Wages and Employment under Uncertain Demand

Martin Neil Baily

The Review of Economic Studies, Vol. 41, No. 1. (Jan., 1974), pp. 37-50.

Stable URL:
http://links.jstor.org/sici?sici=0034-6527%28197401%2941%3A1%3C37%3AWAEUUD%3E2.0.CO%3B2-4

The Review of Economic Studies is currently published by The Review of Economic Studies Ltd..

Wages and Employment under Uncertain Demand [1, 2]

MARTIN NEIL BAILY
Yale University

This paper examines some implications of two postulates for firms' wage and employment policies. The first is that firms, or stockholders, have easier access to capital markets at lower costs or higher returns than do small investors, such as workers. Second, there are important mobility and turnover costs incurred when a worker moves from one firm to another.

The existence of mobility costs means that the labour market is not a perfect market. Each firm is not restricted to taking as given some exogenous market wage, period by period, but has some amount of freedom about the wage strategy it sets. The firm cannot choose any wage-employment path it wishes, however, and I shall assume that in the long-run the firm must offer the same (expected) utility as that available elsewhere. In the short-run there is a constraint that the wage offer must never be so bad that all the firm's workers will quit and incur the mobility cost.

There are solid grounds for believing that great differences exist between stockholders and workers with regard to capital markets. The majority of stocks are held by very wealthy persons indeed, who also hold almost all the state and local bonds and large proportions of the property and other assets.[3] In addition, stockholders are frequently company executives or professionals with greater financial expertise and salaries many times that of the average industrial worker. The worker typically has a rather small net worth. His assets are durable goods and a rather small holding of money. He frequently has consumer credit liabilities outstanding.[4] He also has much less knowledge of financial assets and institutions.

A principal function of capital markets is to allow wealth-holders to diversify their holdings and so reduce the risk of their total portfolios. Stockholders, through their greater wealth and expertise, are much better able to bear risks than are workers.[5] The difference in ability to bear risk between the two groups immediately suggests an opportunity to trade. In deciding what wage-employment strategy to set, the firm will be willing to reduce worker risk. By doing so, the firm is offering a joint product, employment plus an insurance or financial intermediation service. The firm does not do this simply because workers prefer it. Risk-reducing policies are the cheapest and hence most profitable way of attracting any given work-force.

The choice of a risk-reducing policy by the firm will have an important impact on both the wage set and on employment variations—and hence the probability of unemployment. The firm will, in general, wish to reduce the uncertainty of the workers' incomes. An important feature of the model presented here is that the tendency of the firm to reduce risk has an asymmetrical effect on the wage strategy and on the employment strategy.

1 *First version received February* 1973; *final version received May* 1973 (*Eds.*).
2 I am indebted to Robert M. Solow, Franklin M. Fisher, Peter A. Diamond, the members of the theory workshop at MIT and a referee for many helpful comments and criticisms. I retain responsibility for error. Financial support from the Canada Council is acknowledged.
3 Projector [8], Lampmann [4].
4 Katona [2], Projector [8].
5 In addition, one might feel that stockholders as a class are more willing to bear risk simply because of differences in aversion to risk.

Subject to the (somewhat restrictive) assumptions of the model, one can show that a pre-announced non-stochastic wage strategy will be set by the firm. This is true even though the future path of employment is stochastic and hence there is a positive probability of being laid off. An equivalent result is not true for the employment strategy. The firm will wish to vary the size of its work-force.

Workers dislike income uncertainty and dislike being laid off. The asymmetry between the wage and employment strategies arises because when a worker is laid off he receives a non-zero income. To attract workers, the firm must pay a higher wage if there is some positive probability of unemployment than it would if employment were guaranteed. As against this, the firm can save on its wage costs by cutting its work-force during periods of slack product demand. Provided workers have some alternative sources of income when they are laid off, the savings from employment variations will outweigh the higher wage necessary, even though workers are risk averse. The alternative sources of income are from unemployment compensation, from working outside the sector considered and from the income equivalent of avoiding the disutility of work. Workers dislike lay-offs; the question is how much do they dislike them relative to how much the firm saves on its wage bill.

