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DYNAMICS OF UNEMPLOYMENT, VACANCIES
AND REAL WAGES WITH TRADE UNIONS

by

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Abstract

This paper considers the response of wages, unemployment and vacancies to shocks when the number of job slots and real wages are determined by a Nash bargain between a firm and a small union. Unemployment and vacancies co-exist because of search considerations. There is a unique "natural" unemployment rate that ensures that every firm-union's bargained wage is stationary. Shocks that are eventually absorbed by wages cause deviations of unemployment from its natural rate, because the firm-union initial response to a shock is to change vacancies (and possibly wages), which cause changes in unemployment flows via the search process.

In this paper we develop an equilibrium bargaining model for an economy with many firms and trade unions that rationalizes two old-fashioned, and yet still widely discussed views about the labour market. The first and perhaps less widely held view is that trade union negotiators are interested in other unions' nominal wages, at least as much as they are interested in consumer prices. Keynes (1936, Chapter 2) was the first economist to popularize this view, when he argued that labour's main concern is its relative wage, not its real wage. Early rationalizations (e.g. Leontief 1936; Tobin 1947) attributed this view to money illusion, which went against most economists' beliefs of how people behaved and was consequently abandoned. Later, search theory was invoked as carrying this prediction, because a worker's concern is what he is offered at the job compared with what he can get elsewhere (Alchian 1970, Leijonhufvud 1968, pp.75-81). More recently, some authors have returned to the idea by inserting the wage paid elsewhere as a variable in unions' utility functions (Oswald 1979, Gylfason and Lindbeck 1984). It is fair to say, however, that the idea that unions care about other unions' wages has not found a happy home in neoclassical theory.

The second idea explored and rationalized in this paper is that real wages do not respond quickly to unanticipated shocks, and that a change in unemployment is often a prerequisite to real wage adjustment. This idea was behind Lipsey's (1960) view of the inflation-unemployment trade-off but it was better expressed by Phelps (1970) and Friedman (1968) in the expectations-augmented version of the Phillips curve. Shocks that require a real-wage adjustment, such as real

shocks, or unexpected shocks to prices that throw the real wage off-balance, require temporary deviations of unemployment from "natural" equilibrium.

Unemployment acts as a channel through which real wage adjustments are effected.

Rational expectations theory has forcefully criticised this view. The argument is that rational negotiators will by-pass unemployment, and renegotiate on the basis of "news". That is, if a shock has taken place, they will work out its effects on the equilibrium values of variables by applying their model of the economy, and they will renegotiate on the basis of these new equilibrium values. They will not wait until they see the effect of the shock on unemployment.

Recent evidence on the effect of monetary disinflation in the United States and Britain does not appear to be consistent with the view that changes in real wages are independent of unemployment. There is still widespread evidence that inflation changes faster when unemployment deviates from its natural equilibrium. The view that wage inflation, and consequently the level of the real wage, respond to shocks mainly after a change in unemployment is one that is not easy to refute (Buiter and Miller 1983; Perry 1983; Blanchard 1984).

In this paper both wages and employment are determined by Nash bargains between noncooperating pairs of firms and unions. A given pair cares about the wages negotiated elsewhere because they influence the union's threat point in the bargain. If agreement between a firm and a union fails, the union members will attempt to get jobs with other firms, where negotiations have led to agreement. These members will share in the wages negotiated elsewhere, because if employment is subject to turnover, they will stand a chance of taking one of the jobs vacated by quitting workers. Hence the union's threat point depends on the employment rate elsewhere, the wage paid and the workers' income during unemployment. We show that under these circumstances it is possible to write the negotiated wage between a firm and a union relative to the wage paid

elsewhere, with the factor of proportionality depending on the unemployment rate, the replacement ratio and some other parameters. Hence, the chosen nominal wages are deflated by nominal wages elsewhere, not by prices.

Contracts can be renegotiated at any time but we take it as axiomatic that a firm and a union will renegotiate the terms of their contract only after they observe changes in wages paid elsewhere and in unemployment, not on the basis of a future equilibrium value for each of these variables. To illustrate the point, suppose a change takes place in an exogenous variable and both the firm and the union understand well that the ultimate effect of that change will be a rise in money wages and no change in employment elsewhere in the market. The rational expectations solution for this case is that the firm and the union renegotiate on the basis of the ultimate equilibrium values for wages and unemployment elsewhere. In most models this solution is consistent, in the sense that if all firm-worker pairs renegotiated on the same basis, the economy would get instantaneously to the new equilibrium with higher money wages and constant employment.

