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Abstract

In a search and matching model with right-to-manage bargaining, matched workers and firms bargain over wages, given labor demand schedule of firms for hours worked per worker. Wages and hours worked per worker are determined as if they are determined in a competitive labor market with a distortion to wage markups. A positive inefficiency gap in the labor market diminishes workers' effective bargaining power relative to firms, because firms can adjust labor input and wage schedule via intensive margin. The Hosios condition does not necessarily hold even when workers' actual bargaining power is equal to unemployment elasticity of matches.

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1 INTRODUCTION

In the standard labor market search model based on efficient Nash bargaining, workers and firms bargain over both wages and hours worked per worker. Hosios (1990) showed that if workers' bargaining power is equal to unemployment elasticity of matches, the allocation in a decentralized economy is efficient. The marginal product of labor is equal to the marginal rate of substitution at an efficient level of hours worked per worker (intensive margin) as in the social planner's problem, and wage contracts with a particular share of surplus assures that wages are also at an efficient level. Thus the number of jobs (extensive margin) is also at an efficient level. In contrast, in recently investigations of right-to-manage bargaining, in which matched workers and firms bargain over wages, given labor demand schedule of firms for hours worked per worker, the properties of the model in terms of inefficiencies in the labor market have not been studied.[1]

In this note, I describe properties of the labor market search model with the right-to-manage bargaining, as well as the implied inefficiencies in the labor market. The most distinct feature I found is that wages and hours worked per worker are determined as if they are determined by demand and supply in a competitive labor market with a distortion to wage markups. A positive inefficiency gap (Galí, Gertler, and Lopez-Salido, 2007) in the labor market diminishes workers' effective bargaining power relative to firms because firms can adjust labor input and wage schedule via intensive margin. The Hosios condition does not necessarily hold even when workers' actual bargaining power is equal to unemployment elasticity of matches. Workers' bargaining power and wage markups are closely related to each other through inefficiencies in the labor market.

In the next section, I present the model. Section 3 shows the results in steady state. Section 4 concludes.

2 MODEL

Time is discrete and infinite, $t = 0, 1, 2, ..., \infty$. There is an infinite mass of workers and firms. Firms post vacancies to workers seeking jobs. Wages and hours worked per worker are de-

[1] The original contributions are found in Nickell and Andrews (1983) and Trigari (2006). Christoffel and Kuester (2008) and Christoffel and Linzert (2010) studied inflation dynamics of a version of the model with sticky price and monopolistic competition. Christoffel and Kuester (2009) also examined the elasticity of unemployment with respect to firms' benefits in the model.

termined via right-to-manage bargaining (Nickell and Andrews, 1983; Trigari, 2006), in which matched worker and firm bargain over wages, given labor's demand schedule of firms. The timing of events is as follows:

1. $1 - n_{t-1}$ is the measure of unemployed workers at the end of last period. A fraction of the employed workers ρn_{t-1} are exogenously separated:

$$u_t = 1 - n_{t-1} + \rho n_{t-1}. \tag{1}$$

   u_t workers seek jobs in this period.

2. Firms post vacancies v_t to match the unemployed workers u_t by matching function $m(u_t, v_t)$, which exhibits constant returns to scale. The labor market tightness is given by

$$\theta_t = v_t / u_t. \tag{2}$$

   Each worker and firm is as small as such the labor market tightness at the aggregate level is given for them. The job finding rate for workers $s(\theta_t) = m(u_t, v_t)/u_t = m(1, \theta_t)$ and the job filling rate for firms $q(\theta_t) = m(u_t, v_t)/v_t = m(\theta_t^{-1}, 1)$ are also given for them.

3. The number of the newly employed workers is given by

$$n_t = (1 - \rho)n_{t-1} + m(u_t, v_t). \tag{3}$$

   Note that the newly employed workers can work immediately.

4. The employed workers enter into production

$$y_t = f(h_t)n_t. \tag{4}$$

   Each worker works h_t hours and produces $f(h_t)$ which is decreasing returns to scale in terms of hours worked per worker so that firms earn a positive profit period-by-period. Total production is linear in n_t.

