Searching, Matching, And Unemployment Compensation In Search Equilibrium

Chuhwan Park (E-mail: parkch@etri.re.kr), ETRI Technology Valuation Center

Abstract

In search equilibrium model, this paper demonstrates and characterizes the properties of steady state equilibrium of wage, unemployment compensation, entry fee, and taxes. Our research is based on the behavior of a job seeking, unemployed worker with the probability of contact rate of both sides, which may affect the entry of unfilled vacancies and the level of unemployment (U). The steady-state shows that a reduction in the severity of search friction, $m_0 \uparrow$, raises the equilibrium values of the probability of contact rates(μ^* and η^*) and lower the level of unemployment (U) and the number of vacancies(V). An increase in either in the level of output, Y, or decrease in unemployment compensation, entry fee, and tax rate, increase in the number of unfilled vacancies, V^*, makes it easier for workers to find jobs (μ^* rises and U falls) and more difficult for vacancies to find workers(η^* falls).

1.0 Introduction

*I*n the labor market literature, many studies have shown some relationship between unemployment and other economic variables. The economics of unemployment compensation (UC) has especially attracted considerable attention over the past couple of decades. However, the research has primarily been concerned with positive analysis, such as the effects of UC benefits on the duration of unemployment. These examples of UC stem from Bally (1978), Flemming (1978), Shavell and Weiss (1979). They analyzed the problem of UC design in an optimal taxation framework; more generous benefits caused lower search intensity and, subsequently, resulted in longer spells of unemployment. In particular, Shavell and Weiss (1979) focused on the optimal sequencing of benefits, based on a model of the behavior of individual seeking employment. They suggested that the benefits should decline over a spell of unemployment, provided that the unemployed can influence their job-finding probabilities.

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Recently, a number of papers extended the analysis of Shavell and Weiss (1979). Hopenhayn and Nicolini (1997) enlarged the set of policy instruments by considering a wage tax after reemployment in conjunction with the sequence of benefit payments. According to their analysis, while benefits should decrease throughout the unemployment spell, tax at reemployment should increase with the length of the spell. Wang and Williamson (1996) added another source of moral hazards by examining an environment where a worker's employment status depends on this choice of effort. The transition rate from unemployment to employment increased the search effort; analogously, the probability of remaining employed increased the work effort.

Another strand of the recent literature by Davidson and Woodbury (1997) examined whether benefits should be paid indefinitely or for a fixed number of weeks. The analysis was cast in a search and matching framework, albeit with a fixed number of jobs and exogenous wages. They concluded that the optimal UC program should offer risk-averse workers indefinite benefit payments, a conclusion that seemed to suggest that most existing UC programs with finite benefit periods were suboptimal.

Some contributions have addressed the issue of the consequences of the time profile of unemployment benefits in a general equilibrium set up with endogenous wages. Cahuc and Lehmann (1997) and Hansen and Jacobsen (1998) investigated this issue with a model that ignored gob search but allowed for endogenous wages through union-firm bargaining. Cahuc and Lehmann found that a constant time sequence yields a lower unemployment rate than a program with a declining time profile; reason being that a decreasing benefit schedule increases the welfare of the short-term unemployed at the expense of the long-term unemployed, and, in effect increased wage pressure. The idea that a program with a flat sequence of unemployment benefits is desirable has been challenged by Fredriksson and Holmlund (1998) in a search and matching model[1] with both endogenous wage and search effort. The key result is a socially optimal unemployment insurance policy implied a decreased profile of unemployment benefits over the spell of unemployment.

In this paper, we attempt to clarify two things: 1) Show and characterize the properties of steady-state equilibrium with respect to unemployment compensation, entry fee, and the tax rate, given in this model, in the search equilibrium model[2]. This search equilibrium model rectifies the free entry assumption by using the matching and bargaining framework promulgated in the seminal contributions of Diamond (1982a, 1982b, 1984), Mortensen (1982), and Pissarides (1984, 1985, 1987). 2) Analyze the

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[1] Park(2001) looks at the relation between migration and labor market parameters in search equilibrium model upon which steady-state analysis can be based.
[2] There is an existing literature of search-theoretic models in urban labor settings. See for instance, Helsley and Strange (1990) and Abdel-Rahman and Wang (1995) utilize positive matching externalities to generate agglomerative economics.

comparative statistics on the flow probability of contact rates, μ, η with respect to other given parameters, such as output, unemployment compensation, entry cost, and tax rate for workers. We present a theoretical equilibrium model of search and matching, with a stochastic matching functions and the transitional flow contact rate attributed to workers in the urban sector. This process is endogenously determined.

