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SEARCH, WAGE BARGAINS AND CYCLES

by

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In this paper I describe an equilibrium model of job matchings which has the following property. The number of people looking for work changes temporarily when there is a perceived temporary shock to the value of output per man; it does not change when the shock is perceived to be permanent. By contrast, real wages change temporarily by a small amount when the shock is temporary, but change permanently and by a bigger amount when the shock is permanent.

Thus the model offers one more explanation for the observation that over the cycle small wage changes are associated with changes in unemployment, whereas secularly wage growth does not seem to affect the rate of unemployment. The two most common explanations for this observation in the literature - the Phelps-Lucas misperceptions model and the Lucas-Rapping intertemporal substitution model - are well grounded in equilibrium theory, but they have not stood up well to empirical testing. The misperception model requires more ignorance of aggregate changes than what can be reasonably assumed, whereas the intertemporal substitution model requires bigger wage elasticities of labour supply than what have been estimated.¹

In the model of this paper neither misperceptions nor changes in the supply of labour play a role in generating the unemployment cycle. For this reason, I shall analyse the model under perfect foresight and for an

~~exogenous supply of labour. But like the new classical explanations of the~~
 cycle the model is an equilibrium one, in the sense that all private gains from trade are fully exploited at all phases of the cycle. Although the social gains from trade may not be fully exploited because of search externalities, the cycle I derive here is not due to externalities.

The critical equation in the model of this paper, which is responsible for the transmission of output shocks to unemployment, is the equation for wages. In markets such as the one analysed in this paper, where the allocation of jobs takes place through search, both firms and workers have some monopoly power (a point emphasised by Mortensen (1970), though he attributed only *temporary* monopoly power and only to firms). A firm and a worker who are together have an informational advantage over those still searching: they have established the location of a potential trading partner. This informational advantage shows up as monopoly surplus, which is shared between the firm and the worker according to the agreed upon wage rate. I assume that the equilibrium wage rate is the outcome of a non-cooperative Nash game and argue that in the environment of this paper, with continuous labour turnover, the firm's and worker's alternative return (threat point, or status quo in the terminology of bargaining theory) is a powerful influence on the negotiated wage.²

I show that output shocks influence equilibrium unemployment only if they are not fully reflected in the equilibrium wage. With the Nash wage equation, this occurs when either side's threat point does not fully reflect the output shock. I shall argue that under general circumstances it is reasonable to assume that labour's threat point does not fully reflect perceived *temporary* output shocks, though it should reflect perceived *permanent* shocks. Hence, unemployment should respond only to temporary shocks; real wages should fully absorb permanent shocks.

~~In order to simplify the analysis, I assume that all job-worker pairs~~
are equally productive. Thus there are no decisions regarding reservation wages and job rejection, and search is subsumed in a structurally-invariant matching technology. The supply of jobs is endogenous and governed by zero-profit conditions. This framework is the simplest one for demonstrating the results of interest and its conclusions are robust to extensions to cases involving productivity variations (for which see Pissarides, 1985b).

Sections 1 to 3 of the paper develop the model, by discussing in turn unemployment, the supply of jobs and wages. Sections 4 and 5 discuss its ~~steady-state properties~~ and its dynamic adjustment following permanent and temporary shocks to the value of output per job.

1. Job matchings and unemployment dynamics

Trade in the labour market takes place in a completely decentralised manner. There are many firms and many workers, each of whom is either matched with a member of the other side or unmatched. Employment consists of all matched pairs; I refer to unmatched jobs as job vacancies and to unmatched workers as unemployed workers. For simplicity, I assume that any randomly drawn unmatched pair is capable of producing some positive surplus for both sides, so a job vacancy and an unemployed worker who meet will always form a job and produce. The reason job vacancies and unemployed workers are not matched instantaneously is that there are frictions, associated for example with information imperfections or with mobility costs. I do not specify the reason for frictions explicitly, but instead assume that their existence leads to a transactions technology, which gives the number of job vacancies and unemployed workers who meet at any point in time. Let this number be $x(l_u, l_v)$ where l is the labour force, u is the unemployment rate and v is the number of job vacancies as a fraction of the labour force. The function $x(l_u, l_v)$ satisfies the standard neoclassical properties of a production technology, with l_u and l_v playing the role of inputs, and the number of job matchings, x , playing the role of output. Thus, $x(l_u, l_v)$ is an increasing concave function and it is homogeneous of degree 1 (i.e. there are constant returns to scale).³

