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A NOTE ON THE LARGE-FIRM MATCHING MODEL: CAN A NONBINDING MINIMUM WAGE REDUCE WAGES AND EMPLOYMENT?

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We show that, in the large-firm search model, employment may decrease even when the level of the introduced minimum wage lies below the equilibrium wage of the laissez-faire economy. Wages also decrease in the presence of the minimum wage. The argument is based on multiple equilibria and the idea that, in a large-firm context, the representative firm may choose to overemploy workers in order to renegotiate lower wages.

Keywords: Minimum Wage, Employment, Search, Large Firm

1. INTRODUCTION

In a perfect competition model, the introduction of a binding minimum wage implies a decrease in employment [Stigler (1946)]. It has been argued, however, that the opposite may occur in models characterized by search frictions [see Manning (2003) and references therein]. In this note we show that, in the large-firm search model [e.g., Cahuc et al. (2008)], employment may decrease even when the level of the introduced minimum wage lies below the equilibrium wage of the laissez-faire economy. Not only does employment decrease, but wages decrease too with the presence of the minimum wage.

The argument is based on multiple equilibria and the idea from the literature that, in a large-firm context, the representative firm may choose to overemploy

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workers in order to renegotiate lower wages. Although the equilibrium is unique in the laissez-faire economy, another equilibrium may appear when a minimum wage is introduced. In this other equilibrium, the minimum wage acts as a focal point. Low-skilled workers anticipate earning the minimum wage. Because wages are downward rigid by regulation, overemployment by the representative firm is weaker. This depresses labor demand for the low-skilled and, because aggregate labor demand is too low, low-skilled workers cannot negotiate a wage equal to the equilibrium wage of the laissez-faire economy, which results in employment and wages of low-skilled workers being lower than in the latter equilibrium.

The note is organized as follows. Section 2 describes a large-firm search model in which workers may negotiate the wage with firms, or may earn an exogenous minimum wage. Section 3 describes the equilibrium and discusses the possibility of multiple equilibria. In Section 4 we show by means of a numerical example how the introduction of a minimum wage may drive down wages and employment. Section 5 concludes.

2. MODEL

We consider a framework similar to that of Bauducco and Janiak (2014). The economy is in steady state and time is continuous. The exogenous discount rate for firms and workers is r. For notational simplicity, we denote by primes variables evaluated at time $(t + dt)$, where dt is an arbitrarily small interval of time.

2.1. Workers

Two types of workers operate in separate labor markets. In the market for high-skilled workers, workers can be either employed or unemployed. We denote by H employment in this market, whereas u_H is the mass of the unemployed. Similarly, L and u_L denote employment and unemployment among low-skilled workers, respectively. The total mass of each type of workers is equal to ς_i, with $i \in \{L, H\}$.

Each labor market is characterized by search and matching frictions à la Pissarides. Workers of type $i = \{H, L\}$ find jobs at a rate $p(\theta_i)$ that depends positively on the labor market tightness $\theta_i \equiv \frac{V_i}{u_i}$, where V_i is the mass of vacancies for workers of type i opened by the representative firm. The p function is derived from a standard matching function $m(u_i, V_i)$ with constant returns to scale, increasing in both arguments, concave, and satisfying the property $m(u_i, 0) = m(0, V_i) = 0$, implying that $p(\theta_i) = \frac{m(u_i, V_i)}{u_i} = m(1, \theta_i)$. Separations occur at an exogenous rate s_i.

Workers of type $i = \{H, L\}$ either choose to negotiate their wage at a rate $\breve{w}^i$ or earn the minimum wage $\bar{w}$. We allow workers to opt for mixed strategies and call χ_i, $i = \{H, L\}$, the probability of negotiating the wage. Hence, the expected wage of i-type workers w^i reads as

$$w^i = \chi_i \breve{w}^i + (1 - \chi_i)\bar{w}.$$

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Negotiated wages are continuously renegotiated, with $\beta \in (0, 1)$ being the bargaining power of workers.

The value of an employed i-type worker is

$$W_i = \max\{\breve{W}_i, \bar{W}_i\}, \tag{1}$$

where $\breve{W}_i$ is the value of a worker who chooses to negotiate,

$$r\breve{W}_i = \breve{w}^i + s_i(U_i - W_i), \tag{2}$$

and $\bar{W}_i$ is the value when a worker chooses to earn the minimum wage,

$$r\bar{W}_i = \bar{w} + s_i(U_i - W_i). \tag{3}$$

The value of an unemployed worker is

$$rU_i = b + p(\theta_i)(W_i - U_i), \tag{4}$$

for all $i = \{H, L\}$, where b is the flow utility of being unemployed.

