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DYNAMIC SEGMENTED LABOR MARKETS WITH A MONOPOLY UNION: A THEORETICAL APPROACH*

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I. INTRODUCTION

Most models of union behavior are static in that the utility of a union and the profit of firms are assumed to depend only upon current variables. On the other hand, most empirical models of wages and employment are dynamic. Dynamic analysis in the latter case is in general justified by the presence of quadratic adjustment costs of employment associated with hiring and firing costs. The discrepancy between theoretical models and empirical models has recently been narrowed. Recent studies by Blanchard and Summers (1986), Gottfries and Horn (1987), Lindbeck and Snower (1987) have introduced dynamics into the theoretical models. However, the source of dynamics of those models is union membership. Therefore those models have a different source of dynamics from empirical models which identify adjustment costs of employment in firms' profit functions as the source.

To fill this gap, Card (1986) and Lockwood and Manning (1989) have developed dynamic union models by assuming that the profit function contains quadratic adjustment costs of employment. These models, however, are not satisfactory in that the economy in reality contains both a unionized sector and a nonunionized sector, and therefore, are not able to explain some stylized facts of the labor market. One of the stylized facts of the labor market is that the intersectoral wage differential (between union sector and nonunion sector wage rates) widens in recessions and narrows in booms; it is countercyclical. In addition, the above models are unable to explain effects of a union on the nonunion sector nor the cross effects of a sector-specific shock on the other sector. Apparently, these can be explained only if the two sectors are combined into a general equilibrium model. Therefore, it is natural to try and incorporate a unionized labor market with a

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nonunionized labor market, recognizing that both types of labor markets coexist in most economies. The resulting segmented labor market model is regarded as a more complete model of the economy.

Although economists have been aware of such an integration of the labor market and such dynamics of the labor force, these factors have received little theoretical treatment. Oswald (1982) and McDonald and Solow (1985) are among those who consider an integration of the labor market. However, their models are not satisfactory in that they are all static.

In particular, McDonald and Solow (1985) allow for the migration of workers, but as in most two-sector models they can only migrate in one direction, that is from the nonunion sector to the union sector. It is unreasonable to expect union sector workers to remain in the current sector if getting a job in the union sector is extremely unlikely due to negative sectoral shocks, while getting a job in the nonunion sector is guaranteed. A rational worker does not care about the sector in which he supplies labor but does care about the maximization of utilities from present and expected future incomes. Workers therefore may migrate in both directions.

Another problem with McDonald and Solow is that the number of migrants is proportional to the number of workers in the union sector because migration originates only from the nonunion sector to fill job openings in the union sector exogenously created by death, retirement, and so on. This will eventually result in the degeneration of the nonunion sector since migration occurs only in one direction. Migration is not a consequence of job openings being filled, but is due to workers' preferences for the labor supply and utility maximization. Thus the size of migration should be determined endogenously instead of exogenously.

McDonald and Solow also presuppose that the union sector wage rate is a function of the nonunion sector wage rate and that the elasticity of the union sector wage rate with respect to the nonunion sector wage rate is less than unity, which is arbitrarily assumed. Furthermore, countercyclical wage differentials are guaranteed only by this assumption. In other words, the countercyclical behavior of wage differentials is obtained because they have assumed it a priori.

Finally, a shock does not have persistent effects on (un)employment in their model unless the shock is serially correlated. But hysteresis in unemployment is a well-known fact both in the United States and, more severely, in Europe (see Blanchard and Summers, 1986, for a strong argument of this). Even a temporary shock generates long-lasting effects in the economy. Recognizing that McDonald and Solow have these problems and that there exists no theoretical work on dynamic segmented labor markets with a union sector and a nonunion sector makes it necessary to consider a dynamic model of segmented labor markets.

The purpose of this paper is to construct a dynamic model of two distinctive but interrelated labor markets distinguished by the presence of unions, where homogeneous labor is mobile between the two sectors with nonnegative mobility costs.[1] For this purpose, an economy consisting of both a union sector (a contract sector) and a nonunion sector (a spot sector) is considered.[2] The spot sector is defined as the competitive labor market with flexible real wage rates; thus the labor market in this sector always clears. The contract sector is assumed to be unionized: unionized workers and firms jointly determine real wage rates and employment through negotiation processes.

This motivation of the paper is strengthened by the theoretical proof that the two types of labor markets can coexist in the economy. The spot labor market faces significant transaction costs which consist of costs of devising and forecasting, information costs, and so on. If the transaction costs involved in the spot labor market are less than the benefits of quick adjustment to the random shock, then the spot labor market will be chosen and will exist. If the opposite is true, the spot labor market will disappear and the contract labor market will be chosen. Since firms (industries) differ in the distributions of costs and benefits, both types of labor markets coexist in the economy. Similarly, the comparison between the costs and the benefits of unionization vs. nonunionization, which relies on the characteristics of workers (human capital) and firms (technology), makes some sectors unionized and others nonunionized.[3]

The rest of this paper is organized as follows. Section II constructs the dynamic models of segmented labor markets and Section III solves the dynamic monopoly union model. The simulation results for the monopoly union model are reproted in Section IV. The final section concludes the paper by addressing some macroeconomic implications that the analysis of segmented labor market models has.

II. DYNAMIC MODELS OF SEGMENTED LABOR MARKETS

1. The Union Sector

Whereas static models assume that the objective functions of firms and a union depend only on current variables, dynamic models of a union assume that each

[1]A different approach is to rely on the hypothesis of heterogeneous workers. For heterogeneity of workers and its macroeconomic implications, see Clark and Summers (1979), Darby, Haltiwanger, and Plant (1985), and Blanchard and Diamond (1990) in particular.

[2]The contract sector and the union sector are interchangeably used in this paper since this sector should be regarded as the one composed of workers covered by some form of collective bargaining as well as formally unionized workers (say, workers with union membership). Similarly, the nonunion sector and the spot (competitive) sector are interchangeably used.

[3]Cantor (1986) derives the condition for the coexistence of the two sectors and proves that the two sectors can coexist in an economy by assuming that a union is risk-averse and that a firm is risk-neutral. Without assuming any specific attitude toward risks, Lazear (1983) shows that union and nonunion firms exist in the same product market.

party maximizes the present value of returns (profits for firms and utilities for the union). The one-period profit function of a union sector firm in period t+j is assumed to be

$$\pi_{1t+j} = (a_1 + \theta_{1t+j}) L_{1t+j} - \frac{b_1}{2} L^2_{1t+j} - W_{1t+j} L_{1t+j}$$

$$- \frac{c_1}{2} (L_{1t+j} - L_{1t+j-1})^2,$$

where L_1 is union sector employment, W_1 is the union sector real wage rate with a_1, b_1, $c_1>0$, and θ_1 is a union sector-specific technological shock.

This profit function for a representative firm is so convenient that it may be explicitly solved for a demand equation which can be aggregated to yield an industry-wide demand equation. The first two terms in the above profit function make a concave revenue function and the third term denotes the cost in terms of wage payment. A quadratic revenue function is assumed so that the maximization problem of a firm is tractable. This specification also displays the certainty equivalence property. The last term represents widely used symmetric and quadratic adjustment costs (that is, increasing marginal adjustment costs), reflecting hiring and firing costs.

The firms maximizes the present value of profits:

$$(1)\quad \pi_{1t} = E_t \sum_{j=0}^{\infty} \delta^j \pi_{1t+j},$$

where δ is a discount factor and $0 < \delta < 1$.

On the other hand, a union's one-period utility function in period t+j is assumed to be

$$z_{t+j} = L_{1t+j} (W_{1t+j} - W^*_{t+j}),$$

where W^*_{t+j} is the alternative wage available to union members in period t+j. Then, in a dynamic model, the union's objective function to be maximized is

$$(2)\quad Z_t = E_t \sum_{j=0}^{\infty} \delta^j z_{t+j},$$

provided that the discount factor of a union is the same as that of the firm.