This paper is different from the Fredriksson and Holmlund (1998) by endogenouzing the instantaneous contact rates and assuming exogenous unemployment compensation and tax rate for the workers. That is, the mechanics of this paper is based on searching worker's behavior affecting the probability of contact rate of both sides, which in turn affect the entry of unfilled vacancies. This, in turn, affects the level of unemployment (U) and vacancies (V). The basic theoretical model in this paper is based on Park (2001).

This paper is organized as follows: Section 2 presents the economic environment and economic activity. Section 3 analyzes the asset value and wage determination by the explicit matching technology function whereas the steady-state analysis is presented in section 4. Section 5 characterizes comparative properties of steady state. Lastly, Section 6 is devoted to the articulation of preliminary conclusion.

2.0 The Basic Environment and Economic Activity

We consider one sector in a closed economy. Time is continuous. Each worker discounts the future at the rate,δ. Workers are endowed with a unit of labor, which they can supply to firms inelastically. Workers can search for vacancies in the urban sector without any search costs. There is a free entry of firms into the formal urban labor market, in the sense that any number of firms can enter (or exit) the market upon incurring the costs of acquiring the capital necessary for production.

Thus, in urban labor market firms with open vacancies, job-seeking workers are brought together at random points in time through a stochastic matching technology. Upon a successful match, the worker-firm pair negotiates a wage and production takes place. In order to analyze the role of the unemployment compensation in the urban labor market, we assume that the government imposes a tax to the employed workers and then subsidies the unemployment compensation to the unemployed.

Each firm has exactly one opening that can be filled by a single worker. The active mass of firms in the economy is V. There is free entry, in the sense that any number of firms can instantly

enter the labor market and search for workers, after paying a fixed entry fee, v_0, which is taken to be constant through time. In practice, the fixed entry fee reflects unit capital costs and setup costs. So, an improvement in the organization of financial markets that lowers finance costs or tax incentives geared toward promoting investment lowers the entry fee. For simplicity, we assume that vacancies are completely *durable* and that they are identical in every respect.

There is a continuum of agents whose mass is normalized to unity. We assume that the total workforce population in this economy is represented by:

$$N = E^C + U^C = 1 \tag{1}$$

where the total urban workforce consists of unemployed (U^C) and employed workers (E^C).

3.0 Job Search and Matching

Upon locating a successful match, each firm-worker pair produces a fixed stock of output, Y, which is the gross economic surplus that is to be shared between them. So, the total discounted value of accruing to the match between a worker and a vacancy (assuming there is no additional human capital accumulation after employment) equals Y.

Let U denotes the mass of searching workers, and V denotes the mass of vacancies. We denote the flow probability that a worker locates a vacancy with μ and inversely, a vacancy that locates a worker with η. Since a vacancy can be filled by exactly one worker, it is clear that steady-state matching in the primary labor market implies:

$$\mu U = \eta V \tag{2}$$

Although μ and η are determined in equilibrium, both workers and firms treat them as parametric when making their hiring decisions. In order to complete the description of the model, it is necessary to specify the matching technology, $m = m_0 X(U,V)$, which describes the instantaneous flow meeting rate between unfilled vacancies, V, and searching workers, U, and captures some matching externality. Such a stochastic matching function, $m_0 X(U,V)$ satisfies the following properties:

Assumption 1. The matching technology, $m = m_0 X(U,V)$, where $m_0 > 0$ and U and V are strictly increasing and concave and twice continuously differentiable, and exhibits constant - returns - to - scale function of U and V, satisfying the Inada ($\lim_{Z \to 0} m = \infty$ and $\lim_{Z \to \infty} m = 0$, $Z \in \{U,V\}$ and boundary conditions.