Matching values for workers and firms are given by

$$S_t = w_t h_t - g(h_t)/p_t - b + \beta(1-\rho)(1 - s(\theta_{t+1}))\frac{p_{t+1}}{p_t}S_{t+1}, \tag{5}$$

$$J_t = f(h_t) - w_t h_t + \beta(1-\rho)\frac{p_{t+1}}{p_t}J_{t+1}, \tag{6}$$

where S_t is the matching value for a marginal worker in terms of utility and J_t is the matching value for a marginal job. Each Worker earns wage bill $w_t h_t$. A worker also has disutility of labor $g(h_t)/p_t$ and forgone unemployed benefits b. $1 - \rho(1 - s(\theta_{t+1}))$ employed workers continue to match with firms in the next period, and $s(\theta_{t+1})$ unemployed workers find a job in the next period, thus their difference is used as transition probability of net value of employment.[2] Each firm produces $f(h_t)$ and pays wage bill $w_t h_t$. ρ jobs are exogenously separated in the next period. $p_t = c_t^{-1}$ is the price in terms of numeraire (log utility of household consumption is assumed). Free entry is assumed, i.e.,

$$J_t = \frac{c_v}{q(\theta_t)}. \tag{7}$$

The value of a job is equal to the vacancy posting cost c_v times expected vacancy duration $1/q(\theta_t)$.

Right-to-manage bargaining In right-to-manage bargaining, firms have control over hours worked per worker, and maximize the matching value for firms, i.e. $\partial J_t/\partial h_t = f'(h_t) - w_t = 0$. This condition can be solved for hours worked per worker, $h_t = f'^{-1}(w_t) \equiv h(w_t)$. Given this labor demand schedule, workers and firms bargain over wages period-by-period so as to maximize joint surplus $S_t^{\eta} J_t^{1-\eta}$, where $\eta \in [0,1]$ is workers' actual bargaining power. The first-order necessary condition with respect to the wage is given by

$$\eta\frac{\partial S_t}{\partial w_t}J_t + (1-\eta)\frac{\partial J_t}{\partial w_t}S_t = 0,$$

$$\Leftrightarrow \quad \delta_t \equiv -(\partial S_t/\partial w_t)/(\partial J_t/\partial w_t) = [(1-\eta)/\eta]S_t/J_t,$$

[2]The matching value for workers is decomposed into $S_t \equiv W_t - U_t$ where $W_t = w_t h_t + \beta(p_{t+1}/p_t)[(1-\rho(1-s_{t+1}))W_{t+1} + \rho(1-s_{t+1})U_{t+1}]$ and $U_t = g(h_t)/p_t + b + \beta(p_{t+1}/p_t)[s_{t+1}W_{t+1} + (1-s_{t+1})U_{t+1}]$. Employed workers obtain wage bill $w_t h_t$, and remain in their job in the next period with probability $1-\rho(1-s_{t+1})$. Unemployed workers have foregone labor disutility and unemployment benefits $g(h_t)/p_t + b$, and find a job in the next period with probability s_{t+1}.

where $\delta_t = -(\partial S_t/\partial w_t)/(\partial J_t/\partial w_t) = 1-\varepsilon_w(g'(h_t)c_t/w_t - 1)$ is the wedge between the marginal values of matching and $\varepsilon_w = -h'(w_t)w_t/h(w_t) > 1$ is elasticity of labor demand.[3] By solving δ_t for w_t, I have the following labor market conditions:

$$w_t = f'(h_t), \tag{8}$$

$$w_t = [\varepsilon_w/(\varepsilon_w - 1 + \delta_t)]g'(h_t)c_t, \tag{9}$$

where firms' labor demand schedule is given by (8). Also, through wage contracts between workers and firms, workers' labor supply schedule is given by (9). Wages and hours worked per worker are determined as if they are determined in a competitive labor market with a distortion to wage markups. However, the wage markups are determined endogenously here depending on the matching values of workers and firms; $\sigma_t = \varepsilon_w/(\varepsilon_w - 1 + \delta_t)$ and $\delta_t = -(\partial S_t/\partial w_t)/(\partial J_t/\partial w_t) = [(1-\eta)/\eta]S_t/J_t$.[4]

Finally, a general equilibrium is defined by equations (1)-(9).