2.2. The Representative Firm

A representative firm produces using both labor types. To this end, it posts vacancies v_i of $i = \{H, L\}$ at a flow cost c to hire workers in each market. Vacancies are filled at a rate $q(\theta_i) = \frac{m(u_i, V_i)}{V_i} = m(\theta_i^{-1}, 1)$. At equilibrium, $V_i = v_i$ for all $i = \{H, L\}$.

The value of the representative firm is the discounted sum of profits:

$$\begin{aligned}\Pi(H, L) = \max_{\{v_H, v_L\}} \frac{1}{1 + rdt}\{[F(\pi H, L) - w^H(H, L)H - w^L(H, L)L \\ - (v_L + v_H)c]dt + \Pi(H', L')\},\end{aligned} \tag{5}$$

where F is the production function and $\pi > 1$ are labor services provided by skilled workers, subject to the following constraints describing the dynamics of employment levels:

$$H' = (1 - s_H dt)H + q(\theta_H)v_H dt,$$
$$L' = (1 - s_L dt)L + q(\theta_L)v_L dt.$$

The variation in the stocks of employment is equal to the difference between the mass of vacancies that are filled and the mass of workers who exogenously leave the firm.

Notice that the representative firm is *large*, in the sense that it hires more than one worker of each type i. The firm internalizes the fact that the negotiated wage of an i-type worker will be influenced by the quantities H and L of workers hired through the effects of these quantities on the marginal product of labor.

Consequently, the firm will take into account the effects of H and L over wages when deciding how many vacancies to post.

3. EQUILIBRIUM

3.1. Firm's First-Order Conditions

Maximizing (5) with respect to v_L and v_H yields the Euler equations

$$\frac{c}{q(\theta_H)} = \frac{\frac{\partial F(\pi H,L)}{\partial H} - w^H(H,L) - \frac{\partial \breve{w}^H(H,L)}{\partial H}\chi_H H - \frac{\partial \breve{w}^L(H,L)}{\partial H}\chi_L L}{r+s} \tag{6}$$

and

$$\frac{c}{q(\theta_L)} = \frac{\frac{\partial F(\pi H,L)}{\partial L} - w^L(H,L) - \frac{\partial \breve{w}^H(H,L)}{\partial L}\chi_H H - \frac{\partial \breve{w}^L(H,L)}{\partial L}\chi_L L}{r+s}. \tag{7}$$

The left-hand sides of conditions (6) and (7) are the expected search costs of hiring high-skilled and low-skilled workers, respectively. In equilibrium, they have to be equal to the marginal value of a worker of the specified type (the right-hand side), which is given by the discounted sum of marginal profits. Notice that the last two terms on the right-hand sides of conditions (6) and (7) show that, by hiring an additional worker of type i, the firm can influence the negotiated wage of all workers. This effect is larger, the larger the fraction of workers that negotiate the wage with the firm is, that is, the larger χ_H and χ_L are.

3.2. Negotiated Wages

For the purpose of negotiation, only the mass of workers participating in the negotiation process is relevant. We denote by $\breve{H} = \chi_H H$ and $\breve{L} = \chi_L L$ the mass of workers of types H and L that negotiate the wage, respectively. Negotiated wages are determined under negotiation à la Nash as the wages that maximize the joint surplus:

$$\breve{w}^i = \text{argmax } (\breve{W}_i - U_i)^\beta J_i^{(1-\beta)}, \ \forall i = H, L, \tag{8}$$

where J_i is the surplus for the firm of hiring a marginal i-type worker who chooses to negotiate the wage:

$$J_H = \frac{\frac{\partial F(\pi H,L)}{\partial H} - \breve{w}^H(H,L) - \frac{\partial \breve{w}^H(H,L)}{\partial \breve{H}}\breve{H} - \frac{\partial \breve{w}^L(H,L)}{\partial \breve{H}}\breve{L}}{r+s},$$

$$J_L = \frac{\frac{\partial F(\pi H,L)}{\partial L} - \breve{w}^L(H,L) - \frac{\partial \breve{w}^H(H,L)}{\partial \breve{L}}\breve{H} - \frac{\partial \breve{w}^L(H,L)}{\partial \breve{L}}\breve{L}}{r+s}.$$

