L_s = 200$, $\alpha = 1$, $\eta = 6$, $\delta = 0.2$, $F_E = 1$, $\theta^{\min} = 1$. Parameter values follow Montagna and Nocco (2013) except for $\kappa = 2$. As for Behrens and Robert-Nicoud (2013), $\kappa = 2.3$. Chen and Peng (2017) use Luttmer (2007) to derive for $\kappa = 3.18$. Considering this different estimations, we use $\kappa = 2.5$. See Head and Mayer (2014) for more details about estimation of κ.

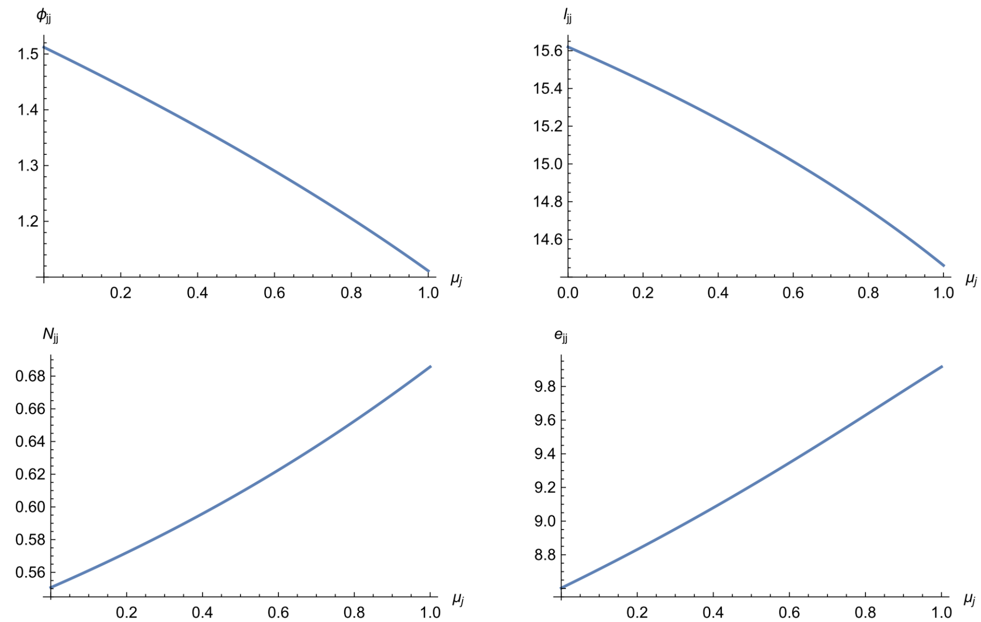

Figure 3: Autarky ($\rho = 0$)

When $\phi = 0$, an increase in bargaining power μ_j decreases the domestic production threshold θ_j^d and the average labor demand $\bar{l}_{jj}$. By proposition 3.2, we can calculate the lower threshold of bargaining power as $\mu_o^a = 1.72 > \mu_j \in (0, 1)$, so the number of firms N_{jj} increases and the total employment $e_j = N_{jj}\bar{l}_{jj}$ increases for all μ_j in this scenario.

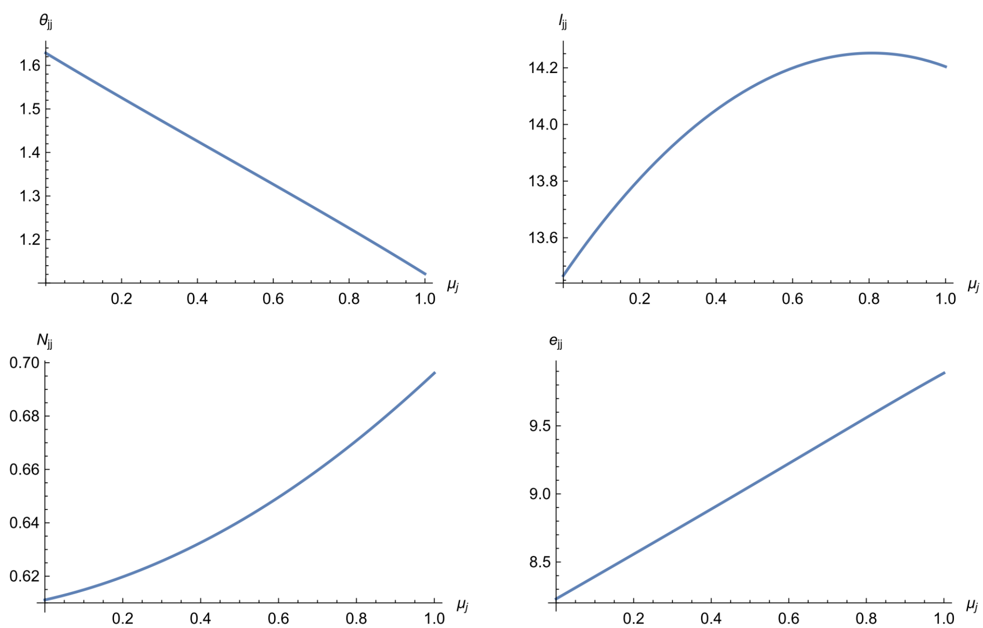

Figure 4: Low level of openness ($\rho = 0.2$)

When $\phi = 0.2$, an increase in bargaining power μ_j decreases the domestic production threshold θ_j^d and the average labor demand $\bar{l}_{jj}$ is bell shape. The number of firms N_{jj} decreases, but the total employment $e_j = N_{jj}\bar{l}_{jj}$ still increases.