One way of thinking about the alternatives facing the firm is to compare two possible policies, one which implies more employment variation and another which implies more wage variation. Such comparisons are an intuitively appealing approach, but it is not the one followed here, nor is it necessary to make comparisons of this type to prove the desired result. This is discussed further in Section IV (including footnote 2, p. 44).

The result, that a pre-announced non-stochastic wage is set by firms, is intended to provide an explanation of the phenomenon of sticky wages. In particular, it suggests an explanation for the fact that the real wage does not seem to adjust in the short-run to clear the labour market.

There is a question of what is meant by sticky wages. In the formal model presented there are a number of rather strong assumptions which allow a clear result. The wage rate is strictly non-stochastic, pre-announced. It does not respond at all to fluctuations in demand. To reach this conclusion firms are assumed to be risk neutral, maximizing the present value of expected profits. Workers are risk averse, and do not operate in capital markets. These assumptions are intended to reflect the asymmetry between workers and capitalists that I described, but clearly they are strong. In Sections VI and VII the consequences of changing these assumptions are discussed.

I. A SINGLE FIRM AND UNCERTAIN DEMAND

I shall discuss first the case of a single firm which has a stochastic demand for its product. The simplest assumption to make is that the firm is a perfect competitor in the product market. It is a price-taker and sets quantity as the decision variable.[1] I shall consider in this model a finite time-horizon of T periods.

Assumption 1. The price of the firm's product in period t, p_t, is a random variable. The p_t are jointly distributed and are bounded above and below. $p_t \in \Omega_t$ $(t = 1, \ldots, T)$.

If the joint density function of the prices is $F(p_1, \ldots, p_T)$, then there is a prior or unconditional expectation of p_t defined by:

$$E(p_t) = \int_{\Omega_1}, \ldots, \int_{\Omega_T} p_t F(p_1, \ldots, p_T) dp_1, \ldots, dp_T. \qquad \ldots(1)$$

[1] I am not examining what determines price. One could assume a fluctuating world price. Also, the price-taker assumption is not essential. It is the easiest way to introduce uncertain demand but a monopolist with a fluctuating demand curve would serve as well.

The unsubscripted expectations operator will be used to denote this expected value, i.e. when the state variables from 1, ..., T (the prices $p_1, \ldots, p_T$ in the above case) are unknown. The operator E_t will denote the expected value of a variable when state variables up to period t are known. It is the conditional expectation defined in the usual way.[1]

It is convenient to take the technology and capital equipment to be constant.[2] It is doubtful if any essential features of the results depend upon this, but a number of awkward problems are avoided.

Assumption 2. The firm's output in period t is x_t and is given by:

$$x_t = g(L_t) \qquad g' > 0,\ g'' < 0, \qquad \ldots(2)$$

where L_t is employment in period t.[3]

Let a worker's income in period t be y_t. The values $(y_1, \ldots, y_T)$, which depend upon the wage and employment prospects of the worker, will in general be stochastic variables. Each worker's decision function is of the form given by:

Assumption 3. A worker making a decision in $t-1$ which affects his path of income $y_t, \ldots, y_T$ will maximize V_{t-1} given by:

$$V_{t-1} = E_{t-1}\left\{\sum_{\tau}^{T} U(y_\tau)(1+\rho)^{-\tau+t-1}\right\}, \qquad \ldots(3)$$

where $U' > 0$, $U'' < 0$ and ρ is a constant.

The assumption implies all workers are alike in their preferences. This makes life much easier, as I shall comment later, but obviously is pretty strong. The firm and industry are assumed small relative to the rest of the economy. The overall price level is constant, and wage and employment prospects in the rest of the economy are given exogenously. There may, in fact, be many choices open to a worker who is not employed with the firm we are analysing. But just as one assumes an equilibrium wage prevailing in the economy in the standard textbook theory, I shall assume a given (possibly stochastic) path of income available elsewhere.