The job vacancies and unemployed workers who are matched at any point in time are randomly selected from the sets l_v and l_u . Hence, a vacancy moves into employment with probability density $x(l_u, l_v)/l_v$ and an unemployed worker moves into employment with probability density $x(l_u, l_v)/l_u$. It is convenient to introduce the new variable $\theta \equiv v/u$, and define

$$p(\theta) \equiv \frac{x}{\ell u} = x\left[1, \frac{v}{u}\right].$$

$p(\theta)$ is the density of the transition probability of unemployed workers. By the homogeneity of $x(\ell u, \ell v)$ it depends only on the v/u ratio with $p'(\theta) \geq 0$, $p''(\theta) \leq 0$ and has elasticity $0 \leq \eta(\theta) \leq 1$. The density of the transition probability for a vacancy is similarly written as $p(\theta)/\theta$, so it decreases in θ with elasticity $\eta(\theta) - 1$. Thus, unemployed workers find jobs more easily if there are more jobs, relative to the available workers, and firms find workers more easily if there are more workers, relative to the available jobs.

There are negative job-specific shocks in this economy, which affect a randomly-selected number of job-worker pairs and which can be observed contemporaneously by all participants. The job-specific shocks are severe enough that when a job-worker pair is affected it separates (by contrast, the economy-wide shocks which I introduce later are never severe enough to induce separations). The job-specific shocks may be associated with structural shifts of demand within the economy, which would normally be reflected in relative price changes. Relative prices do not appear explicitly in the model because the assumptions on productivities and job-specific shocks imply that the relative price of a job-worker pair is either high enough (and constant) to induce production or low enough (and hence may be set arbitrarily small) to lead to a separation.

When a job-worker pair separates, the worker returns to the unemployment pool to look for another job, whereas the job may either be withdrawn or reappear as a vacancy (in equilibrium firms are indifferent between these two options). Suppose that a constant fraction s of the employed workers $\ell(1-u)$, with $0 < s < 1$, is affected by the negative job-specific shocks at each point in time. Since the affected job-worker

pairs are randomly selected, the transition probability from employment to unemployment or vacancy (for workers and jobs respectively) has constant density s .

The labour force is growing at the constant rate $n \geq 0$ and suppose all newly-born workers join the unemployment pool. Then additions to unemployment take place either because of new entry or because of job separations, and exit takes place because of job matchings. Hence, unemployment changes according to the differential equation

$$\frac{d\ell u}{dt} = \frac{d\ell}{dt} + \ell(1-u)s - \ell p(\theta)u .$$

Introducing the dot notation for time derivatives and noting that $\dot{\ell} = \ell n$, this equation may be rewritten as

$$\dot{u} = s + n - [s+n+p(\theta)]u . \quad (1)$$

Equation (1) describes the evolution of the rate of unemployment over time in terms of the exogenous variables s and n , the transactions technology as summarised in $p(\theta)$, and the single endogenous variable θ . For any given θ this equation is stable and 'backward-looking'. Unemployment is a predetermined variable which does not jump in response to news. Negative jumps are excluded by assumption, since the transactions technology prohibits the instantaneous formation of jobs in response to new information. Positive jumps are also not taking place because all jobs are identical and it is to no-one's advantage to break up jobs in response to aggregate shocks.

In the steady state the labour force, unemployment and vacancies grow at the same rate n , so the unemployment rate u and the ratio θ are constant. For a given θ , the steady-state value of u depends inversely on

the growth rate n because all newly-born workers start off by joining the unemployment pool. It also depends inversely on the rate of structural change in the economy, s , because the separated workers return to employment via unemployment.

Equation (1) implies that any shocks to the system other than those to the rate of growth of the labour force and to the separation parameter s , affect unemployment (if at all) via job vacancies. A rise in the vacancy rate raises θ , and this leads to a gradual reduction in the unemployment rate. This gives a demand-side flavour to the model, since variables like interest rates, unemployment benefits and nominal and real output shocks could affect unemployment only through the decisions of firms, as represented by their choice of vacancies. It would, however, be misleading to give exclusively a demand-side interpretation to the model, because the number of vacancies chosen by firms depends crucially on the prevailing wage rate and the wage rate is chosen jointly by firms and workers. Supply-side factors are reflected in the wage rate and they influence unemployment via the influence of the wage rate on vacancies. These supply-side influences are important for the model of this paper, because it is through their influence that temporary aggregate shocks have more impact on employment than permanent shocks.