In practical terms, however, what this solution requires in the present bargaining environment is that the union should be capable of drawing the firm into negotiations for raising wages, because in some future date wages elsewhere would be higher. But since wages elsewhere are important in the bargaining process only because they influence the union's threat point, it seems natural for the firm to refuse to engage in such negotiations, until it observes a stronger threat point for the union members. Union threats can be credible when the alternative opportunities are available, not when they are expected to be available at some future date. If all firm-union pairs behaved in this way the equilibrium could still be consistent, in the sense that for given wages and employment elsewhere at time t , the choice of

wages and employment by a firm-union pair at $t+\delta t$ is an efficient Nash bargain.

In this equilibrium, either wage changes elsewhere or employment changes could be the signal that induced the firm and the union to renegotiate. I develop below a model in which unemployment changes act as the mechanism through which wage changes come about, despite the fact that both wages and employment are negotiated by the firm and the union, not just wages as in some recent models. (Expected price inflation may be incorporated into contracts but since this issue is not important for our purposes we assume that there is no "core" inflation and consequently expected inflation is set equal to zero).

Stationary wage equilibrium is defined by equality of the wages chosen by all firm-union pairs. We show that there is a "natural" rate of unemployment, which depends on the replacement ratio, and which is the unique rate of unemployment consistent with real-wage stability. Real wages can change only if unemployment is different from its natural rate.

Stationary unemployment equilibrium is defined by the equality between the flow out of jobs and the flow into jobs. These flows are determined by simple "search technologies" - a constant fraction of job-worker pairs is broken up in any short period of time and a new number of pairs that depends on the number of vacancies and unemployed workers form. What ensures that the unemployment rate at which inflows and outflows are equal is the natural rate, consistent with wage stability is the number of vacancies. We show that there is a unique stable equilibrium for unemployment and wages consistent with a bargaining solution for both wages and jobs.

The way the model works out of equilibrium is as follows. Suppose a firm and a union observe an increase in the demand for output. Their first response is to open up more jobs at existing wages. With more jobs offered in the market vacancies rise and unemployment falls below the natural rate. Then

wages begin to rise. In response to the rise in wages, the firm and the union withdraw some vacancies and increase their own wage further. The withdrawal of vacancies checks the fall in unemployment and eventually reverses it. In the final equilibrium unemployment and vacancies return to their initial levels and real wages absorb the shock. Convergence is likely to be characterized by oscillations, but even without them the output shock results in a temporary (cyclical) increase in vacancies and fall in unemployment.

The next section describes in detail the bargaining model used for the determination of employment and wages at the level of the firm. Section II defines stationary equilibrium in the market as a whole and shows that it is consistent with the bargaining outcome. Section III moves from statics to dynamics and describes the adjustment paths in response to exogenous nominal and real shocks.

I. The Wage-Employment Bargain

Wages and the number of job slots (employment plus vacancies) are set by an efficient bargain between the firm and the union. Thus, the marginal product of labour is equal to labour's marginal outside return and wages are set by a Nash rule so as to share the net rents from production between the firm, as owner of capital, and its workers. The capital stock, both at the level of the firm and in the economy as a whole, is fixed, and so is the total labour force.

Each firm's labour force is subject to turnover. Workers leave, for reasons that we shall not specify, and new ones come to the firm applying for jobs. Thus the union's members are not always the same people. We assume for simplicity that the union does not discriminate between new and old members. All workers are paid the same wage and the union attaches equal weight to all workers in the wage bargain. Then, what determines union strength in the wage-employment bargain is the "threat point" for the union workers employed by the firm; i.e. their best alternative use if the employment contract with the firm fails.

We assume that labour's threat point is average income elsewhere in the market. Thus, let n_i be employment at the firm, w_i be the wage rate at the firm and w be the average wage elsewhere in the market. It is convenient to think of w_i and w as money wages and assume that there is no perfectly anticipated (core) inflation. Let also b be the replacement ratio (nominal unemployment benefits divided by w), u the level of unemployment and ℓ the labour force. Then average income elsewhere for the typical worker is $(1 - u/\ell + bu/\ell)w$, so the net surplus created by the wage-employment contract for the n_i employees is

$$U = n_i \left[w_i - \left(1 - \frac{u}{\ell} + \frac{u}{\ell} b \right) w \right] \quad 0 \leq b < 1. \quad (1)$$

The rate at which workers arrive to a firm to take jobs depends on the number of genuine job vacancies that the firm has. A genuine job vacancy is

one that represents a job slot with as much capital as one that is occupied and actively producing output. Thus, the firm allocates the same capital to all its job slots, regardless of whether they are occupied or not, and it is always willing to take on as many additional workers as the number of job vacancies that it has. If vacancies did not represent genuine labour needs the firm would be turning down workers applying for some of its advertised vacancies. Soon this policy would become known, and the firm would lose its reputation as one that would advertise only when it had genuine needs. Workers would then stop responding to its advertisements, and long run profits would suffer (see Jackman, Layard and Pissarides, 1984).