An increase in the number of participants on either side of the market increases the instantaneous number of matches, but a diminishing rate. The constant - returns - to - scale assumption is made for convenience. The Inada boundary conditions ensure an interior steady-state solution. The extent of the search frictions in the labor market is conveniently parameterized by $m_0 > 0$: An increase or an improvement in the communication and transportation infrastructure would increase the flow matching rate given the masses of workers (U) and vacancies (V). The properties of the matching function, $m_0 X(U,V)$, ensures a well-behaved, hyperbolic Beveridge curve in which the absence of either side of the matching parties would result in no matches. It is worth noting that both flow probabilities are to be endogenously determined in equilibrium. Nevertheless, both workers and firms treat them as parametric in the decision-making process.

3.1 The Asset Value

We are now prepared to specify the value function of workers and firms. The model I use stems from Park (2001), in which the model utilizes with the migration decision between rural and urban sector. In conjunction with Park's (2001) model, I assume that in the labor market, the worker and filled vacancies never be separated once employed for the convenience.

Let δJ_E denotes the present-discounted gross value of a worker employed by a firm; $\delta \Pi_F$ is the discounted value of income accruing from the match to vacancy; δJ_U denotes the expected discounted value to a worker who continues search in the labor market, and $\delta \Pi_V$ denotes the corresponding asset value of an unfilled vacancy.

Let w denotes the flow value of wage income and β is the birth or death rate, τ is the tax rate that government imposes to the employed in the urban sector, and b denotes the unemployment compensations (UC) for the unemployed in the urban labor sector. In this paper, we assume that b, unemployment compensation is a lump-sum benefit to the unemployed workers, and later we relax the assumption so as to have an optimal value of unemployment compensation (UC) for extension. We thus have the following asset values:

$$\delta J_E = (1-\tau)w = (1-\tau)W \tag{3}$$

$$\delta J_U = b + \mu[J_E - J_U] = [b + \mu(1-\tau)W]/(\delta+\mu) \tag{4}$$

$$\delta \Pi_F = (y - w) = Y - W \tag{5}$$

$$\delta \Pi_V = \eta[\Pi_F - \Pi_V] = \eta[Y-W]/(\delta+\eta) \tag{6}$$

Equation (3) implies that the expected discounted value of an employed worker equals the net flow value of wage income, $(1-\tau)w$. Equation (4) implies that the expected value of an unemployed worker equals the unemployment

compensation from the government plus the capital gain with the probability μ of finding a job. Equation (5) implies that the expected discounted value of a filled firm equals the net flow profit. Equation (6) implies that the expected discounted value of an unfilled firm equals the capital gain of finding a worker.

The Government Budget Constraint (GBC):

$$\tau wE^c = bU$$

(7)

Equation (7) implies the government budget constraint, implying that the amount of unemployment compensation is exactly coming from the tax revenue from the employed in the labor market

3.2 Determination of Wage

We now turn to the determination of the wage bargain in this steady-state setting. We assume that both firms and workers are risk neutral[3]. This simplifies the analysis. With risk neutrality, workers are interested in the expected present discounted value of wages; whereas firms focus on the expected present discounted value of profits. Formally, we need to make two assumptions about the wage bargain. First, we assume that the wage bargain is independent of the means by which worker and job have come together; that is, independent of whether the worker found the job or the job found the worker. Second, we assume that the bargain process is symmetric in the sense that the worker and job split evenly the surplus from their matching. With the assumption of risk neutrality and perfect capital markets, workers focus solely on these present discounted values and the surplus from finding a job, represented by $J_E - J_U$. Similarly, from the expected discounted values of income for filled jobs by $\Pi_F - \Pi_V$, we can express the assumed symmetry in the outcome of the negotiation process as:

Assumption 2(Symmetric Nash Bargain): The wage bargain follows a symmetric Nash rule:

$$J_E - J_U = \Pi_F - \Pi_V \geq 0 \tag{8}$$

In determining the unique wage offer function in the steady state equilibrium, we know that with the free entry equilibrium assumption, the expected value of vacancy is equal to constant capital costs, v_0, so that Π_V is exogenous in determining the unique wage offer function, that is, $\Pi_V = v_0$. Therefore, applying free entry equilibrium assumption, $\Pi_V = v_0$, we have the following stock asset values for unfilled vacancy in the steady state:

$$\Pi_V = \eta[Y-W] / (\delta+\eta) = \mathbf{v_0} \tag{9}$$

From the four value equations (3), (4),(5),(7), and the rule describing the outcome of the negotiation process, (8), we can solve the unique wage offer function, , given the other parameters.