Assumption 4. The path of income available to a worker elsewhere in the economy is $y_1^0, \ldots, y_T^0$. The y_t^0 are stochastic and may be jointly distributed.

Consider a worker who does join the firm we are analysing. If he is employed in period t, his income is simply the firm wage w_t. If there were no mobility or information costs in this economy the firm would have no real choice. It would pay $w_t = y_t^0$ in each period as a perfect competitor in the labour market. More realistically, however, although a firm may face a long-run horizontal supply of labour, this is not true period by period because of information and mobility costs.

The fact that mobility costs exist has been well recognized in the literature.[4] In actual practice the cost of changing jobs may be quite different from one worker to another. Some workers may have many jobs open to them in the same location and have a general skill needed in many industries. There would seem to be many workers, however, for whom changing jobs would involve considerable costs. These might be moving expenses, search expenses, income foregone and possible retraining. For almost all firms there are significant costs involved when a new worker joins the company. He may have to be

1 Thus $E_t(p_t)$ is the expected value over the conditional density of p_t, defined as the ratio of the integral of F over $p_{t+1}, \ldots, p_T$ to the integral of F over $p_t, \ldots, p_T$.

2 Inventory fluctuations are also excluded.

3 The length of the period can be taken as the order of one month or one quarter. This paper is not intended as an analysis of very short-run fluctuations and overtime working. An interesting paper by Lucas [5] deals with such a framework and an incorporation of some of the ideas presented here with his analysis could be a fruitful area for further research.

4 Stigler [9], Oi [6], Phelps *et al.* [7].

given some on-the-job training or equivalently his productivity may be lower during the first few periods after he is hired, as he learns by doing.

It is hard to do justice to the full complexity of the factors described, particularly differences between workers at different skill levels and different geographical locations. Instead, the following simple parametrization is used.

Assumption 5. If a worker leaves the firm where he has been seeking work and moves to another firm in period t he suffers a mobility cost in period τ given by $C_\tau^t \geqq 0 \quad \tau \geqq t$.

The mobility cost experienced by the worker he pays directly. The firm's turnover cost is assumed to take the form of a reduced wage for the first few periods after the worker joins the firm.[1]

II. FIRM WAGE AND EMPLOYMENT STRATEGIES

Once we include mobility and information costs the single firm has a measure of freedom about the wage and employment policies it can set. To model this the distributions of the state variables are assumed known and the firm announces at time zero a strategy with respect to wages and employment. The strategy will consist of two decision rules conditional on the values of the state variables, which are the prices $p_1, \ldots, p_T$ and the incomes available elsewhere $y_1^0, \ldots, y_T^0$.[2] A particular (and not in fact very likely) strategy would be to choose a constant level of employment and let the wage always equal the marginal product times price in each period. The announced strategy can be defined by two sets of mappings from the state variables into employment and wages.

Assumption 6. The firm announces at time zero a strategy S defined by two sets of mappings $(a_1, \ldots, a_T)$ and $(b_1, \ldots, b_T)$ such that

$$\begin{aligned} L_t &= a_t(p_1, \ldots, p_t, y_1^0, \ldots, y_t^0) \\ w_t &= b_t(p_1, \ldots, p_t, y_1^0, \ldots, y_t^0). \end{aligned} \qquad \ldots(4)$$

These mappings could be analytic functions or perhaps integral equations where L_t and w_t depend on some function of the expected values. This assumption is very weak in the sense that the class of possible strategies is very general. The announced strategy together with the known distribution of the variables mean that the worker can evaluate the expected utility of seeking work at the firm.

The knowledge requirements of this formulation are quite considerable but the stylized model makes the framework seem more unrealistic than it actually is. Workers clearly do not make complex calculations upon announced joint probability distributions. They are, however, concerned with the past behaviour of firms, how frequently lay-offs occur and what is the likely path of wages. Firms are concerned about their reputations as employers, suggesting that short-sighted decisions do not necessarily imply long-run profit maximization. In terms of the model, they stick to an implicit strategy since it is in their long run-interests to do so. In addition, the conclusions of this paper suggest that the wage strategy will be one of setting a non-stochastic pre-announced wage path; this is the strategy which reduces the knowledge requirements and simplifies the calculation of utility.