Suppose then, that if the firm's capital stock is K_i , and if it has n_i employees and v_i vacancies, its capital per man is $K_i/(n_i + v_i)$. Hence total output is $F(n_i, n_i K_i/(n_i + v_i))$, where $F(\cdot)$ is the production function. The rate at which workers arrive to the firm is $q v_i$, where q is a number less 1 and it depends positively on the aggregate unemployment/vacancy (u/v) ratio. The functional form of q depends on the "technology of search". For the purposes of this paper we simply postulate that the more job searchers there are in relation to job vacancies, the more likely is a job vacancy to be searched. The firm cannot control the rate at which workers arrive to individual vacancies, so there are no reputations concerning high wage and low wage firms. Since in equilibrium all firms will negotiate the same wage this does not seem particularly restrictive. Also, we simplify matters by assuming that the intensity of search is constant. In more general models the intensity of search would enter as a shift variable in the $q(\cdot)$ function, but these considerations are of secondary concern in the model of this paper (but see Jackman, Layard and Pissarides 1984).

Workers leave the firm at the constant rate s . Assuming that s depends on the u/v ratio, like q but in the opposite direction, would be a trivial extension not worth pursuing. Assuming that s depends on the negotiated wage rate would be a more substantial extension. However, the extension is not so

compelling in the model of this paper, since the wage rate is determined after bargaining, and not by a firm with monopsony power. It seems more straightforward to assume that the firm's labour force is characterized by "natural wastage" at the constant rate s .

Thus, workers come to the firm at the rate qv_i , and leave at the rate sn_i , with both q and s outside the control of the firm. A firm that is neither expanding nor contracting will experience, on average, equality between these two rates. We shall impose this equality as a constraint on the bargaining process, though in a stochastic world it will not be satisfied at all times. The results that we derive are ex ante equilibrium results which describe average behaviour for a typical union and firm, given the behaviour of the rest of the market. Changes in the negotiated outcome come about as responses to changes in the parameters of the problem and not as planned dynamic bargaining solutions in a dynamic environment. The most important of these parameters are the price of output and the endogenous economy-wide variables: unemployment, vacancies and wages paid elsewhere. This procedure, although not entirely satisfactory in an environment of far-sighted optimizing agents, is common practice in micro-oriented macro modelling. It buys considerable tractability for some loss of detail that would be of secondary importance in the workings of the macro model (see e.g. McDonald and Solow 1981, and almost any advanced macro textbook, e.g. Sargent 1979, Part I).

We incorporate the equilibrium constraint $qv_i = sn_i$ into the bargaining problem by introducing a new variable, the number of job slots at the firm, defined by $m_i = n_i + v_i$. Then employment at the firm is given, on average, by

$$n_i = \frac{q}{s + q} m_i. \quad (2)$$

The firm and the union negotiate about job slots, bearing in mind that the turnover process will fix employment according to (2).

With (2), the firm's production function becomes

$$F(\cdot) = F\left(\frac{q}{s+q} m_i, \frac{q}{s+q} K_i\right).$$

We assume that it is subject to constant returns to scale, so we write it as

$$F(\cdot) = \frac{q}{s+q} f\left(\frac{K_i}{m_i}\right) m_i \quad f' > 0 \quad f'' < 0. \quad (3)$$

The firm is the owner of capital and it negotiates with the union on capital's behalf. We assume that there is no market in second-hand capital, so if the firm fails to agree with the union about the employment contract its profits will be zero. This gives the firm's threat point. Its profit from agreement, in nominal terms to conform with (1), is simply

$$\Pi = p \frac{q}{s+q} f\left(\frac{K_i}{m_i}\right) m_i - \frac{q}{s+q} m_i w_i, \quad (4)$$

where p is the price of output.