An attractive feature of equation (1) is that it exhibits persistence. Even i.i.d. shocks to any of the variables affecting it give rise to a serially-correlated response from unemployment. But it does not have endogenous cycles. A once-and-for-all change in any of the variables brings a monotonic response from unemployment. Unemployment cycles, as I will show, arise because θ responds cyclically to temporary shocks. I turn now to the set of equations that characterise the evolution of θ .

2. The supply of jobs

The supply of jobs to the market is given by the sum of employment and job vacancies. Employment, as we saw, is given by the difference between the constantly growing labour force l and the level of unemployment, lu . Since both l and u are predetermined, employment is also predetermined. By contrast vacancies, and hence the v/u ratio θ , are assumed to be non-predetermined jump variables. Firms either cannot or will not influence the level of employment directly but they can open and close vacancies at will. Hence they can influence the ratio θ directly and through this they affect employment.

Firms open vacancies in response to expected profits and any available profit opportunities are exploited instantaneously. This condition - the instantaneous exploitation of profit opportunities from new jobs - yields a dynamic equation which describes the evolution of θ . Vacancies can then be obtained residually from the equations for u and θ , since $v = \theta u$; thus vacancies are at whatever level they have to be to ensure that θ follows the dynamic path derived in this section, given the path of unemployment described by equation (1). Since all shocks in this economy are observable, I first derive the dynamic equations under perfect foresight in a nstochastic setting, and consider the effects of shocks later.

Suppose the value of a vacant job to a firm is V , whereas the value of a filled job is J . I assume that vacancies cost the firm a real (flow) cost γy where γ is constant and y is the output from a filled job, also assumed to be constant. The cost of a vacancy may include advertising costs and any fixed costs associated with a job. I assume that it is a constant fraction of output to simplify the exposition, though it would not be difficult to justify the assumption on its own merits. In any case, it is not an important assumption for the results that I derive.

The equation determining V , the value of a vacancy to the firm, is

$$rV = -\gamma y + \dot{V} + \frac{p(\theta)}{\theta} (J-V). \quad (2)$$

r is the real rate of interest. V is defined such that the real rate of return to the firm on an asset worth V is the same in the capital market as in the labour market. The left-hand side of equation (2) is the capital market return on V , whereas the right-hand side is the labour market return: a cost γy , a capital gain $\dot{V}$ from changes in the value of the asset and another capital gain of $(p(\theta)/\theta)(J-V)$ from the possibility of a change in the state of the job.⁴

The condition that all profit opportunities from new jobs are exploited instantaneously, by jump changes in θ if necessary, implies that $V = 0$ at all times. Any firm could open a vacancy simply by bearing the cost γy and participating in the job-matching process. The value of this action to the firm is V , hence the only possible competitive equilibrium is $V = 0$. Using this condition in (2) we get an equilibrium condition for the ratio θ , in terms of the expected value of a filled job J :

$$\frac{\gamma y \theta}{p(\theta)} = J. \quad (3)$$

For any given J , θ is at the value that ensures that the expected cost of a vacant job is equal to the expected profit from a filled job. $\theta/p(\theta)$ is the expected duration of a vacancy and rises as θ rises.

The equation determining J is similar to equation (2), as capital is subsumed in a constant output for each job, y . Suppose the wage rate is denoted by w . Then, the asset value of a job satisfies

$$rJ = y - w + \dot{J} + s(V-J). \quad (4)$$

The capital-market return from the job, rJ , must be equal to the labour-market return: profit $y - w$, capital gains on changes in the value of the match $\dot{J}$, and capital gains (in this case negative) from changes in the state of the job. s is the separation probability and the job that separates will join the vacancy pool for as long as $V \geq 0$.

In equilibrium $V = 0$, so equation (3) becomes a dynamic equation describing the evolution of J :

$$\dot{J} = - (y-w) + (r+s) J. \quad (5)$$

The dynamic equation for θ can now be derived by substituting J from (3) into (5). However, one more matter needs to be dealt with first. The wage rate is endogenous and its equilibrium value will in general depend on θ .