The utilitarian union is consistent with empirical specifications and is widely used due to its simple form. The maximand of a utilitarian union is simply rent. If the alternative wage rate available to workers is zero, then the objective function is the wage bill which is regarded, by Dunlop (1944), as a standard maximand for the union.

Although various dynamic models of the union sector can be formulated with given objective functions of a firm and a union, only two dynamic models are considered in this paper. First, the right to manage model assumes that in each period, the wage rate is negotiated between a union and firms and employment is unilaterally determined by firms, given the wage rate. This can be formulated as follows. Given L_{1t-1},

$$
(3.1)\quad \begin{aligned} &\max_{\{W_{1t+j}\}} \quad E_t\left[x\left\{ \sum_{j=0}^{\infty} \delta^j z_{t+j} \right\} + (1-x)\left\{ \sum_{J=0}^{\infty} \delta^j \pi_{1t+j} \right\} \right] \\ &\text{s.t. } L_{1t+j} = \underset{L_{1t+j}}{\arg\max} \quad E_t \sum_{j=0}^{\infty} \delta^j \pi_{1t+1} \quad , \text{ given } W_{1t+j}. \end{aligned}
$$

The bargaining maximizes a weighted average of the two parties' objective functions, that is a linear combination of Z_t and π_{1t} with weight on Z_t being x where x is the relative bargaining power of a union. If $x=0$, firms choose the wage rate to maximize expected profit as a monopsonist. The constraint to the maximization problem is the demand for labor equation which is the employer's solution to the objective function (1).

Second, the monopoly union model, as a special case of the right to manage model, assumes that the wage rate is determined solely by a union, and employment is determined by firms, given the wage rate. Under these circumstances, the bargaining process is formulated as follows:

$$
(3.2)\quad \begin{aligned} &\max_{\{W_{1t+j}\}} \quad E_t \sum_{j=0}^{\infty} \delta^j z_{t+j} \\ &\text{s.t. } L_{1t+j} = \underset{L_{1t+j}}{\arg\max} \left\{ E_t \sum_{j=0}^{\infty} \delta^j \pi_{1t+j} \right\}, \text{ given } W_{1t+j}, \end{aligned}
$$

where L_{1t-1} is given. The union maximizes the present value of utilities subject to the labor demand equation derived by the profit maximizing behavior of firms.

2. The Spot Sector

The spot sector's representative firm maximizes the present value of profits by choosing the optimal level of employment, with a given wage rate:

$$
(4)\quad \max_{\{N_{2t+j}\}} \pi_{2t} = E_t \sum_{j=0}^{\infty} \delta^j \pi_{2t+j},
$$

where $\pi_{2t+j} = (a_2 + \theta_{2t+j}) N_{2t+j} - \frac{b_2}{2} N_{2t+j}^2 - W_{2t+j} N_{2t+j} - \frac{c_2}{2} (N_{2t+j} - N_{2t+j-1})^2$,

N_{2t-1} is given, N_2 is spot sector employment, W_2 is the spot sector real wage rate, θ_2 is a spot sector-specific technological shock with a_2 and $b_2 > 0$, and c_2 satisfies the restriction $c_1 > c_2 \geqslant 0$.

Equations (1) and (4) state that firms in the two sectors have the same functional form of profit as well as the same discount factor δ. The Euler equation from the intertemporal maximization problem (4) yields a dynamic labor demand equation for the spot sector.

The labor supply to the spot sector is derived as follows. In the beginning of each period, homogeneous workers choose their sector freely and can change sectors without incurring mobility costs. But it is assumed that, once they decide on a sector, they are not allowed to change sectors in that period. This assumption is compatible with the utility function of the union defined above, which assumes that membership is fixed or that the union operates a closed shop.

Let V_{1t} be the expected value for a worker when he is employed in sector 1 (the union sector) in period t, V_{2t} be the expected value for a worker when he is employed in sector 2 (the spot sector) in period t, and V^u_{1t} be the expected value for a worker when he is unemployed in sector 1 in period t. A worker, who behaves optimally, faces the problem of deciding whether to join sector 1 or sector 2. Then the value function for this worker in period t becomes

$$(5)\ V_t = \max \left\{ \frac{L_{1t}}{N_{1t}} V_{1t} + \left(1 - \frac{L_{1t}}{N_{1t}}\right) V^u_{1t},\ V_{2t} \right\},$$

where the maximization is over two actions; (i) join sector 1 and receive expected value from sector 1 or (ii) join sector 2 and certainly receive V_{2t}. Because the union sector involves equilibrium unemployment, the value from joining the union sector must be an expected value. The weight in that case is the probability of employment in the union sector, say $\frac{L_{1t}}{N_{1t}}$ for a large number of workers, where N_{1t} is the labor force allocated to the union sector in period t. And thus the number of unemployed workers in period t (Ut) is

$$U_t = N_{1t} - L_{1t}.$$

It is apparent that the two arguments in euqation (5) should be equal for the intersectoral equilibrium where no workers change sectors. Then

$$(6)\ \frac{L_{1t}}{N_{1t}} V_{1t} + \left(1 - \frac{L_{1t}}{N_{1t}}\right) V^u_{1t} = V_{2t}.$$

Otherwise, a worker gains extra value by supplying labor to the sector giving a higher value. Only under this condition, is a worker indifferent to whether he is in sector 1 or in sector 2.

Equation (6), using the Bellman's equations, turns out[4]

$$(7)\ \frac{L_{1t+j}}{N_{1t+j}} W_{1t+j} + \left[1- \frac{L_{1t+j}}{N_{1t+j}} \right] b = W_{2t+j}, \quad j= 0, 1, 2, \cdots,$$

where b is unemployment benefits. Equation (7) is the intersectoral equilibrium condition. Since workers incur no mobility costs, their dynamic maximization problem reduces to a sequence of static maximization problems. Finally, the economy contains a fixed labor force satisfying labor endowment constraint:

$$(8)\ N_{1t+j} + N_{2t+j} = L_{1t+j} + N_{2t+j} + U_{t+j} = \overline{N}, \quad j= 0, 1, 2, \cdots.$$

The labor supply to the spot sector is implied by equations (7) and (8). Substituting (8) into (7) gives the supply of labor to the spot sector for a certain period:

$$(9)\ \frac{L_{1t+j}}{\overline{N}\text{-}N_{2t+j}} W_{1t+j} + \left[1 - \frac{L_{1t+j}}{N\text{-}N_{2t+j}} \right] b= W_{2t+j}, \ j=0, 1, 2, \cdots$$

Note that the denominator is zero when $N_{2t+j}= \overline{N}$, implying that the curve becomes vertical at the upper bound, $\overline{N}$. Furthermore euation (9) states that the labor supply to the spot sector is a decreasing function of opportunity costs (the union sector wage rate or unemployment benefits) and that those effects are nullified when the labor supply curve is vertical. However, an increase in the total labor force raises the labor supply to the spot sector by the same amount, namely $dN_{2t}/d\overline{N}=1$.

3. Unionism and Segmented Labor Markets

Workers who are bargaining with a firm take a look at the alternative wage W^* as in (2). The workers seeking a union sector job have two alternatives: employment in the spot sector and unemployment in the union sector whose one-period returns are W_2 and b, respectively. Evidently, it is true that $W_2 > b$. Otherwise, every worker in the spot sector would choose to be unemployed in the union sector rather than to be employed in the spot sector, which implies that the spot sector degenerates. Therefore what union sector workers actually bear in mind is the spot sector wage rate, not unemployment benefits. Thus, the spot sector wage rate will be the alternative wage, say $W^*_{t+j}=W_{2t+j}$, for all j. It follows from $W_{2t+j} > b$ and equation (9) that $W_{1t+j} \geqslant W_{2t+j}$, and thereby it holds that

[4]See Hahn (1991) for derivation.