This section deals with an easy case. Employment variations are excluded so that the wage strategy is considered given a constant employment level. This keeps everything

[1] In practice, this latter cost may be reflected in the fact that a firm will hire workers who have been working for the firm in previous periods in preference to a new, unknown worker. Hence the cost experienced by the worker may be a queuing cost.

[2] As far as the firm is concerned, the product price and incomes available elsewhere have exogenously given densities.

very simple and gives the flavour of the more complex case where employment varies, which is handled subsequently.

Consider the properties then of two specific strategies.

Strategy S_1: the firm pays a constant wage $\tilde{w}$ and employs a constant number of workers $\tilde{L}$.

Any worker taken on is guaranteed employment up to time T. He may, of course, quit if he wishes.

Strategy S_2: the firm employs a constant number of workers $\tilde{L}$ but the path of wages is unknown at time zero, i.e. $w_t = b_t(p_1, \ldots, p_t, y_1^0, \ldots, y_t^0)$ so that w_t is a stochastic variable.

In order for these strategies to be meaningful the level of wages set must be such that the firm actually can employ $\tilde{L}$ workers.

Definition. Strategies S_1 and S_2 are said to be *feasible* if the firm has at least $\tilde{L}$ workers available in each period $t = 1, \ldots, T$.

To model the assumption of a long-run horizontal labour supply, assume that at time zero all workers search for firms to find the best expected utility offer. A single firm can then ensure $\tilde{L}$ workers at the *beginning of period one* by offering the same expected utility as that available elsewhere.

Assumption 7. If the labour supply condition (5) is satisfied by strategies S_1 and S_2 then the firm will have $\tilde{L}$ workers available at the beginning of period one.

$$\begin{aligned} V^0 &= E\left\{\sum_1^T U(y_t^0)(1+\rho)^{-t}\right\} \\ &= \sum_1^T U(\tilde{w})(1+\rho)^{-t} \text{ for } S_1. \qquad \ldots(5) \\ &= E\left\{\sum_1^T U(w_t)(1+\rho)^{-t}\right\} \text{ for } S_2. \end{aligned}$$

The simple form of Assumption 7 depends upon the fact that workers were assumed to have identical preferences. If this assumption were changed the analysis would become a lot more complicated. It seems intuitively likely that if workers, *on the average*, are risk averse, then the risk-reducing strategy S_1 is going to turn out to be the cheapest way of attracting any given size of work-force. It might be tricky to prove, however.

Once workers have chosen to come to this firm they can re-evaluate their positions at any time. If they decide to move they incur the mobility costs C_τ^t. For S_1, consider the inequality:

$$\sum_t^T U(\tilde{w})(1+\rho)^{-\tau+(t-1)} \geqq E_{t-1}\left\{\sum_t^T U(y_\tau^0 - C_\tau^t)(1+\rho)^{-\tau+(t-1)}\right\}. \qquad \ldots(6)$$

If this inequality is satisfied for $t = 2, \ldots, T$ then a worker who leaves the firm operating S_1 will always be worse off. The firm will retain its workers and S_1 will be feasible. To interpret this condition consider a strategy S_1 which satisfies the labour supply condition (5). It is clear that if the variations of y^0 are large relative to mobility costs then the constant wage strategy will not be feasible. A large sustained increase in y^0 will force the firm to adjust its own wage upwards. The force of the inequality (6) is therefore that the constant wage strategy, that satisfies the labour supply condition, will be feasible provided mobility costs are sufficiently large relative to the short-run fluctuations in y^0 (the wage income available elsewhere in the economy).

Definition. The feasibility condition for S_1 will be said to be satisfied if mobility

costs relative to fluctuations in the wage income available elsewhere in the economy are large enough so that a strategy S_1 which satisfies (5) will satisfy the inequality (6).