3. Wage bargains and vacancy dynamics

Wages are determined by a Nash bargain between the meeting firm and worker. The firm and worker who establish a job match will generally have some monopoly surplus to share: they have each established the location of a trading partner and they do not have to re-engage in a costly matching process. I assume that the surplus is shared according to the Nash rule with each side's threat point given by its own expected return from re-engaging in the matching process. The wage rate is determined at the level of the individual firm and worker at the moment they meet, an assumption that may be justified by the fact that if the firm and worker do not agree immediately about sharing the monopoly surplus the exogenous separation process may take away from them the chance of forming a job.⁵

The value of a job match to the firm for any wage w is given by J , the solution to equation (5). The firm's threat point - its maximum expected return should the job match with the worker fail to materialise - is V , the expected return from re-entering the matching process. Since in equilibrium $V = 0$, the firm's net return from agreement is given by J .

The net return of the worker is obtained from two asset equations which correspond to the firm's equations (2) and (4). Let U be the unemployed worker's net worth, i.e. the expected present discounted value of income from participating in the job-matching process. Then U is defined by the asset equation

$$rU = b + \dot{U} + p(\theta)(W-U), \quad (6)$$

where b is the worker's valuation of time spent not working (including unemployment income), W is the expected return from taking a job and $p(\theta)$ is the probability density of making the transition from unemployment to employment. The worker's expected return U could be given the search

interpretation of footnote 4; alternatively, the worker could be thought of as arbitraging between the labour and capital markets. Then U is what the worker could borrow on the basis of his expected future earnings and rU is what he could earn by investing that amount in the capital market. With a perfect capital market, the maximum amount that the worker could get in the capital market must be equal to his labour market return, and this condition defines his net worth U . Since rU is the maximum that the worker could spend without running down his net worth, it is equal to his 'permanent income', a fact that I shall use below.

The net worth of the employed worker is similarly defined. With wage income w and transition probability s , W must satisfy the condition

$$rW = w + \dot{W} + s(U - W). \quad (7)$$

The interpretation is similar to that of the other three asset equations, (2), (4) and (6).

The worker's net return from agreeing to a job match for a wage w is $W - U$; the net worth from taking the job minus the net worth from re-entering the matching process. The Nash solution for wages maximises the product $(J - V)(W - U)$, which in this case amounts to equating the two net returns; more generally, it gives a fraction β of the total surplus to the worker.⁶ Hence wages satisfy,

$$W - U = \frac{\beta}{1 - \beta} J, \quad (8)$$

where normally $\beta = \frac{1}{2}$.

Under perfect foresight equation (8) will be correctly perceived by all firm-worker pairs, so it will hold exactly for market wages too. Then substitution from the asset equations (3), (6) and (7), differentiation of

(8) with respect to time and further substitution from (5), yields the wage equation

$$w = (1-\beta)b + \beta(1+\gamma\theta)y. \quad (9)$$

Wages are a weighted sum of the worker's outside return b (his valuation of time), the return from production y , and the saving of vacancy costs corresponding to each unemployed worker, $\gamma\theta$. In this wage equation the worker's valuation of time b features prominently not so much because workers will frequently take the option not to work (in fact no worker will ever choose not to work if he has the option of taking a job), but because b influences the worker's threat point in the wage bargain. The Nash solution appropriate to the matching model of this paper is such that an option that is never taken (unemployment for an income b) influences strongly the outcome of the option that is always taken (work for wage w).

Wages are a non-predetermined variable which could jump in response to news; in particular, jump changes in b , r or θ bring about immediate jump changes in wages. However, if the worker's valuation of time is not sensitive to market shocks associated with the business cycle, the strong dependence of wages on it will introduce some wage sluggishness into the system: wages will not fully reflect the cyclical shocks.⁷ In this paper I endogenise the worker's valuation of time by making the reasonable assumption that it is a function of the worker's permanent income. In the Appendix I use a particular utility function (the Cobb-Douglas), defined over consumption and leisure, to derive precisely the functional relationship between the worker's valuation of time and his permanent income. More generally, if time is a consumption good, then a perfect foresight model with a perfect capital market like the one of this paper would give the individual's demand for time as a function of his permanent

income. Since the amount of time that the unemployed worker can consume is fixed, the value of that time to him is given by the same function of permanent income as his demand for it.

The unemployed worker's permanent income is rU . Hence, his valuation of time is given by

$$b = \lambda rU, \quad 0 < \lambda < 1. \quad (10)$$

I treat λ as a constant, though in general it may depend on the interest rate. Since the interest rate is constant throughout this paper, this restriction is of no consequence to the analysis. I ignore for simplicity any other sources of income that the unemployed worker may have, which he loses by becoming employed. Unemployment compensation is an obvious source of such income; its existence would not alter the results I derive, especially if it was indexed to real wages. If it was not indexed, it would exacerbate the non-neutralities derived.