(10) $W_{1t+j} \geqslant W_{2t+j} = W^*_{t+j} > b, \quad j=0, 1, 2, \cdots.$

The equality between W_{1t+j} and W_{2t+j} holds only when the two sectors are fully employed, that is $L_{1t+j} = N_{1t+j}$. Equation (10) means that union sector workers receive a wage premium over nonunion sector workers only if unemployment exists in the economy (that is, in the union sector).

The Role of a Union

What is the influence of the union in these segmented labor market models? The union restricts the number of jobs that otherwise would exist in the union sector by raising wage rates. Furthermore the existence of a union seems to increase the supply of labor that otherwise would exist in the spot sector. This results in spot sector wage rates which are lower than competitive wage rates that would otherwise exist in an economy without a union.

This consideration of union effect on segmented labor markets follows from the neoclassical literature. This negative influence of the union is different from the union effect by the conventional segmented labor market literature in which the union plays a positive role. The union is regarded as a party economizing on transaction costs and encouraging the positive feedback between jobs and the productivity of workers. Regarding the positive feedback, Taubman and Wachter say that

> ... job-specific training creates firm-specific or idiosyncratic jobs that introduce problems of bilateral monopoly between workers with idiosyncratic skills and their employers. Absent institutional arrangements, workers and firms will invest too little in this type of training for fear of not realizing their investment. ... By creating an appropriate governance structure, the internal labor market can minimize the transaction costs imposed by the above bilateral monopoly concerns [1986, p. 1195].

Therefore, the union can contribute to the positive feedback to the extent that it economizes on transaction costs. The model in this type of literature assumes that the union does not destroy the jobs in the primary sector and that the size of the primary sector is largely determined by technological elements. In this regard, the segmented labor market models based on the neoclassical literature are differentiated from those based on the traditional dual labor market literature.

The Behavior of Segmented Labor Markets

The equilibrium in these dynamic segmented labor markets is the stochastic sequence of each sector's wage rates and employment satisfying (i) the two Euler equations, one either from the right to manage model (3.1) or from the monopoly union model (3.2) and one from the spot sector's problem (4), (ii) the intersectoral equilibrium condition (7), and (iii) the labor endowment constraint (8). The equilibrium involves unemployment in the union sector because, in general, $W_{1t+j} > W_{2t+j}$ holds. Unemployment is voluntary in that alternative jobs are available in the spot sector. It is involuntary in that incumbent workers in the union sector receive a wage that the productively equivalent unemployed would be willing to accept.

It is now useful to briefly depict how the economy behaves from an equilibrium when there are disturbances. Suppose that a positive union sector-specific shock hits the economy, which brings about an increase in union sector employment. Real wage rates also rise. Given a labor allocation of a previous period, the LHS is higher than the RHS in euqation (7) because of higher probability of employment in the union sector. This will be reinforced if union sector wage rates also rise. Thus workers migrate from the spot sector to the union sector until they are indifferent between the two sectors in terms of the value they have. This process takes a long time because the union sector firm slowly increases employment in the presence of quadratic adjustment costs until the economy arrives at a new equilibrium. Comparing with the previous equilibrium values, L_1, N_1, W_1, and W_2 are higher while N_2 is lower. The comparison of U will be addressed in Section IV.

As an opposite case, suppose that a positive spot sector-specific shock hits the economy. This causes the labor demand curve of the spot sector to shift out, resulting in higher spot sector wage rates. Given a labor allocation of a previous period, the RHS is higher than the LHS in equation (7) and thus workers migrate from the union sector to the spot sector. The difference gradually diminishes as the probability of employment in the union sector becomes higher. This is not because of increasing employment (L_1) but because of the decreasing union sector labor force (N_1). Of course, the speed of adjustment may be reinforced as union sector wage rates rise as a result of collective bargaining in attempts to maintain a certain premium over spot sector wage rates. At a new equilibrium after some periods, N_2, W_1, and W_2 are higher while L_1, N_1, and U are lower.

When the economy experiences a shock, workers will migrate from one sector to the other sector to the point where the expected value from the union sector equals the value from the spot sector and a new equilibrium is eventually achieved. The number of migrants for a certain period t+j, denoted by Mt+j, is measured by

$$(11)\quad M_{t+j} = N_{2t+j-1} - N_{2t+j}, \quad j=0, 1, 2 \cdots .$$

Thus a positive value of M denotes that workers are moving from the spot sector to the union sector and a negative value of M denotes that workers are moving from the union sector to the spot sector.

III. SOLUTIONS

Although tractable and simple functional forms are assumed through the models, it is still not so easy to solve the models because rational expectations are involved for future variables. This section solves the monopoly union model only because implications of the right to manage model are very similar to those of the monopoly union model.

1. The Monopoly Union Model

Given the wage rate, the demand for labor equation is obtained from the constraint of the maximization problem (3.2):

$$\max_{L_{1t+j}} \pi_{1t}, \quad \text{given } W_{1t+j}.$$

The Euler equation for this problem is

$$\delta c_1 E_{t+j} L_{1t+j+1} - (b_1 + c_1 + \delta c_1) L_{1t+j} + c_1 L_{1t+j-1} = W_{1t+j} - (a_1 + \theta_{1t+j}), \quad j=0, 1, 2, \cdots. \tag{12}$$

The solution to the Euler equation that satisfies the transversality condition is

$$L_{1t+j} = \lambda L_{1t+j-1} - \frac{\lambda_1}{c_1} \sum_{i=0}^{\infty} \left[\frac{1}{\lambda_2}\right]^i \left[E_{t+j} W_{1t+j+i} - E_{t+j} \theta_{1t+j+1} - a_1 \right], \; j=0, 1, 2, \cdots, \tag{13}$$

where $1 - \frac{b_1/c_1 + 1 + \delta}{\delta} B + \frac{1}{\delta} B^2 = (1-\lambda_1 B)(1-\lambda_2 B)$, $0<\lambda_1<1<1/\delta< \lambda_2$, and B is the backward lag operator, assuming that $\{W_{1t+j}\}$ and $\{\theta_{1t+j}\}$ are of exponential order less than $1/\delta$.

Equation (13) is a conditional labor demand function that must hold in each period with an adjustment coefficient λ_1, so the lower the coefficient is, the faster is the speed of adjustment to equilibrium. It states that since λ_1, λ_2, and c_1 are positive, the firm's plan makes employment vary directly with respect to once-lagged employment, inversely with respect to the current and expected wage rates, and directly with respect to the current and expected technological shocks. The firm forms expectations of future variables and uses these expectations to formulate its optimal use of labor due to the presence of quadratic adjustment costs. Without quadratic adjustment costs of employment, expectations of future variables would be irrelevant: the firm could adjust the level of employment instantaneously whenever necessary.