Reservation wage bills are derived from $S_t \geq 0$ and $J_t \geq 0$

$$\underline{\omega}_t = g(h_t)/p_t + b - \beta(1-\rho)(1-s(\theta_{t+1}))\frac{p_{t+1}}{p_t}S_{t+1}, \tag{10}$$

$$\overline{\omega}_t = f(h_t) + \beta(1-\rho)\frac{p_{t+1}}{p_t}J_{t+1}. \tag{11}$$

As long as the wage bill is in the set $[\underline{\omega}_t, \overline{\omega}_t]$, the continuity of matching is satisfied. Then, the wage equation is derived from equations (8)-(11):

$$w_t h_t = \chi_t \overline{\omega}_t + (1-\chi_t)\underline{\omega}_t,$$

where $\chi_t = \eta\delta_t/(1-\eta+\eta\delta_t)$ is workers' effective bargaining power.

[3] This is closely related to the labor wedge between marginal product of labor and marginal rate of substitution at individual level. If $\delta_t = 1$, $w_t/[g'(h_t)c_t] = f'(h_t)/[g'(h_t)c_t] \equiv mpl_t/mrs_t = 1$ also holds. In contrast, in the efficient Nash bargaining, in which workers and firms bargain both wages and hours worked per worker, $\delta_t = 1 \forall t$ holds and no labor wedge exists at individual level.

[4] Note that even if S_t/J_t is small, $(1-\eta)/\eta$ and $\delta_t = -(\partial S_t/\partial w_t)/(\partial J_t/\partial w_t) = [(1-\eta)/\eta]S_t/J_t$ can be large. S_t/J_t is concave in w_t; therefore when S_t/J_t is small, $\partial S_t/\partial w_t$ is large relative to $\partial J_t/\partial w_t$ and δ_t is large. See also the numerical example in section 3.

Efficiency The social planner's problem is given by

$$\max \sum_{t=0}^{\infty} \beta^t \left(\log c_t - g(h_t)(1-n_t)\right),$$
$$\text{s.t.} \quad c_t + c_v v_t \leq f(h_t)n_t + b(1-n_t),$$
$$n_t = (1-\rho)n_{t-1} + m(u_t, v_t),$$

where $u_t = 1 - n_{t-1} + \rho n_{t-1}$. First-order necessary conditions are

$$\frac{c_v}{m_{vt}} = f(h_t) + g(h_t)c_t - b + \beta(1-\rho)(1-m_{ut+1})\frac{c_t}{c_{t+1}}\frac{c_v}{m_{vt+1}},$$
$$f'(h_t) = g'(h_t)c_t.$$

On the other hand, the implementability conditions in the decentralized economy are derived from (5)-(9):

$$\frac{1}{1-\chi_t}\frac{c_v}{q(\theta_t)} = f(h_t) + g(h_t)/p_t - b$$
$$+\beta(1-\rho)[1-\chi_{t+1}s(\theta_{t+1})]\frac{p_{t+1}}{p_t}\frac{1}{1-\chi_{t+1}}\frac{c_v}{q(\theta_{t+1})},$$
$$f'(h_t) = \sigma_t g'(h_t)c_t$$

Under the assumption of constant returns to scale matching function $m(u_t, v_t) = m u_t^{\xi} v_t^{1-\xi}$, $m_{ut} = \xi m_t/u_t$ and $m_{vt} = (1-\xi)m_t/v_t$ hold. Then I have a *modified* Hosios condition: $\xi = \eta = \chi_t$. Hosios (1990) showed that if workers' bargaining power is equal to unemployment elasticity of matches, the allocation in the decentralized economy as described above is at efficient level as in the social planner's problem. However, the standard Hosios condition does not necessarily hold; in general, $\eta \neq \chi$ and $\delta \neq 1$ hold even in steady state. I will demonstrate it in section 3 too.

The role of workers' bargaining power In the right-to-manage bargaining, the workers' bargaining power is diminished because firms have control over hours worked per worker. Still, the workers' bargaining power plays an important role in the labor market. When the workers' actual bargaining power η is low, wages are lower than the marginal rate of substitution $w_t = mpl_t < mrs_t$, and the marginal gain for workers by increase in wages is higher than the marginal loss for firms, i.e. $\partial S_t/\partial w_t = h_t - h'(w_t)(mrs_t - w_t) > h_t = -\partial J_t/\partial w_t$.[5] Thus δ_t is high and σ_t is low. On the contrary, when the workers' bargaining power is high, $w_t = mpl_t > mrs_t$ and $\partial S_t/\partial w_t < h_t = \partial J_t/\partial w_t$ hold, and δ_t is low and σ_t is high. As $\eta \to 1$, the slope of the supply curve σ_t becomes steeper and δ_t approaches to zero.[6]