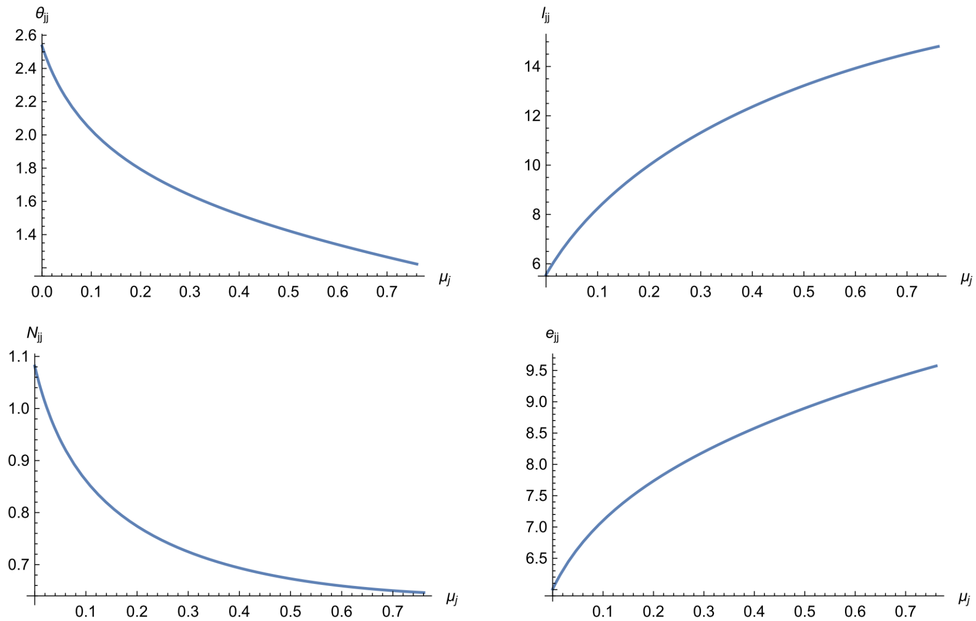

Figure 5: High level of openness ($\rho = 0.6$)

When $\phi = 0.6$, an increase in bargaining power μ_j decreases the domestic production threshold θ_j^d and increases average labor demand $\bar{l}_{jj}$. The number of firms N_{jj} decreases, but the total labors employed $e_j = N_{jj}\bar{l}_{jj}$ increases.

3 Conclusion

In this research, we construct a unionization heterogeneous firm model to investigate the effects of union bargaining power and homogeneous sector reform on unemployment. We find that when the bargaining power is small enough, an increase in the bargaining power could decrease the amount of unemployment in autarky. Although the average labor demand decreases, the rise in bargaining power generates the competition-soften effects, leaving room for the less efficient firms, raising the number of firms. Hence, the total number of labors employed in the manufacturing sector still increases. However, the effects of homogeneous sector reform are ambiguous, because it increases the expected wage and matching rate in the homogeneous sector, but decreases the number of employed labors in the manufacturing decreases. In other words, the total effects are undetermined. When trade is considered, firms deciding to export have two distinct profit centers—domestic and exporting departments. Labors in each department bargain wages with the heads of profit centers and earn different wages because the variable price elasticity and labor demand elasticity faced by two departments are differernt. The average labor demand in the exporting department and the number of surviving firms are negatively related to the union bargaining power, while the employment in the domestic department depends on the magnitude of trade openness and bargaining power. Thus, the effects of bargaining power on the total amount of unemployment are ambiguous. We use simulation to demonstrate the results.

There are still many aspects we can study further, for example, taking heterogeneous labors into account and measuring the welfare gaps between and within different labor groups. Besides, we can consider the unemployment premiums or the minimum wages, and investigate how those policies influence welfare and equilibrium unemployment rates. And what is more, other production factors such as capital should be considered. The growing capital rent to labor wage ratio also draws a great amount of attention.

4 Appendix

Welfare W could be evaluated by the average indirect utility as

$$W = \frac{1}{2}\left(\eta + \frac{\delta}{N}\right)^{-1}(\alpha - \overline{p})^2 + \frac{1}{2}\frac{N}{\delta}\sigma_p^2 + \overline{I},$$

where

$$\begin{aligned} \sigma_p^2 &= \frac{(2-\mu)^2\kappa}{16(\kappa+1)^2(\kappa+2)}\left(\frac{\underline{\omega}}{\theta^d}\right)^2, \\ \overline{I} &= \frac{\overline{VC}N + \underline{\omega}\left(L - N\bar{l}\right)}{L}. \end{aligned}$$

Autarky variable cost $\overline{VC}$ is the average wage paid by a firm defined as equation (17). Insert $\overline{p}$, N from (16) and (18), the welfare becomes

$$\begin{aligned} W &= \frac{1}{2}\left(\eta+\frac{\delta}{N}\right)^{-1}(\alpha-\overline{p})^2+\frac{1}{2}\frac{N}{\delta}\sigma_p^2+\overline{I}, \\ &= \frac{\left(\alpha\theta^d-\underline{\omega}\right)}{4\eta\left(\theta^d\right)^2}\left[2\alpha\theta^d-\frac{2\kappa+\mu+2}{(\kappa+2)}\underline{\omega}\right]+\frac{(2-\mu)\,\kappa\left(\alpha\theta^d-\underline{\omega}\right)}{8\eta\,(\kappa+1)\,(\kappa+2)\,\underline{\omega}}\left(\frac{\underline{\omega}}{\theta^d}\right)^2. \end{aligned}$$

When the bargaining power μ increases, the first part of the welfare decreases, and if μ is small enough, the number of firm increases and consequently the welfare may increase.

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