The bargaining outcome is obtained by maximizing the generalized Nash function B with respect to m_i and w_i , where

$$B = U^\beta \Pi^{1-\beta} \quad 0 \leq \beta \leq 1. \quad (5)$$

The parameter β measures bargaining strength independently of the strength given by each side's threat points. In the symmetric Nash case, $\beta = 1/2$ and the two sides share the surplus equally; i.e. as we shall show below, when $\beta = 1/2$; $U = \Pi$. Then, only the threat points determine bargaining strength. Generalizing, the bargaining outcome with a flexible β gives a fraction β of the total surplus to labour. If $\beta = 1$ we have the monopoly union case, where the union maximizes the workers' net surplus subject to a zero-profit condition for the firm. If $\beta = 0$ we have the firm maximizing profits subject to an exogenously given wage rate that equals the worker's alternative return. In

this case the only stationary equilibrium wage rate is the one that is equal to the value from leisure.

Re-writing now the function (5) by using (1), (2) and (4), we obtain

$$B = \left[w_i - \left(1 - \frac{u}{\ell} + \frac{u}{\ell} b \right) w \right]^\beta \left[pf \left(\frac{K_i}{m_i} \right) - w_i \right]^{1-\beta} \frac{q}{s+q} m_i.$$

Maximizing with respect to m_i and w_i gives the first-order conditions

$$pf \left(\frac{K_i}{m_i} \right) - (1-\beta) pf' \left(\frac{K_i}{m_i} \right) - w_i = 0, \quad (6)$$

$$\beta pf \left(\frac{K_i}{m_i} \right) - w_i + (1-\beta) \left(1 - \frac{u}{\ell} + \frac{u}{\ell} b \right) w = 0. \quad (7)$$

The expression

$$pf \left(\frac{K_i}{m_i} \right) - pf' \left(\frac{K_i}{m_i} \right) \frac{K_i}{m_i}$$

is the marginal product of a job slot, which is proportional to the marginal product of labour (see (3)). Under simple profit maximization (corresponding here with the extreme value $\beta = 0$), the marginal product would have been equated to the wage w_i . However here, because of the firm-union bargain over employment, it is equated to labour's return outside the firm. Substitution of w_i from (7) into (6) yields

$$pf \left(\frac{K_i}{m_i} \right) - pf' \left(\frac{K_i}{m_i} \right) \frac{K_i}{m_i} - \left(1 - \frac{u}{\ell} + \frac{u}{\ell} b \right) w = 0. \quad (8)$$

Thus, the firm and the union look at how well workers can do outside the firm and open up jobs until their marginal product falls down to that level.

Condition (8) is our basic condition for jobs.

Condition (7) may also be written as

$$U = \beta(U + \Pi),$$

which shows that β stands for the share of labour in the total rents created by the employment contract. In terms of wage rates, (7) says that each worker

employed by the firm receives, in the first place, his outside return, and on top of this he receives a fraction β of the net surplus that he creates by giving up outside employment to work for the firm; in symbols,

$$w_i = (1 - \frac{u}{\ell} + \frac{u}{\ell} b)w + \beta \left[pf \left(\frac{K_i}{m_i} \right) - (1 - \frac{u}{\ell} + \frac{u}{\ell} b)w \right] \quad (9)$$

Equations (8) and (9) describe the behaviour of a single unionized firm when behaviour in the rest of the market is taken as given. The main market variables taken as given are wages elsewhere and unemployment, which will be endogenous in an equilibrium labour-market model, and the capital stock, the price of output, the labour force and the replacement ratio, which we shall take throughout to be exogenous.

The properties of the two endogenous variables, m_i and w_i , are easily obtained from (8) and (9). Thus, (8) and (9) can be thought of as two equations in two unknowns, capital per job K_i/m_i and real wages w_i/p , with two parameters, real labour income elsewhere $(1 - u/\ell + bu/\ell) w/p$ and bargaining strength β . Equation (8) solves K_i/m_i uniquely in terms of labour income. Hence, an increase in capital increases the number of jobs in the same proportion, whereas an increase in the replacement ratio or the real wage elsewhere and a decrease in the unemployment rate decrease the number of jobs, through their influence on the workers' alternative return. From equation (9), we then get that the capital stock does not influence the negotiated wage, whereas an increase in the alternative return or in labour's bargaining strength increases it. Bargaining strength as measured by β influences only the distribution of the rents from employment, not the number of jobs.

These results may appear reasonable for an individual firm-union pair, but they will not in general be correct in market equilibrium. We turn to this question presently.

II. Stationary equilibrium

Suppose for simplicity that all firms in the economy are identical: they have identical production functions, capital endowment K_i and output price p . Hence, they all choose the same capital/labour ratio and the same wage rate. The link between the individual optimization conditions (8) and (9) and the market aggregate comes from two sides. First, the number of job slots chosen by firms determines the number of vacancies, which influences the flow out of unemployment. Hence, the search-turnover process summarized in the probabilities q and s provides a link between total job slots m and u . Second, the market wage w is an average of all the individually chosen wages w_i , so if all firms are identical w_i and w must be equal in equilibrium.