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[3] For more detail, see Diamond (1984).

Proposition 1(*The Wage Offer Function with UC*): The unique wage offer function, W (Y,b,v_0, τ), determined in the Nash bargain between worker and vacancy, is given by:

$$W (Y,b,v_0, \tau) =[(\delta+\mu)(Y- v_0) +b] / [\delta (2-\tau)+ \mu] \tag{10}$$

and satisfies

$$\partial W /\partial Y >0; \partial W /\partial b >0; \partial W /\partial v_0 <0; \partial W /\partial\tau>0, \text{ and } \partial W /\partial\mu>0$$

<u>Proof. All proofs are in the Appendix.</u>

The properties of W(Y,b,v_0, τ) have intuitive implications. An increase in either Y,b enhances the size of the `pie' to be divided between both parties and thus the wage increases. Alternatively, an increase in the market value of unfilled vacancies, v_0, improves each firm's threat point and lowers the wage. Intuitively, an increase in employment tax, τ , from the employed leads to an increase in the wage offer function. However, the wage offer function after imposing tax rate, (1-τ), is decrease in τ . That is given by equation (11):

The Wage Function After Imposing Tax Rate:

$$(1-\tau)\mathbf{W(Y,b,v_0, \tau)}= (1-\tau)*[(\delta + \mu)(Y- v_0) +b] / [\delta (2-\tau)+ \mu]$$
(11)

Equation (11) provides the intuitive interpretation that as τ increases the wage after tax rate, (1-τ)W, decreases.

4.0 Steady-State Analysis

Definition 1. (Steady State Analysis): A steady-state equilibrium is a wage function W(Y,b,v_0, τ) and (μ^*, η^*, E^{*c} ,U^*, V^*) satisfying the following conditions:

(i) (Symmetric Nash Bargain):	$J_E - J_U = \Pi_F - \Pi_V \geq 0,$
(ii)(Government Budget Constraint):	$\tau w E^{*c} = b^* U^*$
(iii) (Unrestricted entry):	$\Pi_V = v_0,$
(v) (The steady-state):	$\mu^* U^* = \eta^* V^* = m_0 X(U^*,V^*),$ (12a)
	$\beta = \mu^* U^*$ (12b)

The intuition is as follows. First, condition (i) of the definition 1 ensures that wage W(Y,b,v_0, τ) is consistent with the equal division rule. Part (ii) shows the government Budget Constraint that specifies the source of unemployment compensation is coming from the employed in the urban labor market. Part (iii) reflects the assumption of free entry

into the labor market. Upon paying, v_0, firms can instantly enter the search market to recruit workers. We assume $\Pi_V > v_0$ for entry to be profitable. Part (v) of the definition provides necessary and sufficient conditions for constant populations of vacancies, V^*, and searching workers, U^*. Equation (12a) states that the instantaneous matching rate of vacancies and searching workers is determined by the matching technology, while (12b) indicates that the instantaneous outflow of workers from the unemployment pool, μU, must equal the inflow of the population, β of the urban sector.

The model possesses a convenient recursive structure, which can be utilized to prove the existence of equilibrium and its properties. First, the equilibrium wage can be determined from constant parameters, and the given v_0. Second, the equilibrium values of the matching rate μ^* and η^* can be determined from the unrestricted entry condition, and the steady-state conditions. Third, once μ^* and η^* are determined, U^* and V^* can be obtained.

4.1 The Free Entry Condition (The FE Locus)

Utilizing proposition 1 together with the definition of Π_V enables the unrestricted entry condition, $\Pi_V = v_0$, to be written as:

$$\Pi_V = \eta[Y-W] / (\delta+\eta) = v_0 \tag{13}$$

where $W(Y,b,v_0,\tau) = [(\delta+\mu)(Y-v_0)+b] / [\delta(2-\tau)+\mu]$. Equation (13) implicitly defines a function $\eta = \eta^{FE}(Y,b,v_0,\tau)$, which gives the value of η. We assume that, after paying the fixed entry fee, any number of vacancies can establish themselves and commence searching for unemployed workers. This implies that firms attain zero (ex ante) profits in steady-state equilibrium.