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The solutions to (8) are

$$\breve{w}^H(H,L) = \beta\frac{\partial F(\pi H,L)}{\partial H} + (1-\beta)rU_H - \beta\left[\frac{\partial\breve{w}^H(H,L)}{\partial\breve{H}}\breve{H} + \frac{\partial\breve{w}^L(H,L)}{\partial\breve{H}}\breve{L}\right] \tag{9}$$

and

$$\breve{w}^L(H,L) = \beta\frac{\partial F(\pi H,L)}{\partial L} + (1-\beta)rU_L - \beta\left[\frac{\partial\breve{w}^H(H,L)}{\partial\breve{L}}\breve{H} + \frac{\partial\breve{w}^L(H,L)}{\partial\breve{L}}\breve{L}\right]. \tag{10}$$

As in Pissarides (1985), the negotiated wage for each type of worker comprises a weighted average of the marginal product of labor and the worker's threat point. In the current setup, however, as in Cahuc et al. (2008), the wage also includes a term that reflects the fact that workers can appropriate part of the change in other workers' wages.

3.3. Front-Load Factors

Equations (9) and (10) form a system of differential equations that can be solved using spherical coordinates, as in Cahuc et al. (2008). This leads to the following expressions for wages:

$$\breve{w}^H = \beta\breve{\Omega}_H\frac{\partial F(\pi H,L)}{\partial H} + (1-\beta)rU_H \tag{11}$$

and

$$\breve{w}^L = \beta\breve{\Omega}_L\frac{\partial F(\pi H,L)}{\partial L} + (1-\beta)rU_L, \tag{12}$$

where

$$\breve{\Omega}_H = \frac{1}{\frac{\partial F(\pi H,L)}{\partial H}}\int_0^1 \frac{\partial F(\pi H\zeta_H^z, L\zeta_L^z)}{\partial H\zeta_H^z}\breve{\varphi}(z)dz,$$

$$\breve{\Omega}_L = \frac{1}{\frac{\partial F(\pi H,L)}{\partial L}}\int_0^1 \frac{\partial F(\pi H\zeta_H^z, L\zeta_L^z)}{\partial L\zeta_L^z}\breve{\varphi}(z)dz,$$

$$\zeta_H^z = \chi_H z + 1 - \chi_H,$$

$$\zeta_L^z = \chi_L z + 1 - \chi_L,$$

and

$$\breve{\varphi}(z) = \frac{1}{\beta}z^{\frac{1-\beta}{\beta}}.$$

By inserting the negotiated wages (11) and (12) into (6) and (7) we obtain the following expressions for the vacancy-posting conditions:

$$\frac{c}{q(\theta_H)} = \frac{\Omega_H\frac{\partial F(\pi H,L)}{\partial H} - w^H}{r + s_H} \tag{13}$$

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and

$$\frac{c}{q(\theta_L)} = \frac{\Omega_L \frac{\partial F(\pi H, L)}{\partial L} - w^L}{r + s_L}, \tag{14}$$

where

$$\Omega_i = \chi_i \breve{\Omega}_i + (1 - \chi_i)\bar{\Omega}_i, \quad i = H, L,$$

$$\bar{\Omega}_H = \frac{1}{\frac{\partial F(\pi H, L)}{\partial H}} \int_0^1 \frac{\partial F(\pi H \zeta_H^z, L\zeta_L^z)}{\partial H \zeta_H^z} \bar{\varphi}(z) dz,$$

$$\bar{\Omega}_L = \frac{1}{\frac{\partial F(\pi H, L)}{\partial L}} \int_0^1 \frac{\partial F(\pi H \zeta_H^z, L\zeta_L^z)}{\partial L \zeta_L^z} \bar{\varphi}(z) dz,$$

and

$$\bar{\varphi}(z) = \frac{1-\beta}{\beta} z^{\frac{1-2\beta}{\beta}}.$$

The variables Ω_i and $\breve{\Omega}_i$ are front-load factors resulting from the strategic behavior of agents. When Ω_i takes a value above 1, for $i = \{H, L\}$, the firm overemploys factor i as compared to a benchmark without strategic behavior, whereas it underemploys it when $\Omega_i < 1$ [see conditions (13) and (14)]. Overemployment and underemployment arise when the firm influences the value of the negotiated wage of i-type workers through the value of its marginal product by altering the quantity of each labor type hired. For example, consider the case in which H and L are complements in production, in the sense that the cross derivatives of the production function are positive. In this case, the firm has incentives to underemploy H-type workers to decrease the marginal product and the wage of labor of type L workers, but at the same time it has incentives to overemploy H-type workers to decrease their wage if the production function is concave in H. Depending on which effect dominates, $\Omega_H \lesseqgtr 1$.