Put differently, the wage markup σ_t and the wedge between the marginal values of matching $\delta_t = -(\partial S_t/\partial w_t)/(\partial J_t/\partial w_t) > 0$ have an one-to-one correspondence:

$$\sigma_t = \varepsilon_w/(\varepsilon_w - 1 + \delta_t) \begin{cases} > 1 & \text{if } \delta_t \in (0,1), \\ = 1 & \text{if } \delta_t = 1, \\ < 1 & \text{if } \delta_t \in (1,\infty). \end{cases}$$

Figure 1 graphically shows how wages and hours worked per worker (w, h) are determined. In the efficient Nash bargaining, hours worked per worker is at an efficient level $h = h^{\text{EB}} = h^*$. Wages are determined independently at $w = w^{\text{EB}}$, and if the workers' bargaining power is equal to unemployment elasticity of matches, wages are also efficient at the point E_0 in figure 1, (w^*, h^*). On the other hand, in right-to-manage bargaining, given labor demand schedule of firms, the bargaining process between workers and firms determines the labor supply schedule, which shifts with a varying wage markup σ_t. The equilibrium is the intersection of demand and supply at the point E_1 in figure 1, $(w^{\text{RTM}}, h^{\text{RTM}})$. When η is high, there is a positive inefficiency gap in the labor market (Galí, Gertler, and Lopez-Salido, 2007), and a positive wage markup. When η is low, there is a negative inefficiency gap, which leads to a negative wage markup.

Also, the workers' effective bargaining power χ_t is given as a function of δ_t:

$$\chi_t = \eta\delta_t/(1 - \eta + \eta\delta_t) \begin{cases} < \eta & \text{if } \delta_t \in (0,1), \\ = \eta & \text{if } \delta_t = 1, \\ > \eta & \text{if } \delta_t \in (1,\infty). \end{cases}$$

When η is high (low), a positive (negative) inefficiency gap implies that the effective bargaining power χ_t is lower (higher) than the actual bargaining power η, because firms have control over

[5] In the standard efficient bargaining, $\partial S_t/\partial w_t = -\partial J_t/\partial w_t = h_t$ holds, and marginal gain and loss by increase in wages are always the same for workers and firms.

[6] Note that when $\eta = 1$, $\partial S_t/\partial w_t = h_t + w_t h'(w_t) - mrs_t h'(w_t) = 0 \Leftrightarrow w_t = [\varepsilon_w/(\varepsilon_w - 1)]mrs_t$ holds.

hours worked per worker and firms can affect on the outcome of bargaining by adjusting labor demand via intensive margin. Thus, because of inefficiencies in the labor market, the Hosios condition does not necessarily hold.

[Figure 1 is inserted here]

3 NUMERICAL EXAMPLE IN STEADY STATE

To further investigate the steady state relationship, functional forms are assumed as follows: $m(u_t, v_t) = m u_t^{\xi} v_t^{1-\xi}$, $f(h_t) = h_t^{\alpha}$, and $g(h_t) = \kappa h_t^{1+\phi}/(1+\phi)$. Unemployment benefits are proportional to wage bill, $b = b_w wh$. By solving S and J for the underlying parameters, δ and χ can be written as a function of the workers' actual bargaining power $\eta \in [0,1]$:

$$\begin{aligned}
\delta(\eta) &= \frac{(1-\eta)A}{\eta B + (1-\eta)C}, \\
\chi(\eta) &= \frac{\eta A}{\eta(A+B) + (1-\eta)C}.
\end{aligned}$$

where $A = [(1+\phi)(1-b_w) - \alpha][1-\beta(1-\rho)]\alpha$, $B = [1-\beta(1-\rho)(1-s)](1+\phi)(1-\alpha)$, and $C = [1-\beta(1-\rho)](1-\alpha)\alpha$. Note that under standard assumptions on parameters, $\beta, \rho, s, \alpha, b_w$ are in $(0,1)$ and $\phi > 0$, $B > 0$ and $C > 0$ hold.[7] Then I can show

Proposition 1. *(a) If $(1+\phi)(1-b_w) \in (\alpha, 1)$, $\delta(0) = \bar{\delta} \in (0,1)$ holds. (b) If $(1+\phi)(1-b_w) > 1$, $\bar{\delta} > 1$ holds. Also, there is a threshold $\tilde{\eta} \in (0,1)$ such that $\chi \leq \eta$ if $\eta \geq \tilde{\eta}$.*