The dynamic equation determining U , (6), now becomes

$$\dot{U} = (1-\lambda)rU - \frac{\beta\gamma y}{1-\beta} \theta, \quad (11)$$

where I have used (10) to substitute for b , (8) to substitute for $W-U$, and (3) to substitute for J . To derive an equation for θ we substitute b from (10) into the wage equation (9) and the resulting equation into (5). The result of these substitutions is

$$\dot{J} = -(1-\beta)y + \lambda(1-\beta)rU + \beta\gamma y\theta + (r+s)J. \quad (12)$$

By substituting finally J from (3) into (12), we obtain

$$\frac{\gamma(1-\eta)}{p(\theta)} \dot{\theta} = -(1-\beta)y + \lambda(1-\beta)rU + \left[\beta + \frac{r+s}{p(\theta)} \right] \gamma y \theta. \quad (13)$$

Equations (11) and (13) form a system of two differential equations in the two forward-looking variables U and θ . Together with (1), they close the system describing the evolution of all the endogenous variables.

4. Steady-state analysis

The variables of interest are unemployment, vacancies and wages. Equations (1), (11) and (13) are three equations in the three variables u , U and θ . If they can be solved uniquely then the wage rate is obtained from (9) by substituting into it U and θ , and vacancies are obtained from the definition of θ as the ratio v/u .

In the steady state the rates of growth of the three variables, u , θ and U are equal to zero. Since u and θ are ratios the implication is that unemployment and vacancies are growing at the same 'natural' rate n , which is the rate of growth of the labour force. Employment is also growing at the same rate, whereas real wages are constant. The steady-state equations are

$$u = \frac{s + n}{s + n + p(\theta)} ; \quad (14)$$

$$rU = \frac{\beta\gamma y}{(1-\beta)(1-\lambda)} \theta ; \quad (15)$$

$$\lambda (1-\beta) rU + \left[\beta + \frac{r+s}{p(\theta)} \right] \gamma y \theta = (1-\beta)y. \quad (16)$$

This system of equations can be solved uniquely in u , U and θ . To obtain a system in the three variables of interest, u , θ and w , we use (15) to substitute U out of the wage equation (9) and the condition for θ , (16). The result is

$$w = \beta y \left[1 + \frac{\gamma}{1-\lambda} \theta \right], \quad (17)$$

$$\left[\frac{\beta}{1-\lambda} + \frac{r+s}{p(\theta)} \right] \gamma \theta = 1 - \beta. \quad (18)$$

Equations (14), (17) and (18) can be solved uniquely in u , θ and w .

Consider now the effects of output shocks (changes in the output per job y) on the steady state. Temporary output shocks do not influence the steady state but permanent shocks will influence at least some of the variables. Equation (14) and (18), however, have the interesting implication that output shocks do not influence either unemployment or vacancies. These two equations form a self-contained system in the two variables and output does not enter either of the equations. By contrast, wages absorb fully the shock, as equation (17) indicates. In the steady state wages are proportional to output. Similarly from equation (16) we find that the permanent income of the unemployed, rU also rises by the same proportion as y .

Thus, the model of this paper formalises the view that the 'natural rate of unemployment' is invariant to real shocks in the steady state, whereas real wages absorb fully the shocks. However, out of the steady state the equilibrium unemployment rate (which would still be described as 'natural' according to Friedman's definition) responds to shocks, as I show next.

6. An equilibrium employment cycle

The system of adjustment equations corresponding to the steady-state conditions (14), (15) and (16) consists, respectively, of equations (1), (11) and (13). This system consists of three differential equations in the three variables u , U and θ , one of which is predetermined (u) and the other two non-predetermined. Its characteristic roots are easily computed because of the block-recursive nature of the system: the block (11) and (13) gives two roots and equation (1) gives the other. The block (11) and (13) has coefficient matrix $\begin{bmatrix} + & - \\ + & + \end{bmatrix}$ so both its roots are positive. Equation (1) has a negative root (equal to $-(s+n+p)$) so the entire system has two positive roots corresponding to the two non-predetermined variables and one negative root corresponding to the predetermined variable. Hence, the initial condition on the predetermined variable and the terminal conditions on the non-predetermined variables define an adjustment path for all the variables.⁸ With knowledge of the adjustment path for u , U and θ , the adjustment path for real wages is obtained from (9), with b substituted in from (10):

$$w = (1-\beta)\lambda rU + \beta(1+\gamma\theta)y. \quad (19)$$

To obtain the path of unemployment (and employment) following a change in y we first study the adjustment path derived from the block (11) and (13). This block is the key to the model, since the path of unemployment is driven by the ratio θ , and no other variable. Unemployment will cycle only if θ cycles; if θ changes once and for all, unemployment will adjust monotonically towards its new equilibrium value.