Notice also the role of χ_i in the determination of $\breve{\Omega}_i$. As the fraction of workers with whom the firm negotiates increases, the strategic behavior of the firm is amplified and the $\breve{\Omega}_i$'s diverge from 1.

Finally, because each worker can appropriate part of the change in the wages of the other workers [see equations (9) and (10)], the front-load factors also appear in the wage equations (11) and (12). Holding the marginal product of labor and the worker's threat point constant, overemployment increases wages, whereas underemployment decreases them.

3.4. Unemployment

In a steady state, flows into employment have to equal flows out of employment. This property allows us to determine aggregate employment levels in steady state:

$$H = \varsigma_H \frac{p(\theta_H)}{s_H + p(\theta_H)} \tag{15}$$

and

$$L = \varsigma_L \frac{p(\theta_L)}{s_L + p(\theta_L)}. \tag{16}$$

Similarly, the masses of unemployed L and H-type workers follow

$$u_L = \varsigma_L \frac{s_L}{s_L + p(\theta_L)} \text{ and } u_H = \varsigma_H \frac{s_H}{s_H + p(\theta_H)}.$$

Combining equations (1)–(4), the value of an unemployed worker can be written as

$$rU_i = \frac{(r + s_i)b + p(\theta_i)w_i}{r + s_i + p(\theta_i)}, \quad \forall i = H, L. \tag{17}$$

3.5. Definition of Equilibrium

When deciding whether to negotiate the wage with the firm or earn the minimum wage, an i-type worker will compare $\breve{w}_i$ with $\bar{w}$ and decide which option is better according to which salary is higher. This, in turn, will determine the fraction of i-type workers who choose to negotiate the wage with the firm. Hence, the strategy the workers decide to follow has to be consistent at equilibrium with the value taken by wages.[1] The following definition of equilibrium specifies this condition and summarizes the other relevant equilibrium conditions of the model:

DEFINITION 1. *Given a minimum wage $\bar{w}$, a steady-state equilibrium is a set of employment levels H and L, a set of fractions χ_H and χ_L of workers who earn the negotiated wage, values of unemployment U_H and U_L, negotiated wages $\breve{w}_H$ and $\breve{w}_L$, and labor market tightness θ_H and θ_L such that the vacancy-posting conditions* (13) *and* (14)*, the wage equations* (11) *and* (12)*, the value of unemployment* (17)*, and the Beveridge relations* (15) *and* (16) *are satisfied, and the workers' wage strategies are optimal; that is,*

1. *The fraction $\chi_i = 1$, $i = \{H, L\}$, is an equilibrium if $\breve{w}_i > \bar{w}$.*
2. *The fraction $\chi_i = 0$, $i = \{H, L\}$, is an equilibrium if $\breve{w}_i < \bar{w}$.*
3. *The fraction $\chi_i \in (0, 1)$, $i = \{H, L\}$, is an equilibrium if $\breve{w}_i = \bar{w}$.*

The three conditions stated in Definition 1 that determine if the workers' wage strategies are optimal suggest the possibility of multiple equilibria, as the three listed possibilities are not mutually exclusive. This is because there is a feedback effect in the model between the strategic behavior of agents at the micro level and the determination of aggregate variables. To see this, consider the case in which $\breve{w}_i > \bar{w}$ when $\chi_i = 1$. The first listed condition in Definition 1 tells us that this is an equilibrium. However, if $\chi_i < 1$, the firm will have lower incentives to act strategically (e.g., it will overhire less), and V_i, θ_i, and $\breve{\Omega}_i$ may be lower. From (11) and (12), $\breve{w}_i$ would be lower, because the value of unemployment is lower. Therefore, it might be the case that there exists a $\chi_i \in (0, 1)$ such that $\breve{w}_i = \bar{w}$, consistent with the third listed condition in Definition 1. In this case, this value of

TABLE 1. Parameterization

Parameter	Value
b	0.71
s_L	0.036
s_H	0.036
r	0.004
β	0.5
c	0.356
η	0.5
m_0	0.7
α	0.5
ρ	0.401
π	4.7
ς_L	1
ς_H	1

$\chi_i < 1$ would also represent an equilibrium. In this example, the minimum wage would not be binding in the former equilibrium, whereas it would be binding in the latter one.