The bargaining problem under the monopoly union model (3.2) then can be rewritten as a Lagrangian function.

$$\text{(14)}\quad \max \pounds = E_t \sum_{j=0}^{\infty} \Big[\delta^j L_{1t+j} (W_{1t+j} - W^*_{t+j}) - \mu_j \{ \lambda_1 L_{1t+j-1} - \frac{\lambda_1}{c_1} \sum_{i=0}^{\infty} \Big[\frac{1}{\lambda_2}\Big]^i \Big[E_{t+j} W_{1t+j+i} - E_{t+j} \theta_{1t+j+i} - a_1 \Big] - L_{1t+j} \} \Big],$$

where μ_j is the Lagrange multiplier attached in period $j=0, 1, 2, \cdots$.[5]

The first-order condition for this problem, for $j=0, 1, 2, \cdots$, is

$$\text{(15)}\quad E_{t+j}\Big[\sum_{i=0}^{\infty} \Big[\frac{1}{\lambda_2}\Big]^i \Big[W_{1t+j+i} - W_{2t+j+i} \Big]\Big] - \frac{c_1}{\lambda_1} L_{1t+j} = 0$$

2. The Demand for Labor in the Spot Sector

A firm's problem in the spot sector is to determine the demand for labor by solving (4), given the spot sector wage rate and N_{2t-1}. The Euler equation for this intertemporal optimization problem is

$$\delta c_2 E_{t+j} N_{2t+j+1} - (b_2 + c_2 + \delta c_2) N_{2t+j} + c_2 N_{2t+j-1} = W_{2t+j} - (a_2 + \theta_{2t+j}), \quad j=0, 1, 2, \cdots.$$

As in the union sector case, it is assumed that $\{N_{2t+j}\}$, $\{W_{2t+j}\}$, and $\{\theta_{2t+j}\}$ are of exponential order less than $1/\delta$. Then the solution to this Euler equation that satisfies the transversality condition yields a demand for labor equation in the spot sector,

$$\text{(16)}\quad N_{2t+j} = \gamma_1 N_{2t+j-1} - \frac{\gamma_1}{c_2} \sum_{i=0}^{\infty} \Big[\frac{1}{\gamma_2}\Big]^i \Big[E_{t+j} W_{2t+j+i} - E_{t+j} \theta_{2t+j+i} - a_2 \Big], \quad j=0, 1, 2, \cdots,$$

where $1 - \frac{b_2/c_2 + 1 + \delta}{\delta} B + \frac{1}{\delta} B^2 = (1 - \gamma_1 B)(1 - \gamma_2 B)$ and $0<\gamma_1<1<1/\delta<\gamma_2$.

[5] This problem can be solved by either a Lagrangian function or a dynamic programming technique. For the latter, see Appendix.

The case in which no adjustment costs are incurred by spot sector firms follows from the standard static maximization problem, or directly from the above Euler equation. The labor demand equation for this case, by setting $c_2 = 0$ and dividing by $b_2 > 0$ in the Euler equation, is

$$(17)\quad N_{2t+j} = -\frac{1}{b_2}(W_{2t+j} - a_2 - \theta_{2t+j}), \quad j = 0, 1, 2, \cdots,$$

where $a_2 + \theta_{2t+j} > W_{2t+j}$. Therefore spot sector employment varies inversely with a spot sector wage rate and varies directly with a technological shock.

3. Equilibrium of the Model

The equilibrium of dynamic segmented labor markets with a monopoly union in the union sector is a sequence of functions, $\{L_{1t+j}, N_{1t+j}, N_{2t+j}, W_{1t+j}, W_{2t+j}\}_{j=0}^{\infty}$, such that it satisfies the following conditions, given L_{1t-1} and N_{2t-1},

(i) the solution to the bargaining problem of a trade union (3.2), that is equations (13) and (15),

(ii) the solution to the firm's maximization problem in the spot sector (4), that is

(a) the spot sector firm is always on its dynamic labor demand schedule (16) when there exist adjustment costs, or

(b) the spot sector firm is always on its static labor demand schedule (17) when there exist no adjustment costs,

(iii) the intersectoral equilibrium condition (7), and

(iv) the labor endowment constraint (8).

IV. THE MONOPOLY UNION MODEL: A SIMULATION ANALYSIS

1. The System

Since the analysis is not affected a lot by the presence of adjustment costs in the spot sector (see Hahn, 1991), this section, for simplicity, assumes that spot sector firms do not incur adjustment costs when they change the level of employment. The system for this case then consists of equations (7), (8), (13), (15) and (17).

To determine union sector employment and the union sector wage rate for the monopoly union case, it is necessary to substitute (15) into (13). Then union sector employment becomes

$$(18)\quad L_{1t+j} = \frac{1}{2}\left[\lambda_1 L_{1t+j-1} - \frac{\lambda_1}{c_1} E_{t+j} \sum_{i=0}^{\infty}\left[\frac{1}{\lambda_3}\right]^i \left[W_{2t+j+i} - \theta_{1t+j+i} - a_1\right]\right], \quad j = 0, 1, 2, \cdots.$$

Substituting (18) into (15) to obtain the union sector wage rate yields

$$(19)\quad E_{t+j}\sum_{j=0}^{\infty}\left[\frac{1}{\lambda_2}\right]^i W_{1t+j+i} = \frac{c_1}{2}L_{1t+j-1} + \frac{1}{2}\left[E_{t+j}\sum_{j=0}^{\infty}\left[\frac{1}{\lambda_2}\right]^i \left[W_{2t+j+i} + \theta_{1t+j+i} + a_1\right]\right], \quad j=0,\ 1,\ 2,\ \cdots.$$

Equation (19) fails to give a reduced form of the union sector wage rate for a certain period. Instead it states that the present value of current and expected future union sector wage rates is a function of once-lagged employment and the present value of expected future spot sector wage rates and technological shocks. Thus further operation is necessary to get the reduced form of the union sector wage rate for a certain period.

Equation (19) can be rewritten as follows:

$$(20)\quad \left[\frac{1}{1-\lambda_2^{-1}B^{-1}}\right]E_{t+j}W_{1t+j} = \frac{1}{2}\left[\frac{1}{1-\lambda_2^{-1}B^{-1}}\right]E_{t+j}(W_{2t+j} + \theta_{1t+j} + a_1) + \frac{c_1}{2}L_{1t+j-1},$$

where B is the backward operator, that is $B^{-i}E_tW_t = E_tW_{t+i}$.

Operating both sides of (20) with an inverse of $\frac{1}{1-\lambda_2^{-1}B^{-1}}$ yields

$$E_{t+j}W_{1t+j} = \frac{1}{2}E_{t+j}[W_{2t+j} + \theta_{1t+j} + a_1] + \frac{c_1}{2}\left[\frac{1}{1-\lambda_2^{-1}B^{-1}}\right]^{-1}L_{1t+j-1},$$

or,

$$(21)\quad W_{1t+j} = \frac{1}{2}(W_{2t+j} + \theta_{1t+j} + a_1) + \frac{c_1}{2}(L_{1t+j-1} - \frac{1}{\lambda_2}L_{1t+j}),$$

for all $j=0, 1, 2, \cdots$, since $\left[\frac{1}{1-\lambda_2^{-1}B^{-1}}\right]^{-1} = 1-\lambda_2^{-1}B^{-1}$. Euqations (18) and (21) now determine union sector employment and the union sector wage rate under the dynamic monopoly union model.

For the purpose of a simulation analysis, expectation operators in equation (18) should be eliminated. A promising approach is to assume the stochastic structures of variables with expectations are AR(1) processes. That is,

$$\theta_{1t} = \rho_1 \, \theta_{1t\text{-}j} + \eta_{1t},$$
$$\theta_{2t} = \rho_2 \, \theta_{2t\text{-}j} + \eta_{2t\text{-}1},$$
$$W_{2t} = \rho_0 \, W_{2t} + \eta_{0t},$$

where $|\rho_0|$, $|\rho_1|$, and $|\rho_2| < 1/\delta$ and η_{0t}, η_{1t}, and η_{2t} are serially and mutually uncorrelated innovations. Using the Wiener-Kolmogorov formula and the Hansen-Sargent formula gives

$$L_{1t+j} = \frac{1}{2}\Bigg[\lambda \, L_{1t+j} - \frac{\lambda_1}{c_1}\frac{\lambda_2}{\lambda_2 - \rho_0} W_{2t+j} + \frac{\lambda_1}{c_1}\frac{\lambda_2}{\lambda_2 - \rho_1}\theta_{1t+j} + \frac{\lambda_1}{c_1}\frac{\lambda_2}{\lambda_2 - 1} a_1\Bigg], \tag{22}$$

for j = 0, 1, 2, ….. Now equations (21) and (22), along with (7), (8), (17) constitute the system that will be used for the simulations of the dynamic segmented labor market model with a monopoly union.