Proof. (a) If $(1+\phi)(1-b_w) > \alpha \Rightarrow A = [(1+\phi)(1-b_w)-\alpha]C/(1-\alpha) > 0$, $\delta(0) = A/C = [(1+\phi)(1-b_w)-\alpha]/(1-\alpha) = \bar{\delta} > 0$ holds.[8] (b) If $(1+\phi)(1-b_w) > 1$, $\bar{\delta} = A/C > 1$ also holds. Solving $\tilde{\eta} = \chi(\tilde{\eta})$ for $\tilde{\eta}$, I have $\tilde{\eta} = (A-C)/(A-C+B)$. Note that if $\bar{\delta} = A/C > 1 \Rightarrow A - C > 0$, $\tilde{\eta} \in (0,1)$ also holds. □

If $(1+\phi)(1-b_w) > \alpha$, the workers' period-by-period gain from bargaining is positive, which is required for incentive compatibility for workers to hold.[9] In this case, wages and hours worked

[7] $s = m/u = \rho n/(1-n+\rho n)$ is a function of ρ and $n = 1-\tilde{u}$, where $\tilde{u}$ is the steady state unemployment at the end of the period. Steady state calculation is found in the appendix.

[8] $\delta(1) = 0$ and $\chi(0) = 0$ are immediately obtained. Also, if $A > 0$, $\chi(1) = A/(A+B) \in (0,1)$ holds. Further, $\partial\delta(\eta)/\partial\eta \propto -A(\eta B + (1-\eta)C) - (1-\eta)A(B-C) = -AB < 0$ and $\partial\chi(\eta)/\partial\eta \propto A(\eta(A+B)+(1-\eta)C) - \eta A(A+B-C) = AC > 0$ also hold.

[9] Otherwise, $\bar{\delta} < 0$ and $S/J < 0$ hold. Note that $J \propto f(h) - wh = f(h)[1 - f'(h)h/f(h)] > 0$ for any $h > 0$.

per worker are determined at the intersection of demand (8) and supply (9). Furthermore, if $(1+\phi)(1-b_w) > 1$, for some η there exists a threshold of workers' bargaining power $\tilde{\eta} = \eta = \chi$, i.e. the actual bargaining power is equal to the effective bargaining power as in the standard model. If and only if $\xi = \eta = \tilde{\eta} = \chi$, the Hosios condition holds at steady state. When $\eta > \tilde{\eta}$, there is a positive inefficiency gap and $\delta < 1$, $\sigma > 1$ and $\chi < \eta$ hold.

The top panel in figure 2 shows $\delta(\eta)$ in steady state with the calibrated parameters.[10] Note that the latter condition (b) is satisfied with these parameters. As shown in proposition 1, $\delta(0) = \bar{\delta} > 1$, and $\delta(\eta)$ is decreasing in η and converges to zero as $\eta \to 1$. The second panel in figure 2 shows that $\sigma(\eta) = \varepsilon_w/(\varepsilon_w - 1 + \delta(\eta))$ is increasing in η and converges to its upper bound $\sigma(1) = \varepsilon_w/(\varepsilon_w - 1)$ as $\eta \to 1$. The third panel in figure 2 shows that χ is not as high as η as $\eta \to 1$. Even when $\eta = 1$, workers can get only a fraction of firms' surplus, because firms can adjust labor input by intensive margin to insure positive period-by-period profit $f(h)(1-\alpha) > 0$. In the bottom panel, S/J is increasing as $\eta \to 1$, because S/J is an increasing function of wages and workers can earn more wages by a higher bargaining power. The marginal value obtained by increasing wages $\delta = -(\partial S/\partial w)/(\partial J/\partial w)$, however, decreases as $\eta \to 1$, because S/J is also concave in w due to labor demand schedule $h(w)$. Last but not least, the Hosios condition does not necessarily hold with the calibrated parameters. There is only one parameter set with $\xi = \eta = \tilde{\eta} = 0.3$ where the efficiency in the labor market is restored, namely $\delta = \sigma = 1$.[11]

[Figure 2 is inserted here]

4 CONCLUDING REMARKS

In this note, I presented the property of efficiencies in the labor market search model with right-to-manage bargaining. Wages and hours worked replicates the allocation in the Walrasian labor market with a variable wage markup. Because of inefficiencies in the labor market, the Hosios condition does not necessarily hold. Workers' bargaining power and wage markups are closely related to each other by exploiting inefficiencies in the labor market.