Consider now the effects of changes in y in a phase diagram in U , θ space. The fact that both U and θ are nonpredetermined and the subsystem (11) and (13) is unstable, implies that adjustment will always be on a

unique trajectory which ensures that in the absence of anticipated exogenous shocks the equilibrium will be stationary. Also, there cannot be jump changes in either U or θ in response to anticipated shocks. Thus, in the phase diagram jump changes take place only when there are unanticipated shocks, and smooth adjustments take place only when there are anticipated future changes in y or in the other exogenous variables; otherwise the U , θ equilibrium is stationary.

In Figure 1, the stationary locus for U is derived from (11) as an upward-sloping line through the origin. The stationary locus for θ , derived from (13), is downward-sloping. Figure 1 shows two sets of stationary loci. The arrows of motion correspond to the set with stationary point B. To focus ideas, consider the two cases where the output per job either rises permanently to a higher level, or rises temporarily and is expected to fall again. It follows from (11) and (13) that when y rises, both stationary loci shift up. Since we know that in the steady state U rises in response to the rise in y but θ does not change, the intersection of the new curves is at some point directly above the original intersection. In Figure 1, the original and new steady-state equilibria are shown as points A and B respectively.

If the rise in output per job is permanent and no other changes are expected, the perfect-foresight solution for U and θ is an immediate jump from A to B. Any other changes would put the system on an unstable trajectory and would make it diverge in the absence of future jumps in U and θ . But if the rise in y is expected to be temporary, the initial movement from A must be on to an unstable trajectory associated with B, which will bring the system to A precisely at the time when the shock is expected to reverse itself. There is a unique such trajectory and a unique point on it A', on which the system must be at the time of the rise in y .

The point A' is chosen such that when y falls again, the solution of the differential equations is such that the system finds itself at point A.

Thus, a permanent shock to output leads to no change in θ and to a big rise in U , shown by point B. A temporary shock leads to a rise in θ and a smaller rise in U . If the temporary shock is expected to be long, the initial rise in θ may be small but θ will continue rising before it starts falling. This is the case where the interval A' A is long enough to push point A' above the $\dot{\theta}' = 0$ locus. If the shock is expected to be short-lived, θ rises on impact and then falls monotonically (point A' is below the $\dot{\theta}' = 0$ locus).

Before considering the implications of this analysis for unemployment, we discuss the reasons for the difference in the response of U and θ when the output shock is expected to be permanent and when it is expected to be temporary. The difference in the response of U is not difficult to understand. U is the unemployed worker's net worth, so it is the present discounted value of the expected future income stream. A temporary shock to output raises net worth by less than a permanent shock, because in the case of a temporary shock wages are expected to go up for a short period of time but fall again at the end of the shock.

Changes in U affect θ via their effect on the equilibrium wage rate. A rise in U raises the individual's valuation of time and this raises the negotiated wage rate. If the output shock is temporary, the rise in U is small, so the wage rate does not rise by very much. If the output shock is permanent, the wage rate rises by more, in response to the bigger rise in U . Hence, in the case of a temporary shock wages exhibit sluggish behaviour, and this raises profits and the number of jobs offered; θ responds to a temporary shock in output because wages do not respond fully to the shock.

The path followed by unemployment during adjustment is given by equation (1). In Figure 2 we plot the stationary locus for unemployment, derived from (1) by setting $\dot{u} = 0$. This curve is often referred to as the uv locus, or the Beveridge curve. The 'stylised fact' about the Beveridge curve is that it slopes downward and the business cycle traces anti-clockwise loops around it (see Dow and Dicks-Mireaux (1958) and Jackman, Layard and Pissarides (1984)). In the same figure we also plot the line $v = \theta u$. Since $\dot{u} = 0$ is a downward-sloping stable curve, the economy is always on a $v = \theta u$ line and moves toward the $\dot{u} = 0$ line.

Suppose now the economy is originally at point A, corresponding to point A of Figure 1. A permanent shock to output does not change θ , so the economy does not move from point A. If, however, the shock is temporary, θ rises and so the economy jumps up to a higher point, A'. θ may continue rising for a while, in which case the economy may move to the left of A', but it will eventually turn and meet the old θu line at the end of the temporary expansion. Following this it will converge to the original equilibrium A. Thus, temporary shocks to output trace the familiar anti-clockwise loops around the uv curve.