Eliminating the serial correlation in technological shocks and representing equations as functions of serially uncorrelated innovations yields a VAR(2) model. Only $L_{1t+j\text{-}2}$ enters equations of the VAR(2) whereas $W_{1t+j\text{-}2}$, $W_{2t+j\text{-}2}$, and $N_{2t+j\text{-}2}$ do not enter any of the above equations of the VAR(2).

2. The Dynamic Effects of Shocks

To investigate the effects of shocks and to see the dynamic adjustment paths the two sectors follow, a simulation method is used. The parameter values used in the simulations are chosen so that they satisfy the model restrictions and summarized in Table 1. Some of them are obtained from existing empirical studies

[**Table 1**] Parameter Values

Parameter	Name	Value
$\overline{N}$	labor force	10
δ	discount factor (quarterly)	0.99
$a_1 = a_2$	revenue function parameter	7
$b_1 = b_2$	revenue function parameter	0.5
c_1	adjustment cost parameter	2
λ_1	adjustment coefficient	0.61
b	unemployment benefits	1
ρ_0	coefficient of AR(1)	0.9
$\rho_1 = \rho_2$	coefficient of AR(1)	0.6

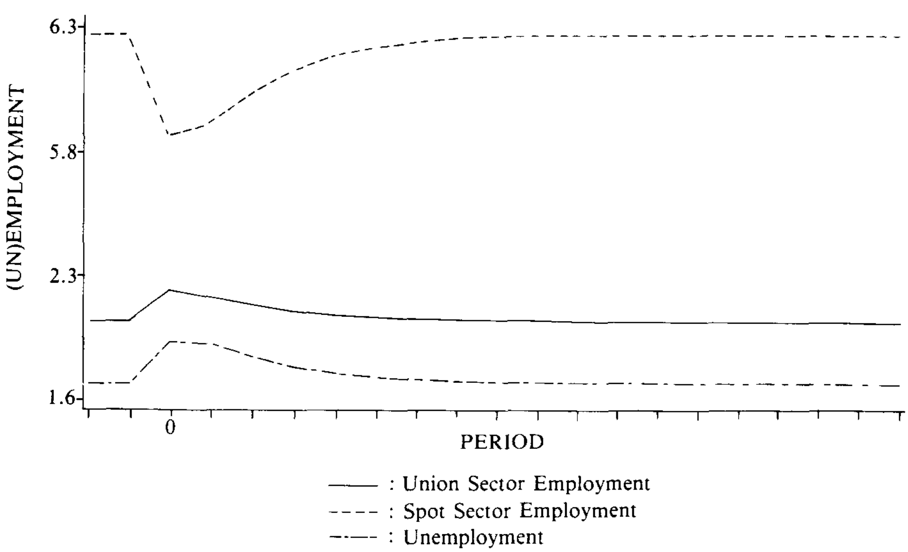
and some of them are arbitrarily chosen. Note that the simulation results are quite robust to the parameter values used.

A Union Sector-specific Shock

Suppose that the economy is in equilibrium, in which there are no disturbances and no labor relocations. The equilibrium is then disturbed by shocks in the economy. First, suppose that the shock is union sector-specific. When a positive union sector-specific shock hits the economy, workers migrate from the spot sector to the union sector, resulting in higher union sector employment and lower spot sector employment.[6] The simulation for this case is presented in Figure 1.

Note that unemployment increases in this case. This happens because the union attempts to derive higher wage rates and thus the union sector fails to fully absorb the migrants from the spot sector into employment. As a result, economy-wide unemployment increases even with a positive shock if it is union sector-specific. On the other hand, wage rates of both sectors increase in response to a positive union sector-specific shock. The effects of this shock gradually diminish unless the shock is permanent.

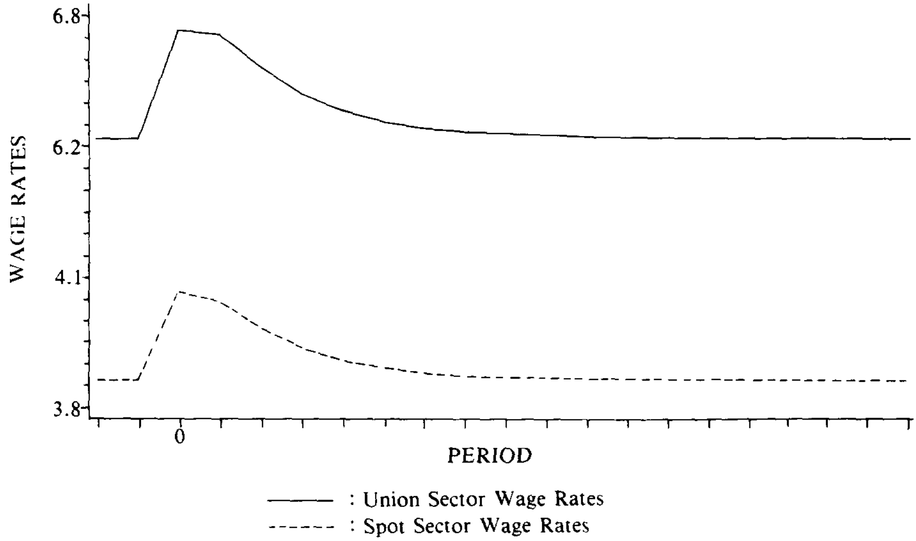
[**Figure 1a**] Effects of a One-period Shock to the Union Sector



Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

[6]Workers move in response to small transitory shocks as well as permanent shocks to the economy because no mobility costs are incurred by workers. In general, the factors that prohibit workers from moving in response to small transitory shocks are mobility costs, search costs, worker-firm attachments, imperfect information, and so on.

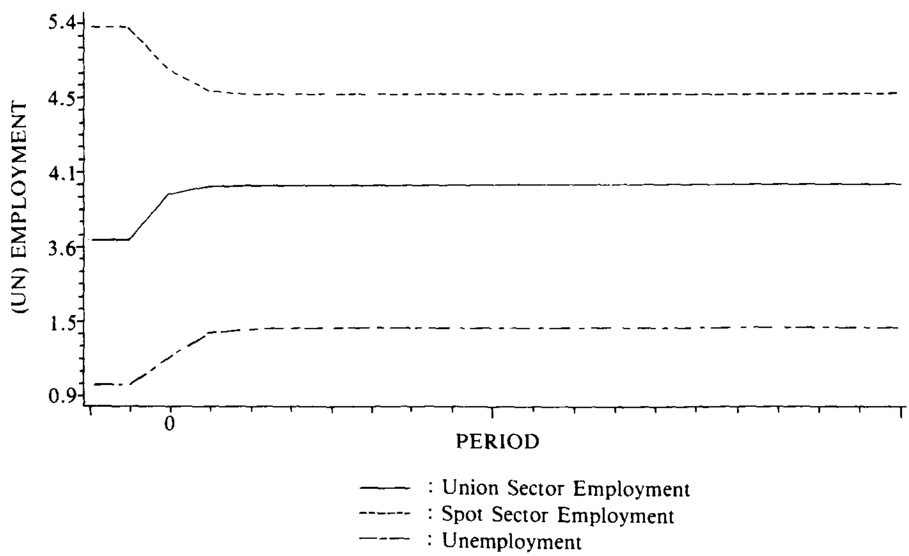
[**Figure 1b**] Effects of a One-period Shock to the Union Sector



Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

Figrue 2 shows the simulation results for the case in which a permanent and positive union sector-specific shock hits the economy. This shock causes the union

[**Figure 2**] Effects of a Permanent Shock to the Union Sector



Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

sector to expand and the spot sector to contract. Like the case of a transitory union sector-specific shock, contemporaneous unemployment jumps. It approaches the new steady state value which is obviously higher than that before the positive shock. Note that union sector wage rates rise more and union sector employment less when the positive technological shock is temporary than when the positive technological shock is permanent because workers' horizons make them increase wage rates rather than employment when the shock is perceived to be temporary.