Consider first the link between aggregate m and u . Since u is aggregate unemployment and the aggregate labour force ℓ is fixed, total employment is given by $\ell - u$. Hence, the flow into unemployment is $s(\ell - u)$. The number of vacancies in the market is given by total jobs minus employment, $m + u - \ell$. Since each vacancy is taken with probability $q(u/v)$, the flow out of unemployment is $(m + u - \ell) q(u/(m + u - \ell))$. Hence, in stationary equilibrium m and u are related by

$$(m + u - \ell) q(u/(m + u - \ell)) = s(\ell - u). \quad (10)$$

This gives an inverse relation between m and u : higher m implies more vacancies offered, and this increases the flow out of unemployment, reducing the stock.

It is instructive to consider the solution of the model when all market participants hold the same exogenous expectation about wages elsewhere; i.e. to ignore the link between w_i and w and treat w as a parameter. Then, (8) and (10) are two equations in the two unknowns, m and u (note that (8) holds for aggregate K and m too, because the ratio K_i/m_i is the same for all firms).

Since by (10) m and u are inversely related, (8) implies that an increase in K increases m and reduces u , an increase in the real wage w/p decreases m and increases u , and an increase in the replacement ratio also decreases m and increases u .

Substitution of the solutions for m and u into (9) gives the effect of these variables on the negotiated wage. An increase in b and w increase the wage, and an increase in K also increases the wage, an effect we did not have when u was treated parametrically. However, suppose now we impose the equilibrium requirement $w_i = w$, i.e. in equilibrium all agents hold correct expectations of wages elsewhere. This requirement could bring drastic changes to the nature of the solution.

To see this most clearly let α be the elasticity of $f(\frac{K}{m})$ with respect to its argument; i.e. define α by

$$\alpha\left(\frac{K}{m}\right) = f'\left(\frac{K}{m}\right) \frac{K}{m} / f\left(\frac{K}{m}\right).$$

If the production function is Cobb-Douglas α is a constant and equals the index coefficient of capital. More generally, α falls as K/m rises if the elasticity of substitution of the production function is greater than one, and it rises with K/m if the elasticity of substitution is less than one. Then, omitting the argument of α for simplicity we write (8) as,

$$f\left(\frac{K}{m}\right) = \frac{1 - (1-b)u/\ell}{1 - \alpha} \frac{w}{p}, \quad (11)$$

and so (9) implies

$$\frac{w_i}{w} = \frac{1 - \alpha(1-\beta)}{1 - \alpha} \left[1 - (1-b) \frac{u}{\ell} \right]. \quad (12)$$

Thus, if α and b are constant, the only endogenous variable that can yield so

as to satisfy the wage equilibrium condition is unemployment. But if unemployment is fixed by the wage equilibrium requirement then the turnover condition (10) determines the number of jobs, and so the wage rate is determined by the job condition (8) or (11). Thus there is a reversal of the conditions determining each market variable. What used to be the condition determining wages now determines unemployment; what used to determine job slots now determines wages.

Under this reversal equilibrium unemployment depends only on the constants α and β , and on the replacement ratio b . Equilibrium unemployment then conforms to the notion of a "natural" unemployment rate, since what determines it is the requirement that each firm's bargained wage correspond exactly to other firms' and workers' expectation of wages in the market. We shall have more to say about this later. What is more important here, is that supply and demand shocks that change output price or the capital stock do not influence equilibrium unemployment or vacancies (job slots), but affect only real wages. Vacancies, which are determined by (10), depend on the unemployment outcome and on the turnover parameters only, whereas real wages bear the whole brunt of output shocks through (11).

The requirements for these results are two, that the elasticity α be constant, i.e. the production function be Cobb-Douglas, and the replacement ratio b be constant, i.e. unemployment benefits and the implicit value of leisure during unemployment be fully indexed to the mean wage rate. Consider first the elasticity α and suppose the production function is not Cobb-Douglas. Then the capital stock and the turnover parameters influence equilibrium unemployment through their influence on K/m . The unemployment rate we get from (12) when $w_i = w$ is

$$\frac{u}{\ell} = \frac{\alpha\beta}{1 - \alpha(1-\beta)} \frac{1}{1-b}. \quad (13)$$

Unemployment increases in α , so if the elasticity of substitution is greater than 1 and α decreases in K/m , any factor that increases K/m , such as an exogenous increase in K or a decrease in turnover s , decrease unemployment. If, however, the elasticity of substitution is less than 1 the results are reversed.