4. NUMERICAL EXERCISE

4.1. Parameterization

We illustrate the result that a minimum wage may reduce wages and employment with respect to the laissez-faire economy by means of a numerical example.

The parameterization is as follows. We assume a CES form for the production function, i.e., $F(\pi H, L) = [\alpha(\pi H)^\rho + (1-\alpha)L^\rho]^{1/\rho}$, and a Cobb–Douglas specification for the matching function, i.e., $m(u, v) = m_0 u^\eta v^{1-\eta}$. Table 1 shows the values of the parameters used in the exercise. Most of these values are simply taken from Pissarides (2009). The value for ρ corresponds to the estimation by Krusell et al. (2000), whereas the value for π, along with the assumption that the masses of both types of workers, ς_H and ς_L, are equal to one, produces a skill premium of roughly 80%, as shown in Krueger et al. (2010) for the United States.

4.2. Quantitative Exercise

Under this parameterization, the equilibrium is unique absent a minimum wage, whereas the introduction of a minimum wage may give rise to multiple equilibria, even though the minimum wage lies below the equilibrium wage of the laissez-faire economy. This latter claim is illustrated in Figure 1 for a value of the minimum wage set 2.5% below the equilibrium wage of L-type workers in the laissez-faire economy.

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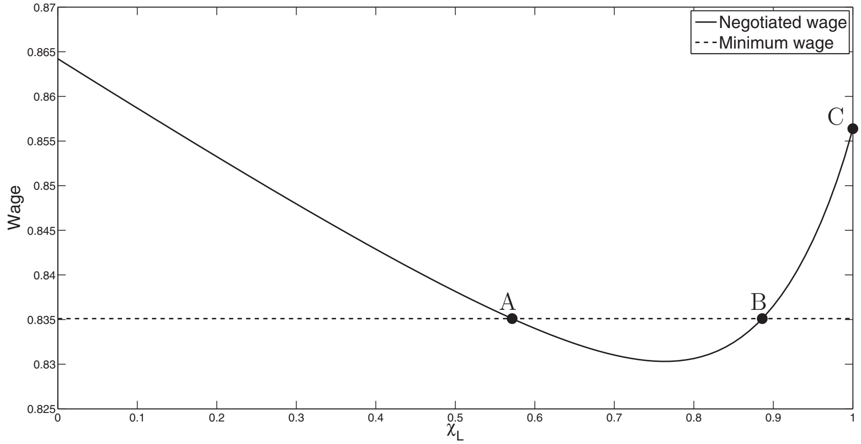

FIGURE 1. Determination of χ_L in the presence of a minimum wage.

Figure 1 compares the negotiated wage of L-type workers (the solid line) with the minimum wage (the dashed line) for several values of χ_L in order to identify the possible values for χ_L that are consistent with any of the three listed conditions in Definition 1. Notice that the value of the negotiated wage changes with the value of χ_L because aggregate variables, including the labor-market tightness and the value of unemployment, depend on χ_L, whereas the value of the minimum wage $\bar{w}$ is exogenous.[2]

There are three equilibria displayed in Figure 1, labeled A, B, and C from left to right: one in pure strategy in which all L-type workers negotiate the wage with the firm ($\chi_L = 1$, equilibrium C) and two equilibria in mixed strategy, in which a fraction $0 < \chi_L < 1$ of L-type workers receive the negotiated wage, and a fraction $(1 - \chi_L)$ receive the minimum wage (equilibria A and B). Obviously, in these two equilibria, both wages coincide. In all three equilibria, $\chi_H = 1$.

Equilibrium B is unstable, whereas the other two equilibria are stable. To see this, suppose the L-type labor market is off equilibrium, to the right of point B. In this case, for a given $\chi_L < 1$, $\breve{w}_L > \bar{w}$ (the solid line is above the dashed line), so a larger fraction of workers will want to negotiate the wage. This will increase the negotiated wage, until equilibrium C is reached. Similarly, suppose the L-type labor market is off equilibrium, to the left of point B. Now, for a given $\chi_L < 1$, $\breve{w}_L < \bar{w}$ (the solid line is below the dashed line), so a smaller fraction of workers will want to negotiate the wage. χ_L will decrease until equilibrium A is reached. Thus, only equilibria A and C are stable.