Lemma 1:(*The Free Entry condition*) The function $\eta = \eta^{FE}(\mu; Y,b,v_0,\tau)$ is linear in μ with a positive intercept and given by the following equation:

$$\eta^* = [\delta v_0(2-\tau)+\mu] / [\delta(1-\tau)(Y-v_0)-b] \tag{14}$$

and satisfies:

$$\partial\eta^{FE}/\partial\mu>0; \; \partial\eta^{FE}/\partial Y<0; \; \partial\eta^{FE}/\partial v_0>0; \; \partial\eta^{FE}/\partial\tau>0; \; \partial\eta^{FE}/\partial b>0$$

The lemma 1 states that an increase in the rate at which workers contact vacancies, μ, raises the wage(Proposition 1) and lowers profits(Y-W). This discourages entry and raises η. An increase in the output, Y, raises the value of employing a worker. This in turn, increases the expected return from a match, which stimulates the entry of vacancies and lowers η. An increase in either the entry fee, v_0, unemployment compensation, b, and tax rate, τ, makes entry less attractive which lowers the number of vacancies and consequently raises η.

4.2 Steady-State Matching (The SS Locus)

The constant-returns-to-scale property of matching technology (assumption 1) implies , $m = m_0 X(U/V,1)$, in conjunction with (12a) and the fact that $U/V = \eta/\mu$, yields $\eta = m_0 X(\eta/\mu,1)$, which implicitly defines the relationship $\eta = \eta^{SS}(\mu;m_0)$ along which $\grave{U}=\grave{V}=0$. Thus, the properties of the SS locus follow directly from assumption 1 and are summarized in lemma 2:

Lemma 2 (*The SS locus*). Under assumption 1, the function $\eta = \eta^{SS}(\mu;m_0)$ satisfies the following properties:

(i) $\partial\eta^{SS}/\partial\mu < 0$,

(ii) $\partial\eta^{SS}/\partial m_0 > 0$,

(iii) $\lim_{\mu \to 0}\partial\eta^{SS}/\partial\mu = -\infty$,

(iv) $\lim_{\mu \to 0}\partial\eta^{SS}/\partial\mu = 0$.

5.0 Steady State Equilibrium

By exploiting the properties of the steady state contact rate and unemployment it is straightforward to prove the existence of a steady-state equilibrium and to characterize its properties:

Proposition 2 (*Steady State Equilibrium*). Under assumption 1, a unique steady-state equilibrium exists, which provides the following properties:

(i)Matching rate:

(a) $d\mu^*/d\,m_0 > 0; d\mu^*/dY > 0; d\mu^*/db < 0; d\mu^*/dv_0 < 0; d\mu^*/d\tau < 0$

(b) $d\eta^*/d\,m_0 > 0; d\eta^*/dY < 0; d\eta^*/db > 0;. d\eta^*/dv_0 > 0; d\eta^*/d\tau > 0$

(ii)Steady state population of unemployment (U*) and vacancy (V*):

(a) $dU^*/d\,m_0 < 0; dU^*/dY < 0; dU^*/db > 0; dU^*/dv_0 > 0; dU^*/d\tau > 0$.

(b) $dV^*/d\,m_0 < 0; dV^*/dY > 0; dV^*/db < 0; dV^*/dv_0 < 0; dV^*/d\tau > 0$.

(iii)Wage offers:

(a) $dW^*/d\,m_0 > 0; dW^*/dY > 0; dW^*/db > 0; dW^*/dv_0 < 0; dW^*/d\tau > 0$.

With this proposition, we have a steady state equilibrium with unemployment compensation, which is given by the combination of the free entry locus (FE) and the steady state matching locus (SS).