Consider next the replacement ratio b , for a constant α . If we assume instead that b falls as the wage rate rises, i.e. that the value of leisure and unemployment benefits are not fully indexed to the wage rate, the variables that did not influence unemployment before now influence it via the wage rate. — For example, an increase in K increases the wage rate, so it reduces the equilibrium unemployment rate. Similarly, an increase in s increases m via (10) and so it reduces the wage rate. This increases unemployment via the effect on the replacement ratio.

In the dynamic analysis that follows we shall assume that both α and b are constant. This simplifies the analysis considerably and enables us to concentrate on the short-run effects of output shocks that would also be present if α and b were variable. What we lose are potential equilibrium effects of output shocks on vacancies and unemployment, and some additional adjustment effects that would result from them.

Of the two assumptions — constant α and b — perhaps the more serious one is that b is constant. Sufficient conditions for a constant α are a constant share of capital in output or a constant wage elasticity of employment. Neither seems to be too unreasonable as a first approximation, especially since the ambiguity that arises if the production function is not Cobb-Douglas does not enable us to say much about a potentially second-order effect. But the assumption that the replacement ratio is constant, although reasonable in the long run, is less appealing in a short-run analysis. Indeed some authors (e.g. McDonald and Solow, 1981) have made nonindexation a cornerstone

of some of their results in an efficient bargain model. In a model related to this one but with decentralized individual bargaining with perfect foresight I showed (Pissarides, 1984) that nonindexation of the alternative return is crucial in deriving the prediction that real wages are not fully responsive to output shocks in the short run. These results carry over to the present model if nonindexation is assumed. However, since we concentrate on other channels in this paper, it seems that the simplification of fully indexed benefits is worth having.

III. Short-Run Dynamics

The long-run equilibrium of this economy is given by the three equations (13), (10) and (11). The short-run dynamics originate in two sources. First, the turnover equation (10) holds only in a steady-state. If the economy is not in steady-state flows into unemployment may not be equal to flows out of unemployment and the adjustment to a steady-state equilibrium is not instantaneous. The search process that matches workers to jobs takes time, so in general

$$\dot{u} = s(\ell - u) - (m + u - \ell) q(u/(m + u - \ell)).$$

We assume that the "search technology" is linear, i.e.

$$vq\left(\frac{u}{v}\right) = \gamma(u + v) \quad 0 < \gamma < \frac{1}{2},$$

so the unemployment dynamics are given by the linear differential equation

$$\dot{u} = (s + \gamma)\ell - \gamma m - (s + 2\gamma)u. \quad (14)$$

In terms of unemployment and vacancies this equation becomes, given that

$$m = \ell - u + v,$$

$$\dot{u} = s\ell - \gamma v - (s + \gamma)u. \quad (15)$$

Second, there are money-wage dynamics that result from the wage-setting equation (12). The idea here is that the firm and the union negotiate a money wage on the basis of what they observe the money wage to be in the rest of the market, and not on the basis of what they perceive the money wage to be in an equilibrium state. There is continuous recontracting, so firms and workers are not stuck with a wage that was agreed upon on the basis of wrong expectations; i.e. information is not necessarily ignored. But if,

for example, there is an increase in the demand for output, the firm and the union do not immediately solve the new equilibrium model and renegotiate a wage on the basis of what they perceive the new equilibrium wage elsewhere to be. Instead, they renegotiate first on the basis of the new demand by taking the wage elsewhere as given, and subsequently revise their wage on the basis of what they are actually observing wages elsewhere to be.

This idea of wage dynamics is related to Keynes' view that unions are interested in their relative wage and they will not want to be the first ones to reduce wages when there is a decline in demand. Thus, our wage equation is one for a relative wage, not a real one; see (12). Even though unions may know that eventually w will fall, they do not immediately reduce w_i by the full amount of the expected fall in w , but change it smoothly so as to maintain their desired relative wage. The idea is also related to Hicks' (1974, Chapter 3) leap-frogging, where unions want to maintain a certain relative wage with respect to other unions, and if the relative wages chosen by all unions are not compatible, inflation or deflation results. This is the process that gives the money-wage dynamics in our model too. In terms of the Hicksian week, the bargaining may be thought of as taking place at the end of the week, on the basis of what the firm and the union observe wages elsewhere to be during the week. The wage they choose is the wage for the following week. If a typical firm-union pair chooses $w_i > w$, then wages will be bid up between weeks, and the rate of inflation will be $(w_i - w)/w$. Inflation will continue to take place for as long as the typical wage exceeds the average wage in the market, since the average wage in the market is made up of firms' and unions' choices (see also Phelps 1970, and Pissarides 1976, Chapter 14, for similar analyses of inflation). Hence in continuous time we write the proportional rate of money wage inflation when price inflation is expected to be zero, as