[10] I follow the calibration strategy in Christoffel and Kuester (2008; 2009), which is found in the appendix.

[11] $\tilde{\eta}$ is a function of the parameters other than ξ and η, therefore $\xi = \eta = \tilde{\eta}$ can be chosen if the other parameters are fixed. This is more restricted than in the standard case with efficient Nash bargaining, where $\xi = \eta$ can be chosen freely regardless of the other parameters.

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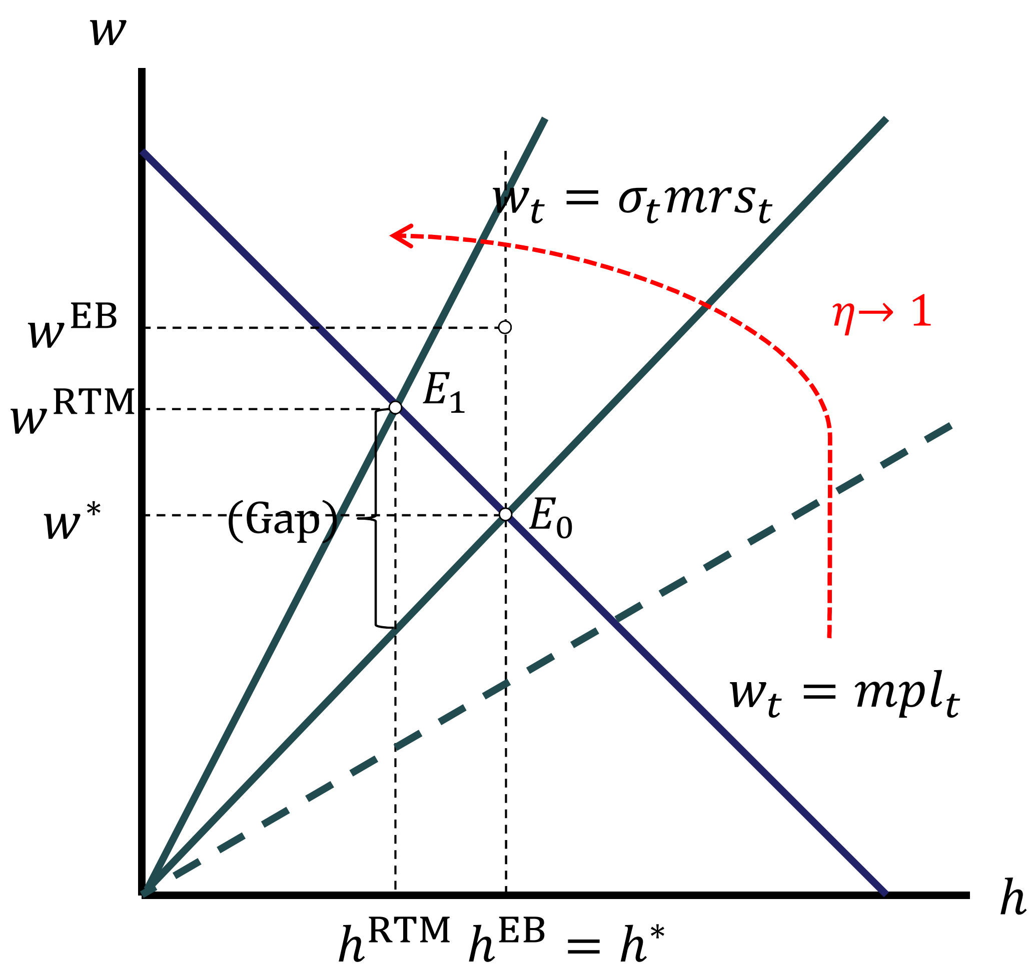
APPENDIX

Given steady state unemployment at the end of period $\tilde{u} = 1 - n$, steady state job finding rate is $s = m/u = \rho n/(1 - n + \rho n)$. By normalizing h, $wh = \alpha h^{\alpha}$ and $b = b_w wh$ are obtained. Then steady state matching values are

$$J = (1/\alpha - 1)/[1 - \beta(1 - \rho)]wh,$$
$$S = [1 - b_w - \sigma^{-1}/(1 + \phi)]/[1 - \beta(1 - \rho)(1 - s)]wh$$