Strategy S_2 is really the class of strategies with stochastic wage paths which the firm may wish to choose. The set of these which is feasible must also satisfy a feasibility constraint as well as the labour supply condition. This is given by:

$$E_{t-1}\left\{\sum_{t}^{T} U(w_t)(1+\rho)^{-\tau+(t-1)}\right\} \geqq \text{ the RHS of (6).} \qquad \ldots(7)$$

The formulation has a slight musical chairs air to it, since everybody searches at once and then joins a firm when period one starts. This feature results from the synchronization of everyone's actions, rather as the exact consumption loan model does. Let me try and relate the model a little more closely to reality as follows.

Workers enter the labour force or retire at random. Some workers quit to look for better conditions and some others come from other firms. What I am trying to capture in the labour supply condition is that, provided the firm offers an expected utility over a period equal to that available elsewhere in the economy, it will find that it can balance quits and retirements with new entrants and hiring. The feasibility condition is a measure of the amount of period by period freedom open to the firm resulting from the mobility costs of the labour market.

The strategy S_1 is defined in terms of a constant wage. Constancy is stronger than certainty but it is the latter that is really the key feature of S_1. This model has ignored such factors as capital accumulation and technical change. In a more general model, or in thinking about the relevance of the results, one might plausibly generalize by allowing S_1 to include a trend rate of change of real wages. Wage stickiness then consists of smoothing fluctuations around the trend. I have commented (and will comment) on uncertain or stochastic strategies compared with pre-announced, non-stochastic wage strategies in the course of the general discussion since it is the wage certainty not the wage constancy that is important.

III. EXPECTED PROFITS AND ALTERNATIVE STRATEGIES

The firm will make a profit in period t given by: [1]

$$\Pi_t = p_t g(L_t) - w_t L_t. \qquad \ldots(8)$$

The present value of expected profits evaluated at the beginning of period one is given by:

$$E(\Pi) = \sum_{1}^{T} (1+r)^{-t} E\{p_t g(L_t) - w_t L_t\}, \qquad \ldots(9)$$

where r is the discount rate and the mappings (4) define the distributions of w_t and L_t. There is a minor complication introduced by the parameter ρ in the utility function and the discount rate r. I will set $r = \rho$ to keep things simple.[2] With the framework developed the following proposition can be shown.

Proposition 1. *Provided the feasibility constraint is satisfied, the strategy S_1 with constant wage and employment yields larger expected profits than S_2 with a stochastic wage.*

Notice that the worker's expected utility and the firm's expected profits are evaluated at the beginning of period one, when future values of the state variables are unknown. The expected values are, therefore, the prior or unconditional values. Developing the formal proof of the proposition for this case does not seem worth while. The result is

[1] Ignoring a constant capital cost term. This is important only for the long-run shutdown decision.

[2] This simplification would be unnecessary if S_1 was not defined in terms of wage constancy. If $r \neq \rho$ we could get effects familiar from Fisher interest theory but not central to the issues here.

intuitively clear. Both strategies S_1 and S_2 have the same constant employment path. The difference in expected profits between the two is therefore given by:

$$E(\Pi \mid S_1) - E(\Pi \mid S_2) = \sum_1^T (1+r)^{-t}\{E(w_t) - \tilde{w}\}\bar{L}, \qquad \ldots(10)$$

which is the difference in the present value of wage costs. The two strategies must both yield the same expected utility for workers from condition (5). Since workers are risk averse, the non-stochastic wage $\tilde{w}$ can be less than the expected value of the stochastic wage $E(w_t)$. The firms costs are, therefore, lower and its expected profits higher.

In the next section simultaneous employment and wage variations are dealt with, but in a somewhat different context. Instead of a single relative price changing, overall fluctuations in an economy are considered.

IV. WAGES UNDER UNCERTAIN AGGREGATE DEMAND

We now consider an economy where the price level and aggregate output fluctuate. The economy consists of M firms producing a single (composite) good with the same technology. Even though the general equilibrium framework (in which wages and profits feed back into aggregate demand) is not allowed for, the force of the result, it will be argued, does not depend upon this.