$$\frac{\dot{w}}{w} = \frac{w_i}{w} - 1:$$

Substituting w_i/w from (12) inflation becomes

$$\frac{\dot{w}}{w} = \frac{\alpha\beta}{1-\alpha} - \frac{1-\alpha(1-\beta)}{1-\alpha} (1-b) \frac{u}{\ell}. \quad (16)$$

The equation for wage dynamics conforms to the definition of the natural rate and has strong implications for the control of inflation. Thus, wage inflation is greater than its equilibrium value of zero if unemployment is less than its natural rate, given by (13). Starting from any stationary equilibrium, the only way to bring about a change in real wages is to push unemployment away from the natural rate temporarily, so as to induce money wage dynamics independently of prices. Despite the fact that there are autonomous unemployment dynamics governed by (15), it is the wage dynamics that determine equilibrium unemployment, not the unemployment flow dynamics. The unemployment dynamics are made to conform to the equilibrium requirement obtained from the wage condition by vacancies. These ideas are firmly in line with Phelps's (1970) and Friedman's (1968) view of how equilibrium wage and unemployment dynamics interact. They are also consistent with recent experience in Europe, where wage inflation declined only after unemployment rose (see, e.g., Buiter and Miller, 1983). They are not consistent with the Lucas-Sargent view that the announcement of policy changes could bring about instantaneous adjustments by step changes in negotiated wages. Equilibrating step changes in wages are excluded by the fact that unions and firms negotiate their wages on the basis of what wages are elsewhere, and not on the basis of what they perceive them to be in equilibrium.

One final link remains in the description of adjustment and this is provided by equation (11). Equation (11) holds at all times, in and out of long run equilibrium. The firm observes what unemployment and real wages are elsewhere in the market and chooses its number of job slots.

However, since the number of job slots will have to be given by equation (14), in equilibrium (11) becomes the equation for wages. Wages will change until the number of job slots consistent with stationary in (14) is precisely the number that firms would wish to choose according to (11).

It is now possible to sketch the adjustment process that takes place in response to various unanticipated shocks. We shall consider two permanent changes, an increase in the price of output and an increase in the capital stock.

An increase in the price of output will have no real effects in equilibrium. From the equilibrium equations (10), (11) and (13) it follows immediately that the only effect will be an increase in the money wage by the same proportion. But there will be real short-run effects, because money wages will not change without a temporary change in unemployment. Thus, when the increase in price is first observed, the firm and the union renegotiate, and their first reaction is to increase the number of job slots and the money wage rate. But if the production function is Cobb-Douglas, the money wage rate will not increase, because the increase in job slots (and employment) offsets the increase in average product caused by the price increase (see (8) and (9) in particular). So the initial impact of an increase in the price of output is an increase in vacancies for given employment. With more vacancies, more unemployed workers start finding jobs and unemployment begins to fall below the natural rate. This results in money-wage inflation which gradually increases the real wage, reducing the number of job slots. Eventually the withdrawal of jobs leads to an increase in unemployment back towards the natural rate. The process will converge to a new equilibrium with the same unemployment and vacancies as before, and with the money wage higher by the same proportion as the increase in prices.

We may sketch the adjustment paths in wage-unemployment and vacancy unemployment space. The wage dynamics are given by the linear differential equation (16). To express the unemployment dynamics in an equation linear in u and w we solve for m from (11) and substitute into (14). Noting that $f(K/m)$ is Cobb-Douglas with index coefficient α , we obtain

$$m = \left(\frac{1-(1-b)u/\ell}{1-\alpha} \frac{w}{p} \right)^{-\frac{1}{\alpha}} K. \quad (17)$$

Hence, in a linearized (14), w has coefficient $\gamma m / \alpha w$, with m and w evaluated at their equilibrium values, and u has coefficient

$$-\frac{\gamma(1-b)}{\alpha} \frac{m}{\ell-(1-b)u} - s - 2\gamma < 0,$$

with m and u also evaluated at equilibrium values. Hence the two-equation dynamic system (16) and (14) has coefficient matrix

$$\begin{pmatrix} 0 & -\frac{1-\alpha(1-b)}{1-\alpha} (1-b) \\ \frac{\gamma m}{\alpha w} & -\frac{\gamma(1-b)}{\alpha} \frac{m}{\ell-(1-b)u} - s - 2\gamma \end{pmatrix}.$$

The diagonal elements are non-negative and the determinant is positive, so the system is stable. However, the characteristic roots are almost certain to be complex, given realistic values of the parameters, so the equilibrium point is likely to be a spiral. These oscillations around the equilibrium point are not important for our argument.