7. Conclusions

We have demonstrated in this paper that an equilibrium model of job matchings could generate cycles in unemployment in response to temporary shocks to output, even in the absence of informational errors. By contrast, unemployment does not change when the shocks are expected to be permanent. Thus, the conclusions reached here are different from the ones reached by the search models of Phelps (1970) and Mortensen (1970), where no distinction could be drawn between the effects of temporary and permanent shocks, and where informational errors were the reason behind the fluctuations in unemployment.

The key element to the model of this paper is the wage equation. Wages are determined by a Nash bargain between the firm and the worker, who have to share the monopoly surplus from a job match. The structure of the model is such that each side's threat point in the bargain is a strong influence on the negotiated wage. The worker's threat point depends on their permanent income (or wealth), since this is what determines their welfare in the event of leisure. Hence, a permanent shock to output raises permanent income and this causes a bigger than otherwise rise in wages. We have shown that the only consistent perfect foresight solution in this case is a proportional rise in wages and no change in employment. But a temporary shock raises permanent income by less and so wages exhibit sluggish behaviour. In this case the (unique) perfect foresight solution is a less-than-proportional rise in wages and a rise in employment, followed by an employment cycle around the steady-state path.

APPENDIX

The Worker's Valuation of Time

Consider an unemployed worker with initial assets A_t , known income during the period b_t and a random income prospect in future periods. The worker chooses his consumption c_t but not the number of hours of work. He enjoys leisure l^0 when he is unemployed and l^1 when he is employed. The randomness in his income stream comes from randomness in wages and also from changes in the worker's status.

Let $\Omega(A_t)$ be the maximum value of the worker's objective function conditional on inherited assets A_t . $\Omega(A_t)$ satisfies the recursive equation

$$\Omega(A_t) = \text{Max} \left\{ u(c_t, l^0) + E \frac{\Omega(A_{t+1})}{1+\sigma} \right\} \quad (A1)$$

where $u(\)$ is the instantaneous utility function, σ is the pure rate of time preference and the expectation is taken over the future income prospect. A_{t+1} is defined by

$$A_{t+1} = (1+r)(A_t + b_t - c_t). \quad (A2)$$

Hence, the optimal c_t satisfies

$$u_1(c_t, l^0) - \frac{1+r}{1+\sigma} E \Omega'(A_{t+1}) = 0.$$

Consider now the following experiment. For one period only, a worker is asked to work, i.e. his leisure falls from l^0 to l^1 . In the next period he returns to the state he would have been without this substitution. We are interested in finding out how much this substitution is worth to the worker, i.e. how much income x_t the worker needs to be given in period t so as to keep him on the same indifference curve.

Let c'_t be the new consumption level chosen by the individual and let

$$A'_{t+1} = (1+r)(A_t + b_t + x_t - c'_t). \quad (A4)$$

Then x_t is defined by

$$\Omega(A_t) = \max_{c'_t} \left\{ u(c'_t, l^1) + E \frac{\Omega(A'_{t+1})}{1+\sigma} \right\} \quad (A5)$$

where the $\Omega(A_t)$ in (A5) is the same as the one in (A1).

Expand now the terms in the curly brackets of (A5) around c_t, l^0 and A_{t+1} :

$$\begin{aligned} u(c'_t, l^1) + E \frac{\Omega(A'_{t+1})}{1+\sigma} &= u(c_t, l^0) + E \frac{\Omega(A_{t+1})}{1+\sigma} = u_1(c_t, l^0)(c'_t - c_t) \\ &\quad + u_2(c_t, l^0)(l^1 - l^0) + E \frac{\Omega'(A_{t+1})}{1+\sigma} (A'_{t+1} - A_{t+1}). \end{aligned}$$

By the definition of the primed terms we must have

$$u_1(c_t, l^0)(c'_t - c_t) + u_2(c_t, l^0)(l^1 - l^0) + \frac{E\Omega'(A_{t+1})}{1+\sigma} (A'_{t+1} - A_{t+1}) = 0 \quad (A6)$$

From (A4) and (A1) we get

$$A'_{t+1} - A_{t+1} = (1+r)(x_t - c'_t + c_t), \quad (A7)$$

and making use of (A3) and (A7) we rewrite (A6) as

$$u_1(c_t, l^0)(c'_t - c_t) + u_2(c_t, l^0)(l^1 - l^0) + u_1(c_t, l^0)(x_t - c'_t + c_t) = 0.$$