The simulation results in Figures 1 and 2 suggest the importance of sectoral analysis. When the shock is union sector-specific, the effects of the shock are transmitted from the union sector to the spot sector through intersectoral relocation of labor. A positive union sector-specific shock stimulates the labor movement to the union sector, yielding a higher level of unemployment. As a result, the spot sector contracts while the union sector expands.

The implication that a positive union sector-specific shock is a cause of high unemployment is consistent with the argument by Lilien (1982), Davis (1986), and Davis and Haltiwanger (1990), stating that the shifts in product demand or technical change require large movements of labor across sectors (firms) and thereby unemployment is likely to increase. The economy is continuously adjusting the size of employment in response to the sectoral shock and this sectoral shock has adverse aggregate consequences in terms of economy-wide unemployment.

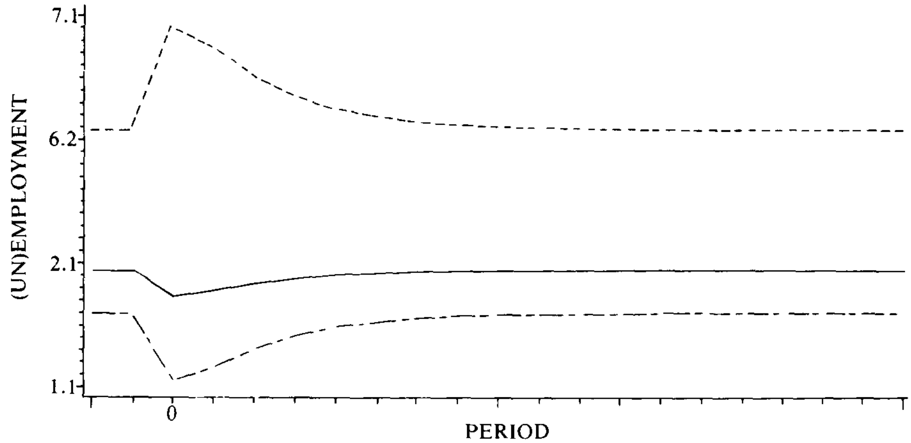
This model, however, should be distinguished from the previous sectoral shift models by Lucas and Prescott (1974), Rogerson (1987), Hamilton (1988), and Davis and Haltiwanger (1990) who regard time-consuming mobility of workers as the source of slow movements. In other words, they assume that workers changing sectors are necessarily idle for one period. On the other hand, the source of slow adjustment is the quadratic adjustment costs of firms in this model.

The second distinction from the preceding models is that in their models, the number of newly unemployed workers necessarily equals the number of migrants who change sectors since migrants are assumed to be idle in that period, which is clearly absurd. The present model shows that those two numbers are not necessarily identical. Furthermore, unemployment always rises whenever there exists a relative sectoral shock in the preceding sectoral models since it always causes the movement of workers. However, this model shows that it depends on the sectoral origin of the shock. A positive spot sector-specific shock does not increase unemployment but decreases it, as will be shown below; only a positive union sector-specific shock increases unemployment.

A Spot Sector-specific Shock

Figure 3 shows the simulation results for the case in which a temporary shock is positive and spot sector-specific. In this case, $\rho_1 = \eta_{1t+j} = 0$ in equation (22) and thereby both spot sector employment and union sector employment are AR (1) processes. A positive shock tightens the spot sector and thus raises the spot sector

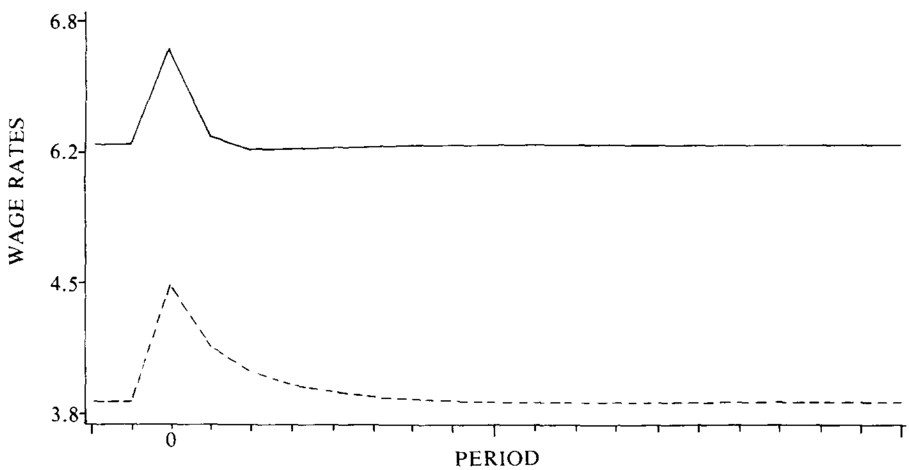
[**Figure 3a**] Effects of a One-period Shock to the Spot Sector



——— : Union Sector Employment
------ : Spot Sector Employment
—-— : Unemployment

Notes: A positive shock hits the spot sector only in period 0.
The scale of the vertical axis varies.

[**Figure 3b**] Effects of a One-period Shock to the Sport Sector

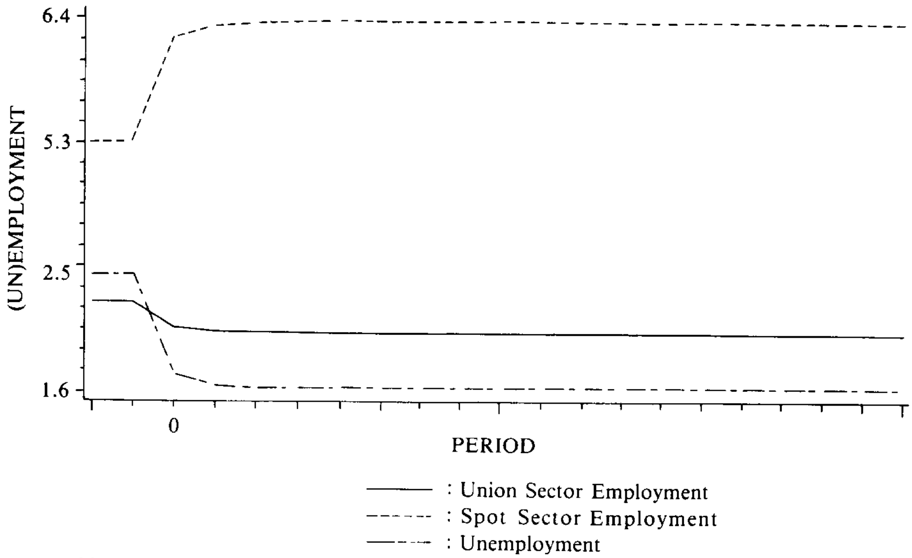


——— : Union Sector Wage Rates
------ : Spot Sector Wage Rates

Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

wage rate, which induces workers to move from the union sector to the spot sector, resulting in lower union sector employment and higher spot sector employ-

[**Figure 4**] Effects of a Permanent Shock to the Spot Sector



Notes: A positive shock hits the spot sector only in period 0.
The scale of the vertical axis varies.

ment. Like the previous case, both the union sector and the spot sector wage rates move procyclically, but unlike the previous case, unemployment falls. In other words, the expansion of the spot sector not only fully absorbs the unemployed moving from the union sector but also dominates the decrease in union sector employment resulting from the increase in union sector wage rates.