From lemma 1 the FE locus begins at a positive finite value of η_0 and is linearly monotone increasing in the matching rate, μ. The SS locus begins at infinity and approaches zero asymptotically as μ approaches infinity. Since both functions are continuous, there must exist a unique point at which the two loci cross(depicted by E in Figure 1), which determines μ^* and η^*.

Figure 1: Steady state and comparative statics of the equilibrium (m_0, $Y\uparrow$)
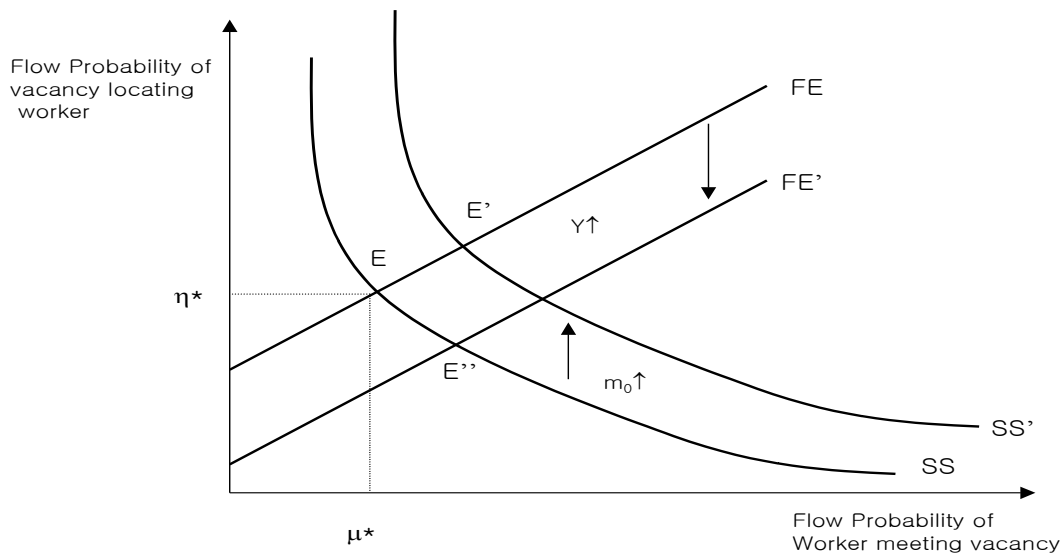
We now turn to the analysis of the comparative static result of these two locus with respect to m_0, Y, b, v_0, and τ. The following shows the properties of the steady state equilibrium when any of these variables change.

Case 1: A reduction in the severity of search friction ($m_0\uparrow$):
 An increase in m0, implying a reduction in the severity of search friction, shifts the SS curve to the right to SS'. This raises the equilibrium values of both μ^* and η^* and shifts the economy from E to E'. The increase in μ^* and η^* lower the level of unemployment and the number of vacancies.
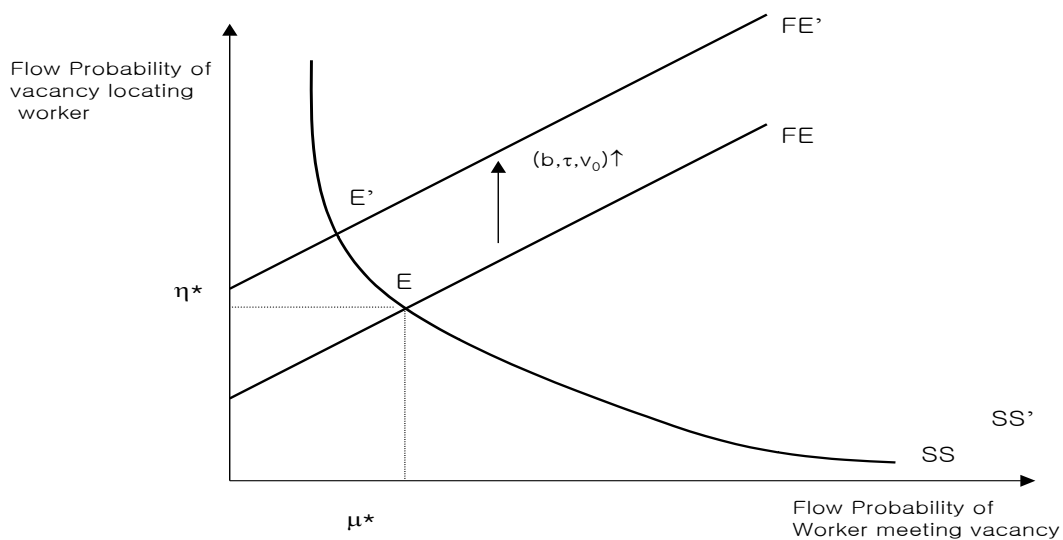
Case 2: An Increase in the output ($Y\uparrow$):
The output increases, shifts the FE curve to the right to FE' by encouraging the entry of new firms (lemma 1). The resulting increase in the number of unfilled vacancies, V*, makes it easier for workers to find jobs(μ^* rises and U falls) and more difficult for vacancies to find workers(η^* falls) and the equilibrium moves from point E to point E".