Hence, x_t satisfies

$$x_t = \frac{u_2(c_t, l^0)}{u_1(c_t, l^0)} (l^0 - l^1) \quad (A8)$$

Our result that x_t is a proportional function of the worker's permanent income follows exactly if the utility function is Cobb-Douglas,

$$u = c_t^\alpha \lambda^\beta$$

Then, (A8) becomes

$$x_t = \frac{\beta}{\alpha} \left(1 - \frac{\lambda^1}{\lambda^0}\right) c_t.$$

For the Cobb-Douglas utility function c_t is a proportional function of permanent income (see eg. Hall (1978)), which, using the notation of the text is rU . Hence, dropping the time subscript we have

$$x = \frac{\beta}{\alpha} \left(1 - \frac{\lambda^1}{\lambda^0}\right) \zeta rU,$$

where ζ is itself a function of α , r and σ . Hence, the proportionality factor λ is defined by

$$\lambda = \frac{\beta}{\alpha} \left(1 - \frac{\lambda^1}{\lambda^0}\right) \zeta,$$

and it is a function of the parameters α , β , λ^0 , λ^1 , r , and ζ .

Footnotes

- * Work on this paper started at the Stockholm Institute for International Economic Studies, to whose members I am grateful for their hospitality and comments. A version of the paper was also read at the Economic and Social Research Council conference on involuntary unemployment at York where I received helpful comments. Financial support was generously provided by the Stockholm Institute and by the Economic and Social Research Council through its grant to the Centre for Labour Economics at the London School of Economics.
- 1 For criticisms of the misperceptions model see, among others, Okun (1980) and the other contributors to the same volume, Grossman (1983) and some of the comments in Barro (1981). For criticism of the intertemporal substitution model see Hall (1980), Altonji (1982) and Ashenfelter and Card (1982).
- 2 For more discussion of this kind of wage equation in search equilibrium see Moretensen (1982), Diamond (1982) and Pissarides (1985a). For some of the bargaining theory underlying it see Binmore, Rubinstein and Wolinski (1985).
- 3 Constant returns may be justified by the fact that size does not appear to be a systematic influence on an economy's equilibrium unemployment rate (either in a cross-section or over time). Without it the size of the economy, l , would have been a systematic influence on the percentage of the labour force unemployed, and in a growing economy a steady-state with constant unemployment rate would not have existed.
- 4 In its discrete version, equation (2) is the same as the standard recursive equation of search theory. Thus, the expected discounted return from search in period t , V_t , satisfies

$$V_t = -\frac{\gamma y}{1+r} + \frac{p(\theta)}{\theta} \frac{J_{t+1}}{1+r} + \left[1 - \frac{p(\theta)}{\theta}\right] \frac{V_{t+1}}{1+r}, \quad (2')$$

where V_t , J_{t+1} and V_{t+1} are stocks evaluated at the beginning of the period, γy is a flow paid at the end of the period and $p(\theta)/\theta$ is the transition probability. A simple rearrangement of (2') gives the discrete-time equivalent of equation (2) of the text. The same interpretation can be given to equations (4), (6) and (7) below.

- 5 Recently Binmore, Rubinstein and Wolinski (1985) have shown that when there is a chance that the opportunity of sharing some surplus may be lost, a perfect equilibrium sequential bargain can be reduced to the static Nash bargain, with each side's threat point given by its return in the event of the loss of the opportunity. The wage bargain in this paper satisfies all the conditions of the perfect equilibrium which they describe. It also corresponds to the static Nash bargain of Diamond (1982) and Mortensen (1982).
- 6 Here, the Nash rule equates the two returns because there are no 'leakages', so one side's loss is the other side's gain. If there are wage taxes the sharing implied by the Nash rule is more complicated, because the negotiated outcome determines to some extent the fraction of the surplus lost to a third party (the tax authorities). See Pissarides (1985a) for a steady-state analysis of the effects of taxes in this environment.
- 7 On this point see also McDonald and Solow (1981) and Pissarides (1985b), where a fixed external return induces employment responses to output shocks.
- 8 See Blanchard and Kahn (1980) and Buitier (1984) for proof.

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FIGURE 1

The effects of permanent and temporary output shocks on U and θ

FIGURE 2

Vacancy-unemployment dynamics in response to a temporary output shock