Workers and producers are assumed to be uncertain about the level of aggregate demand over the future period $t = 1, \ldots, T$. There is uncertainty about the actions of consumers or investors or the government or the foreign trade sector or some combination of these. Producers, in turn, will react to changes in aggregate demand—leading to price and output movements. There is no very satisfactory theory of price and output dynamics in response to overall fluctuations. As long as prices do not respond fully and instantaneously then output will certainly fluctuate. *Some breakdown in competition in the product market seems to occur,*[1] at least in the short-run. Each producer has to guess what demand will be and how other producers will respond. He then forms expectations about the movements of output and the price level. Based upon these expectations each producer, as before, sets a strategy for wages and employment. This will in general, be conditional on the values of output and price that actually occur. The strategy then defines the distributions of wages $(w_{i1}, \ldots, w_{iT})$ and employment $(L_{i1}, \ldots, L_{iT})$ for $i = 1, \ldots, M$.

All firms operate under the same conditions with the same technology. For the purposes here, they differ only in scale. Consider first the properties of *equilibria such that all firms adopt the same wage, employment and output strategy.*[2] The results do not necessarily mean that this economy would actually reach or remain at such a point under competitive conditions. This question is examined subsequently.

The labour force consists of N workers who seek work over the periods $t = 1, \ldots, T$. Each firm sets the same wage and employment strategy over the period so that workers distribute themselves between firms to equalize the probability of employment at each firm.[3]

Assumption 9. The probability of finding employment in period t is the same in each firm and is, hence, equal to the overall probability of employment q_t given by:

$$q_t = \frac{L_t}{N}, \quad L_t = \sum_1^M L_{it}. \qquad \ldots(11)$$

[1] Hence we are dropping the assumption that each firm can sell all it wants at the going price.

[2] Apart from scale differences.

[3] Since the strategies are all the same, it does not matter here whether there are mobility costs and workers search only at time zero or whether there are no mobility costs and they can move freely in each period.

There is no money illusion in the economy. Workers are concerned about their real wage and producers about the real value of profits. The real wage in t is v_t. In any period when a worker is laid off he receives unemployment compensation and avoids the disutility of work. Realistically one might also allow him to do temporary work within the household sector, but this is not specifically modelled here. The worker's real income in any period when he is unemployed is v_u, a constant.[1]

Consider any strategy, S, set by all M firms which involves some uncertainty of future wages. The wage under S may respond to fluctuations in demand and employment. The strategy may also involve employment variations and hence a positive probability of a lay-off for each worker. I shall now show the following proposition:

Proposition 2. *There exists a strategy $\hat{S}$ with a non-stochastic wage, and the same path of employment and output as S, which has the following properties. (a) Each worker's expected utility under $\hat{S}$ is the same as under S. (b) The present value of expected real profits of the firms is higher under $\hat{S}$.*

We are comparing two economies, as it were, one where all firms adopt S and the other where all adopt $\hat{S}$. Notice that the proposition states that the profit-maximizing strategy (for all firms) involves a non-stochastic wage, whatever the path of employment. If you consider any strategy S with a stochastic wage path, there is always another that yields higher profits, for a given expected utility.[2] For those who find it natural to make comparisons between more employment uncertainty with less wage uncertainty versus less employment uncertainty with more wage uncertainty, the form of Proposition 2 may seem incomplete, since it compares strategies with the same employment path. This is not so. Compare two strategies: (i) S_α with a large degree of wage uncertainty but with a small or zero probability of unemployment and (ii) S_β with little or no wage uncertainty but a large probability of unemployment. It is not possible (without much more information) to say which of the two is preferred or yields larger profits. Proposition 2, however, tells us that there exists a strategy $\hat{S}_\alpha$ which gives higher expected profits than S_α. *This means that a strategy like S_α cannot be profit-maximizing even though it might possibly be better than S_β.*

There is, however, a much more fundamental, and much harder, question of the extent to which the existence of a market equilibrium involving a wage that does not adjust to fluctuations in demand is inefficient, and may exacerbate unemployment in the economy or sector as a whole. Proposition 2 says nothing about the social efficiency of alternative strategies. It is quite possible for a strategy like $\hat{S}$ to maximize expected profits and for an alternative strategy, with less unemployment to be more socially efficient. There are transactions (or mobility) costs and other market imperfections involved in the model.