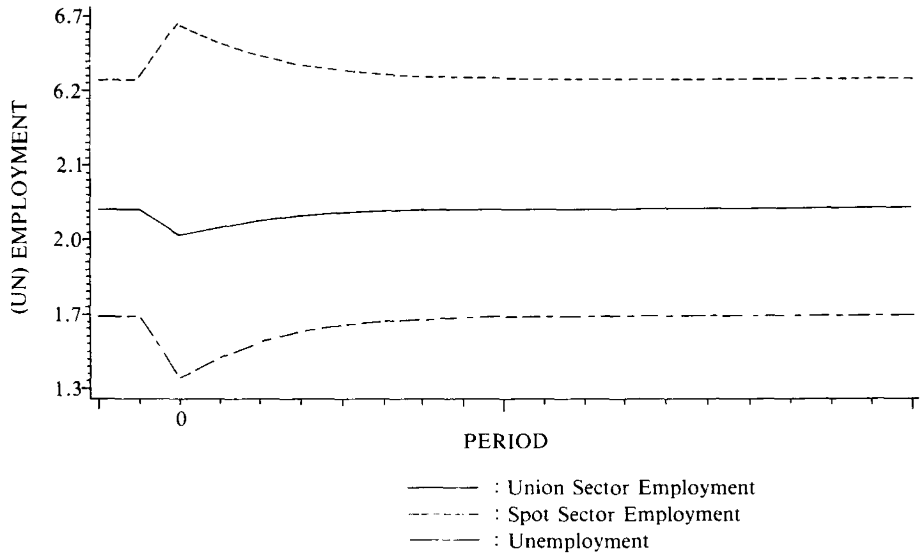
Figure 4 shows the simulation results for the case in which a positive spot sector-specific shock is permanent. As expected, the spot sector expands and the union sector shrinks. The steady state rate of unemployment is lower than that before the shock.

Comparing the simulations resulting from the two kinds of shocks leads to the conclusion that sectoral relative shocks affect the economy in quite different ways, according to whether they are spot sector-specific or union sector-specific. A positive spot (union) sector-specific shock brings about the relocation of the labor force toward the spot (union) sector and reduces (increases) total unemployment in the process of intersectoral relocation.

An Aggregate Shock

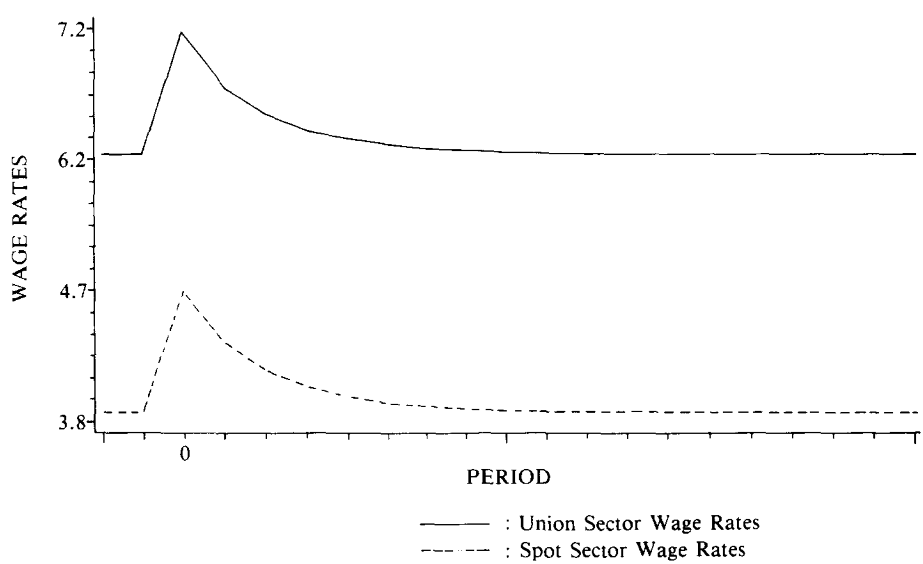
The result in Figure 5, which shows the simulation result for the case in which the economy experiences an aggregate shock, demonstrates that union sector employment decreases and spot sector employment increases. As a consequence, unemployment decreases as is expected; total employment behaves procyclically. Although a positive shock is common to both sectors, the shock affects the two

[**Figure 5a**] Effects of a One-period Aggregate Shock



Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

[**Figure 5b**] Effects of a One-period Aggregate Shock



Notes: A positive shock hits the union sector only in period 0.
The scale of the vertical axis varies.

sectors in quite different ways because the two sectors are asymmetric.[7] It tightens the spot sector and thus increases both spot sector employment and spot sector wage rates as a standard theory predicts: the spot sector fluctuates procyclically. On the other hand, it decreases union sector employment and increases union sector wage rates because the union raises wage rates. As a result of the bargaining process, union sector employment shrinks and some unemployed workers and newly fired workers are absorbed by the spot sector so that economy-wide unemployment falls.

However, this is not always the case. The simulation result for very low c_1, with the other parameters unchanged, tells that both union sector employment and spot sector employment increase and that unemployment decreases. What happens, and must happen is that a positive effect on the demand for employment of union sector firms is so strong that it dominates a negative effect caused by an increased wage rate. Summing up, the spot sector and economy-wide employment are procyclical whereas union sector employment is ambiguous.[8]

Countercyclical Wage Differentials

This model is also able to account for the countercyclical behavior of wage differentials. Figure 6 presents dynamic effects of intersectoral wage differentials when a positive and permanent aggregate shock is realized. Before the shock, the equilibrium wage differential was about 32 percent. With a positive shock (thus the labor market tightens), it declines and then converges to a new equilibrium wage differential, say about 27 percent. Therefore, the present model accounts for a stylized fact of the labor market that intersectoral wage differentials fluctuate countercyclically.

It is worth noting that the wage differential exists in equilibrium and it persists. A wage differential is not a result emerging from a temporary disequilibrium. There is no equilibrating force to eliminate the intersectoral wage differential; it is an equilibrium wage differential. When temporary shocks hit the economy, the wage differential temporarily deviates from the equilibrium wage differential but eventually converges to the equilibrium wage differential. This means that the actual wage differential observed in a certain period is the sum of the equilibrium wage differential and the temporary deviation.

Notice that policies directed at reducing the wage differential may have harm-

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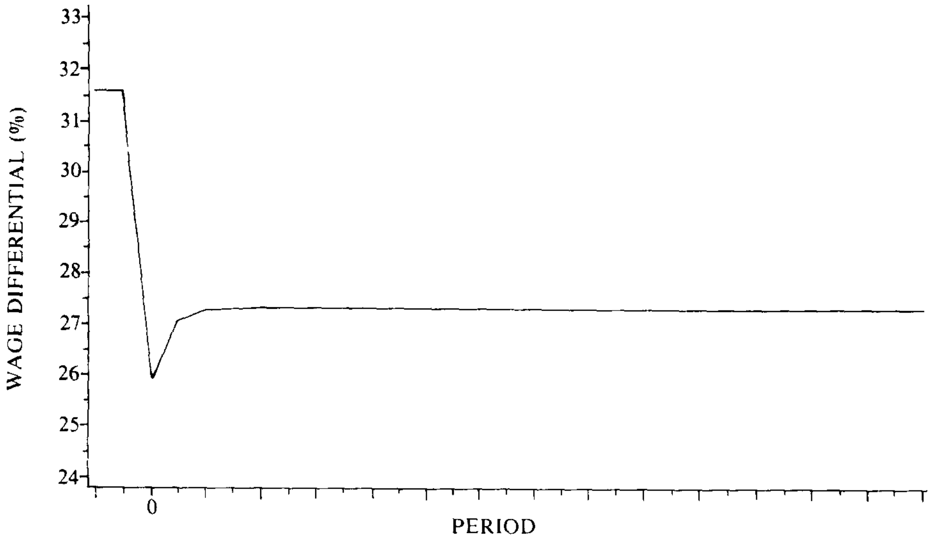
[7]Abraham and Katz (1986) criticize Lilien (1982), pointing out that an aggregate shock, when sectors are different in sensitivity to shocks, can increase the dispersion of employment growth rates which is regarded as a proxy for sectoral shifts by Lilien. The simulation result in this section shows that this is indeed the case and that Lilien's interpretation of the result should be modified to the extent that sectors are heterogeneous.