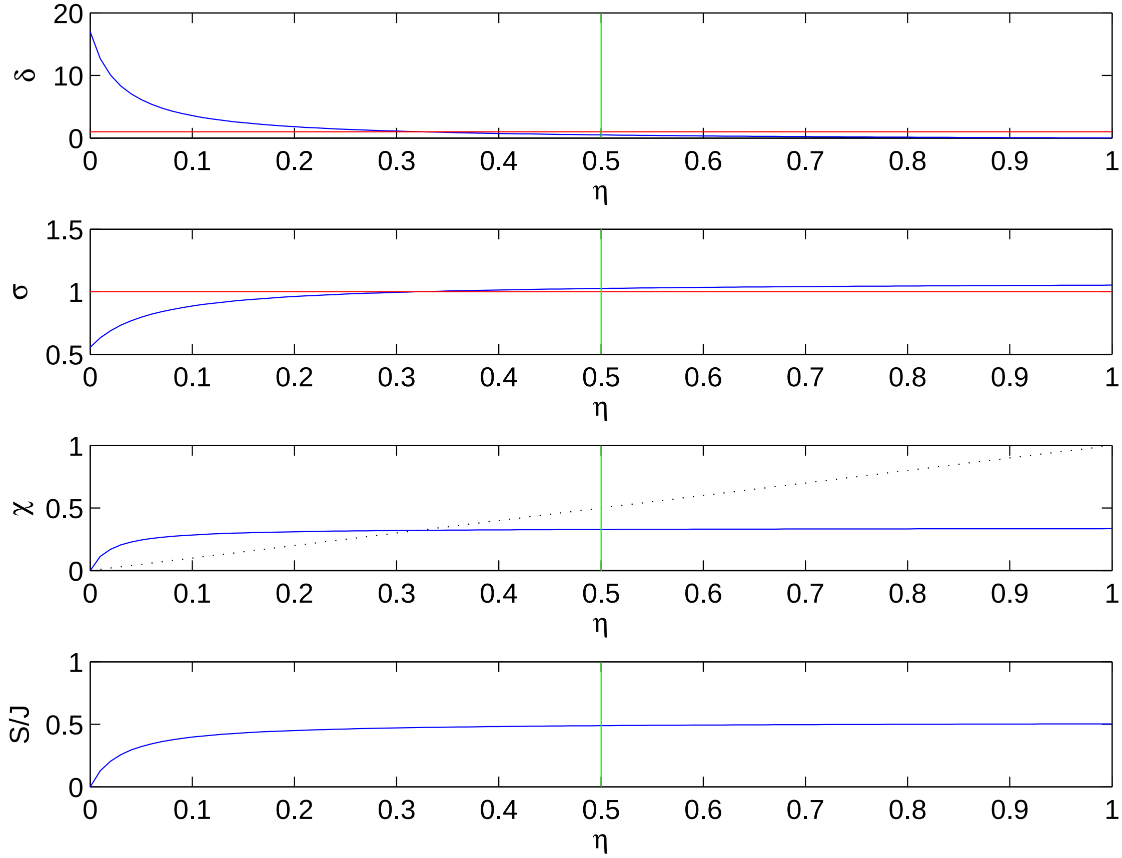
where $\sigma = \varepsilon_w/(\varepsilon_w - 1 + \delta) = 1/[1 - (1 - \alpha)(1 - \delta)]$ and $\delta = [(1 - \eta)/\eta]S/J$. These equations can be solved for δ. Decreasing returns to scale in hours worked per worker $\alpha < 1$ is assumed so that firms earn positive profit period-by-period $J > 0$ and $\varepsilon_w = -h'(w)w/h(w) = 1/(1-\alpha) < \infty$. Given steady state job filling rate q, steady state vacancy cost is $c_v = qJ$.

Figure 1: Labor market equilibrium.



Notes: EB denotes allocation in efficient Nash bargaining. RTM denotes allocation in right-to-manage bargaining. * denotes allocation at the social optimum.

Figure 2: Steady state relationship.



Notes: The parameter values other than η are fixed at $\beta = 0.998$, $\rho = 0.03$, $\alpha = 0.95$, $\phi = 2$, $b_w = 0.4$, and $\xi = 0.5$. The length of period is a month, and parameters are chosen to match steady state unemployment rate after matching $1 - n = 0.06$ and job finding rate $q = 0.3306$ in the U.S. labor market, which implies $s = 0.2126$ and $c_v = 0.047y$.