The multiplicity of equilibria is the consequence of a coordination failure. The intuition for it is the following. Equilibrium C is the equilibrium of the laissez-faire economy. At this equilibrium, the representative firm overemploys more than in equilibrium A, keeping a higher labor demand at the aggregate level, resulting in higher bargained wages (above the minimum regulatory level). At equilibrium

TABLE 2. Statistics describing two equilibria

	w^L	w^H	u_L	u_H	$\frac{u_L+u_H}{2}$	χ_L	χ_H	Ω_L	Ω_H
High wage equilibrium	1	1.80	7.7%	3.32%	5.5%	1	1	1	1
Low wage equilibrium	0.975	1.81	29.2%	3.29%	16.3%	0.57	1	0.87	1.06

Note: Values for wages are normalized by the wage level of low-skilled workers at the high-wage equilibrium.

A, because the minimum wage is binding, the representative firm chooses to overemploy less than at equilibrium C because it cannot influence the wage of many workers. This results in a lower labor demand at the aggregate level and lower negotiated wages (low enough to make the minimum wage bind). In sum, at equilibrium C, strategic considerations are strong, keeping negotiated wages above the minimum wage, whereas they are weak at equilibrium A, resulting in bargained wages equal to the minimum wage. The fact that one equilibrium is chosen over the other is a matter of coordination.[3]

Table 2 compares the two stable equilibria: the high-wage equilibrium corresponds to equilibrium C of Figure 1, whereas the low-wage equilibrium is equilibrium A on the same figure. The high-wage equilibrium is also the equilibrium of the laissez-faire economy.

The low-skilled wage is 2.5% lower at the low-wage equilibrium because it is equal to the minimum wage. At this equilibrium, the minimum wage acts as a focal point: low-skilled workers anticipate earning the minimum wage, hence the lower probability of negotiating the wage (57%). Because it is more difficult to influence the wage of the low-skilled at the low-wage equilibrium, the representative firm underemploys low-skilled workers in order to influence the wage of the high-skilled: the front-load factor Ω_L is below 1, whereas it is 1 in the laissez-faire economy because of constant returns to scale in the production function, as shown in Cahuc and Wasmer (2001). At the same time, the representative firm overemploys high-skilled workers at the low-wage equilibrium in order to exploit the concavity of the production function in this factor (Ω_H lies above 1). As a result, low-skilled unemployment increases when one moves from the high-wage equilibrium to the low-wage equilibrium, whereas high-skilled unemployment decreases. Because the impact on the low-skilled labor market is much more pronounced than that on the high-skilled labor market (a 21.5% increase vs. a 0.03% decrease), the overall unemployment rate in the economy increases.

5. CONCLUSIONS

In this note we show that, within a framework in which there are search frictions in labor markets and firms may overemploy or underemploy workers in order to affect negotiated wages, the introduction of a minimum wage may have a negative effect on equilibrium wages and employment. Although the effect on employment is present in other models of the labor market (i.e., the perfect competition framework), the effect on wages is novel.

The argument is based on multiple equilibria. We illustrate that there is a strategic complementarity between the overhiring behavior of the representative firm and the decision of workers to negotiate. In the presence of a minimum wage, coordination failure may lead to an equilibrium with lower wages and higher unemployment. At this equilibrium, the representative firm overemploys less because workers bargain less, making labor demand lower at the aggregate level, as well as wages. Hence, even by fixing a minimum wage below the level of wages of the laissez-faire economy, employment could drop because of a coordination failure.

For the result to hold, one needs strategic complementarities in the model. We provide an example with constant returns to scale and concavity of the production function in each factor. The result would also hold in a context without constant returns to scale by simply considering one type of labor and a production function with decreasing returns to scale.

If strategic complementarities are not present in the model, the result breaks down. Consider, for example, the case in which the two types of labor are substitutes, which also requires moving away from constant returns to scale. In this case, the low-wage equilibrium with a binding minimum wage of our simulations may not exist, as the representative firm would choose to overemploy low-skilled workers in order to decrease the wage of high-skilled workers, keeping negotiated wages of the low-skilled above the minimum wage. Another example in which strategic considerations would be absent in the model is the case in which the production function is linear in each factor.

NOTES

1. If this condition fails to be met, the equilibrium does not exist.
2. For all combinations of $\breve{w}_L$ and χ_L in Figure 1, and for the specific $\bar{w}$ considered in this example, all remaining equilibrium conditions listed in Definition 1 are met.
3. The model could be extended to include aggregate shocks, as in Cooper and John (1988). In this case, one equilibrium could disappear because of aggregate fluctuations, leading agents to coordinate toward the other equilibrium and stay there when the business cycle returns to normal.

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