Case 3: An increase in b, v_0, τ ($b, v_0, \tau\uparrow$)

An increase in unemployment compensation, entry fee, and tax rate shifts the FE locus to the left or up to FE' by decreasing the entry of new firms. The resulting decrease in the number of unfilled vacancies, V*, makes it difficult for workers to find jobs(μ* falls and U rises) and more easy for vacancies to find workers (η* rises) and the equilibrium moves from the point E to point E' in the Figure 2.

Figure 2: Steady state and comparative statics of the equilibrium ($b, v_0, \tau\uparrow$)

6.0 Conclusions

In this paper, the use of the search and bargaining framework allows explicit analysis of the interaction between workers and firms. We characterized the division of the surplus between vacancies and workers. This paper also shows that in the steady state, a reduction in the severity of search friction, $m_0\uparrow$, raises the equilibrium values of both μ*and η* and lowers the level of unemployment (U) and the number of vacancies(V). An increase in either in the level of output, Y, or decrease in unemployment compensation, entry fee, and tax rate, shifts the FE curve to the right to FE' by encouraging the entry of new firms (lemma 1). The resulting increase in the number of unfilled vacancies, V*, makes it easier for workers to find jobs(μ* rises and U falls) and more difficult for vacancies to find workers(η* falls).

The mechanics of this paper is based on searching worker's behavior. The searching behavior affects the probability of contact rate of both sides, which in turn affect the entry of unfilled

vacancies. Subsequently, this affects the level of unemployment (U) and vacancies (V). In this respect, we believe that this paper has some implications of the government's unemployment compensation policy, suggesting that the social development of infrastructure with decrease in the worker's search friction in the labor market should be in advance of implementing unemployment compensation policy to the unemployed workers so as to decrease the level of unemployment in the labor market.

I certainly believe that my model could be extended in a number of ways including the worker's experience and knowledge, considering the endogenous unemployment compensation and optimal tax rate in the search model. 📖

Appendix

Proof of Proposition 1 (The wage offer function).

Substituting equations (3)(4)(5),(7) in (8) yields the wage function:

: $W(Y,b,v_0,\tau) = [(\delta + \mu)(Y - v_0) + b] / [\delta(2-\tau) + \mu]$. Differentiation yields the reported comparative static results.

Proof of Proposition 2 (Steady state equilibrium).

(i)   Matching rates: The equilibrium is characterized by a pair(μ^*, η^*)

$$\eta^* - \eta^{FE}(\mu; Y,b,v_0,\tau) = 0 - (1)$$

$$\eta^* - \eta^{SS}(\mu; m_0) = 0 - (2)$$

Total differentiation of (1) and (2) in conjunction with lemma 1 and 2, yield the results reported.

(ii)   Steady-state population of searching workers (U*) and vacancies (V*).

(a) The steady state level of unemployment is $U^* = \beta/\mu^*$. Hence, sign $(dU^*/d\lambda) = -\text{sign}(d\mu^*/d\lambda)$, where $\lambda = m_0, Y, b, v_0, \tau$.

(b) The steady state level of vacancies is $V^* = \beta/\eta^*$. Hence, sign $(dV^*/d\lambda) = -\text{sign}(d\eta^*/d\lambda)$

(iii)   Wage offers: Totally differentiating the wage offer function gives the reported results.

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Notes