[8]Considering that the value for adjustment costs, which makes the second case possible, is too low from the empirical viewpoint, it seems to be that the first case (that is, Figure 5a) is the case.

[**Figure 6**] Wage Differentials



Notes: A positive and permanent aggregate shock in period 0.

ful effects. If government policies set the spot sector wage rate at the union sector wage rate to eliminate the wage differential, the bargaining process would again yield a higher union sector wage rate with a positive wage differential. And thus the average wage rate would rise without reducing the wage differential.

V. CONCLUSIONS

There has been no theoretical model that explains the countercyclical behavior of wage differentials between union and nonunion sector wage rates, the dynamic and cross effects of unionism on the nonunion spot sector, and so on. This paper develops dynamic segmented labor market models and carries out the simulation analysis for the dynamic monopoly union model only, combined with a standard nonunion spot sector model.

Segmented labor market models motivated by the fact that labor markets are heterogeneous provide very different macroeconomic implications than do traditional homogeneous labor market models. Actually, the models developed in this paper suggest several macroeconomic features that were largely ignored in earlier works on the labor market.

First, segmented labor market models are able to account for cyclical fluctuations caused by aggregate shocks without introducing ad hoc assumptions. The anlaysis of segmented labor markets suggests that not only sector-specific shocks but also aggregate shocks are an important cause of cyclical fluctuations. Differences between the wage-setting behaviors of the union and the nonunion spot sectors make unemployment and wage rates fluctuate even when aggregate shocks are realized. This contrasts sharply with earlier studies of cyclical fluctuations that have made ad hoc assumptions to show that aggregate shocks cause fluctuations in unemployment.

Second, the coexistence of high wage and low wage industries makes problems more difficult to deal with and complicates the analysis of macroeconomic policies. Some policy implications follow from this. Policies directed at reducing the wage differential may increase both wage rates and unemployment without reducing the wage differential. Such policies make unions increase their wage rates, thus decreasing employment and increasing unemployment. Furthermore, policies directed at tackling the problem of a sector may have deleterious effects due to the interaction of the two sectors which behave quite differently.

A third macroeconomic implication of segmented labor market models is that they can provide a simple tool to explain flows of workers. From a macroeconomic viewpoint, the labor market is characterized by large flows of workers not only between employment and unemployment but also between one sector and another. Technological shocks, whether they are sector-specific or aggregate, affect the demand for labor and thus the probability of employment. This in turn affects the labor supply. This mechanism generates the large labor market flows of workers in this paper.

APPENDIX
Derivation of Equation (15)

The monopoly union model (3.2) can be solved by a dynamic programming technique. Let g denote the right side of the constraint in equation (3.2) or equivalently, the right side of (13), say

$$L_{1t+j} = g(W_{1t+j+i};\ L_{1t+j-1})$$

Then Bellman's equation for the maximization problem (3.2) is

$$\text{(A.1)} \qquad V(L_{1t-1}) = \underset{W_{1t}}{\text{mas}}\{z_t + \delta E_t V(L_{1t})\}$$

$$= \underset{W_{1t}}{\max}\{g(\cdot;L_{1t-1})\ (W_{1t} - W_t^*) + \delta E_t V(L_{1t})\}.$$

The first-order necessary condition for the problem on the right side of (A.1) is

$$\text{(A.2)} \quad \frac{\partial g(\cdot;\ L_{1t-1})}{\partial W_{1t}}\ (W_{1t} - W_t^*) + g(\cdot;\ L_{1t-1}) + \delta E_t\left[\frac{\partial V(L_{1t})}{\partial L_{1t}}\ \frac{\partial L_{1t}}{\partial W_{1t}}\right] = 0,$$

$$\text{where } \frac{\partial g(\cdot;\ L_{1t-1})}{\partial W_{1t}} = -\ \frac{\lambda_1}{c_1}\ .$$

And, off corners, the value function is differentiable and satisfies

$$\frac{\partial V(L_{1t-1})}{\partial L_{1t-1}} = \frac{\partial g(\cdot;\ L_{1t-1})}{\partial L_{1t-1}}\ (W_{1t} - W_t^*) + \delta E_t\ \frac{\partial V(L_{1t})}{\partial L_{1t}}\ \frac{\partial L_{1t}}{\partial L_{1t-1}}$$

or

$$\text{(A.3)} \qquad \frac{\partial V(L_{1t-1})}{\partial L_{1t-1}} = \lambda_1\ (W_{1t} - W_t^*) + \delta\ \lambda_1 E_t\left[\frac{\partial V(L_{1t})}{\partial L_{1t}}\right],$$

$$\text{since } \frac{\partial g(\cdot;\ L_{1t-1})}{\partial L_{1t-1}}\ \lambda_1.$$

Substituting (A.3) into (A.2) yields

$$\text{(A.4)} \qquad -\ \frac{\lambda_1}{c_1}\ (W_{1t} - W_t^*) + L_{1t} + \delta\ E_t\Big[\ \lambda_1\ (W_{1t+1} - W_{t+1}^*)_{c_1}$$

$$+\delta\lambda_1 \frac{\partial V(L_{1t+1})}{\partial L_{1t+1}}\Bigg]\left[-\frac{\lambda_1}{c_1}\right]=0.$$

It follows immediately from (A.3) that

$$\frac{\partial V(L_{1t+1})}{\partial L_{1t+1}} = \lambda_1 (W_{1t+2} - W^*_{t+2}) + \delta\lambda_1 E_{t+2}\left[\frac{\partial V(L_{1t+2})}{\partial L_{1t+2}}\right]$$

$$= \lambda_1 (W_{1t+2} - W^*_{t+2}) + \delta\lambda_1 E_{t+2}\left[\lambda_1 (W_{1t+3} - W^*_{t+3}) + \delta\lambda_1 E_{t+3}\left\{\frac{V(L_{1t+3})}{\partial L_{1t+3}}\right\}\right]$$

$$= \cdots\cdots$$

$$= \sum_{i=2}^{\infty} \delta^{i-2}\lambda_1^{i-1} (W_{1t+i} - W^*_{t+i}).$$

Therefore,

$$\delta\lambda_1 E_t\left[\frac{\partial V(L_{1t+1})}{\partial L_{1t+1}}\right] = E_t \sum_{i=2}^{\infty} \delta^{i-1}\lambda_1^i (W_{1t+j} - W^*_{t+i})$$

Then the term in the bracket of equation (A. 4) becomes

$$E_t\left[\lambda_1 (W_{1t+1} - W^*_{t+1}) + \delta\lambda_1 \frac{\partial V(L_{1t+1})}{\partial L_{1t+1}}\right]$$

(A. 5)

$$= E_t\left[\sum_{i=1}^{\infty} \delta^{i-1}\lambda_1^i (W_{1t+i} - W^*_{t+i}).\right]$$

Substituting (A. 5) into (A. 4) to obtain

(A. 6) $$-\frac{\lambda_1}{c_1} E_t \sum_{i=0}^{\infty} (W_{1t+i} - W^*_{t+i}) (\delta\lambda_1)^i + L_{1t} = 0.$$

By using $W^*_{t+j} = W_{2t+j}$ for all j and $\lambda_1 \lambda_2 = 1/\delta$, equation (A. 6) can be rewritten as follows.

$$E_{t+j} \sum_{i=0}^{\infty}\left[\frac{1}{\lambda_2}\right]^i W_{1t+j+i} = E_{t+j} \sum_{i=0}^{\infty}\left[\frac{1}{\lambda_2}\right]^i W_{2t+j+i} + \frac{c_1}{\lambda_1} L_{1t+j},$$

j = 0, 1, 2, ⋯, which turns out equation (15).

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