A formal proof of Proposition 2 is desirable for this case, where employment can vary, since the result is less obvious. When employment varies, a worker's income is still somewhat uncertain even under a constant wage strategy. The proposition goes through because variations in L_t affect only the probability of being in each of the two states—employed or unemployed. The setting of a constant, non-stochastic, wage represents a partial reduction of risk for the worker. Income, in the event of being employed, is non-stochastic. The firms' expected profits under strategy S are given by:

$$E(\Pi \mid S) = \sum_1^T (1+r)^{-t} E\left\{\sum_1^M g_i(L_{it}) - v_t L_t\right\} \qquad \ldots(12)$$

and under strategy $\hat{S}$ by:

$$E(\Pi \mid \hat{S}) = \sum_1^T (1+r)^{-t} E\left\{\sum_1^M g_i(L_{it}) - \hat{v} L_t\right\} \qquad \ldots(13)$$

[1] Two arguments of the utility function—income and leisure—are reduced into an income equivalent.

[2] In particular, if we knew the profit-maximizing employment strategy $\{L_t^*\}$ then we would know that the profit-maximizing wage strategy that went with it was non-stochastic. The strategy S *may* involve employment variation *but it need not*. If the profit-maximizing strategy were to offer an employment guarantee, then the profit-maximizing wage strategy would be to offer a non-stochastic wage in addition.

where $\hat{v}$ is the non-stochastic wage under $\hat{S}$ and $g_i(L_{it})$ is the output of the ith firm. The difference between the two is given by:

$$E(\Pi \mid \hat{S}) - E(\Pi \mid S) = \sum_1^T (1+r)^{-t} E\{v_t L_t - \hat{v} L_t\}. \qquad \ldots(14)$$

In the economy under S the worker has an income v_t with probability q_t and an income v_u with probability $(1-q_t)$. His expected utility when he joins the firm is given by:

$$V = \sum_1^T (1+\rho)^{-t} E\{q_t U(v_t) + (1-q_t) U(v_u)\}. \qquad \ldots(15)$$

n the economy under $\hat{S}$ we have:

$$\hat{V} = \sum_1^T (1+\rho)^{-t} E\{q_t U(\hat{v}) + (1-q_t) U(v_u)\}. \qquad \ldots(16)$$

If we now choose $\hat{v}$ so that (15) and (16) are equal—as specified in the proposition—we have that: [1]

$$\sum_1^T (1+\rho)^{-t} E\{L_t U(v_t) - L_t U(\hat{v})\} = 0. \qquad \ldots(17)$$

$U(v_t)$ can be expanded in a Taylor series to give:

$$U(v_t) = U(\hat{v}) + U'(\hat{v})(v_t - \hat{v}) + \tfrac{1}{2} U''(\phi_t)(v_t - \hat{v})^2, \qquad \ldots(18)$$

where ϕ_t lies between v_t and $\hat{v}$. Multiply through by $L_t(1+\rho)^{-t}$, sum over t and take expected values. Substitution of the condition (17) then gives:

$$\sum_1^T (1+\rho)^{-t} E\{v_t L_t - \hat{v} L_t\} = \sum_1^T (1+\rho)^{-t} \frac{1}{2U'(\hat{v})} E[-U''(\phi_t) L_t (v_t - \hat{v})^2]. \qquad \ldots(19)$$