In a w - u phase diagram (Figure 1), the $\dot{w} = 0$ locus is a vertical line at the natural unemployment rate. This line corresponds, vaguely, to the "long-run Phillips curve". The $\dot{u} = 0$ line is upward sloping, cutting the $w=0$ line at point A, the point of stationary equilibrium before the increase in prices. When prices rise, the $w=0$ line is unaffected, but the

$\dot{u}=0$ line shifts up by the proportional increase in p (this is easily seen by the fact that the $\dot{u}=0$ locus is an equation in w/p and u). Hence there is a new stationary equilibrium at point C, with the same unemployment and real wage as before. The economy moves from A to C via some point B, and approaches C asymptotically with oscillations. Thus, unemployment falls temporarily to induce the money-wage inflation.

In vacancy-unemployment space the response to the shock traces the familiar anti-clockwise loops around the "uv" locus. Thus, now the $\dot{u}=0$ line is derived from equation (15) as a negatively-sloped line, with slope $-(1+s/\gamma) < -1$ (see Figure 2). Vacancies are defined by

$$v = m - \ell + u, \quad (18)$$

with m given by (17). Hence $\partial v / \partial u > 1$ for given w . When p rises, w is temporarily unaffected and vacancies absorb all the shock. This gives a new locus for (18), lying above the old one, and an instantaneous equilibrium at point A', directly above A. However, A' will not last for more than an instant, for then unemployment will start falling and wages rising, moving the economy down towards point B. Point B corresponds to point B in Figure 1. In the transition from A' to B unemployment falls, but from point B unemployment starts rising towards the initial point A. As with the convergence in Figure 1, the return to point A in Figure 2 is likely to be characterized by dampening oscillations.

We consider finally the effects of a real shock on the system, which we take to be an increase in the exogenous capital stock K . From the equilibrium conditions (10) and (13), it follows that neither unemployment, nor vacancies are permanently affected by the shock. By contrast, (11) shows that in stationary equilibrium the real wage absorbs the entire shock: an increase

FIGURE 1

Unemployment and money-wage dynamics
in response to positive output shocks

FIGURE 2

Unemployment/vacancy dynamics in response
to a positive output shock

in K increases w/p unambiguously. The adjustment problem is, as in the case of a change in the price of output, how to induce firms and unions to negotiate a new wage rate that will put the economy in stationary equilibrium. As before, this is done by a temporary change in vacancies and unemployment.

Consider again the phase diagram in w - u space (Figure 1). The wage dynamics are given by (16) so the $\dot{w}=0$ locus is a vertical line at the natural unemployment rate. The unemployment dynamics are given by (14), with m expressed in (17) as a function of u , w/p and K . Hence the $\dot{u}=0$ line slopes upwards and K is a shift variable. So for given prices, an increase in K shifts the $\dot{u}=0$ line up, moving the economy from point A to point C. As in the case of a price shock, the movement is clockwise and it is likely to be characterized by dampening oscillations.

Thus, the dynamics in response to a real shock are similar to the dynamics in response to an unanticipated nominal shock. In both cases full adjustment requires the adjustment of nominal wages, for-given prices. But the individual firm-union pair has no incentive to renegotiate a nominal wage before the rest of the market does. Their initial response to the shock is to open up more jobs, and through the effect of this expansion on unemployment wages begin to rise. Thus unemployment changes provide the incentive to renegotiate wages, which the news of a price change alone could not provide.

IV. Conclusions

This paper has modelled within a bargaining framework the old Keynesian ideas that unions are concerned about other unions' wages, and that temporary unemployment changes provide the channel through which output shocks affect wages. Other unions' wages enter the bargain between a firm and a union via the union's threat point; they determine, partly, the union members' best alternative use in the event of a breakdown in the bargaining negotiations. Unemployment provides the channel for wage changes from the requirement that the firm and the union renegotiate only when they observe a change in the parameters of their problem, not when they think the parameters will change at some time in the future. Under this requirement, only minor extra conditions are needed to make unemployment the only channel that could bring about wage changes.

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