We know that $U'' < 0$, $U' > 0$, $L_t \geqq 0$ and $(v_t - \hat{v})^2 \geqq 0$ so that the left hand side of (19) is positive (strictly positive unless $v_t = \hat{v}$ for all $L_t > 0$). Since $r = \rho$ the left hand side of (19) is equal to (14), the difference in expected profits between the two strategies, so the proposition is proved. If we ignore U''' and higher order terms the expression in (19) for the profit difference can be simplified to:

$$E(\Pi \mid \hat{S}) - E(\Pi \mid S) = R_A \left[\sum_1^T (1+r)^{-t} \tfrac{1}{2} E\{L_t (v_t - \hat{v})^2\} \right], \qquad \ldots(20)$$

where R_A is the degree of absolute risk-aversion of workers. The more risk averse the workers, the greater is the return from the non-stochastic wage.[2]

Proposition 2 has shown that it is profitable for all firms together to set a constant wage. This does not show that it will be profit-maximizing for each firm taken singly. To show this requires introducing mobility costs once again.

We have not really considered mobility in this economy so far. Let us now apply essentially the same framework as that used in the previous section. Suppose that all firms in the economy follow a strategy S with a stochastic wage. Consider a single firm deciding on its wage strategy over the period. Let this firm decide to offer $\hat{S}$ instead. This implies the same employment path and the same expected utility for a worker joining the firm, so that the firm will expect the same number of workers to join it at time zero as it would have had under S. The firm's expected profits will be higher, provided it can ensure that it still has the same share of the work force over the time-period $t = 1, \ldots, T$ (or at least whenever

1 We have multiplied by the constant N. Recall that $q_t = L_t/N$.

2 There seems to be no terribly illuminating manipulation of the term in parenthesis. Clearly the greater the variation of v_t around $\hat{v}$ the greater is the difference in expected profits.

there is full employment). A sufficient condition for the firm to retain its workers is given by: [1]

$$E_{t-1}\left\{\sum_{t}^{T}(1+\rho)^{-\tau+(t-1)}(q_\tau U(\hat{v})+(1-q_\tau)U(v_u))\right\}$$
$$\geqq E_{t-1}\left\{\sum_{t}^{T}(1+\rho)^{-\tau+(t-1)}(q_\tau U(v_\tau-C_\tau^t)+(1-q_\tau)U(v_u))\right\} \quad ...(21)$$

for $t = 2, ..., T$. Rearranging gives:

$$E_{t-1}\left\{\sum_{t}^{T}(1+\rho)^{-\tau+(t-1)}(U(\hat{v})-U(v_t-C_\tau^t))q_\tau\right\} \geqq 0. \quad ...(22)$$

This is the equivalent of the feasibility condition used earlier. If (22) is satisfied, the firm can retain its workers. $\hat{S}$ will then be feasible and will hence maximize expected profits for each firm separately.

There is a corresponding condition associated with a sustained fall in v_t. The effect of this is not to force a reduction in $\hat{v}$, but we might expect a reduction, as I shall describe. Consider the following condition:

$$E_{t-1}\left\{\sum_{t}^{T}(1+\rho)^{-\tau+(t-1)}(q_\tau U(\hat{v}-C_\tau^t)+(1-q_\tau)U(v_u))\right\}$$
$$>E_{t-1}\left\{\sum_{t}^{T}(1-\rho)^{-\tau+(t-1)}(q_\tau U(v_\tau)+(1-q_\tau)U(v_u))\right\} \quad ...(23)$$

or rearranging:

$$E_{t-1}\left\{\sum_{t}^{T}(1+\rho)^{-\tau+(t-1)}q_\tau(U(\hat{v}-C_\tau^t)-U(v_\tau))\right\} >0. \quad ...(24)$$

If this condition were violated by a fall in v_t then workers from other firms would come to this firm looking for work. This would mean the probability of employment for workers already at the firm would decline. The firm could adjust the wage downwards, increasing its profits, deterring new workers and leaving its current workers no worse off than they would have been had their probability of employment declined. There is not a perfect symmetry, however, between upward and downward wage rate adjustments and this would be accentuated if we allowed for the general practice of favouring existing workers when a firm reduces its work-force. This feature of the model, showing more definite downward stickiness of the wage strategy, seems not undesirable.

To summarize the results of this section, we have shown that the profit-maximizing strategy for all firms together is to set a pre-announced wage path that does not respond to period by period fluctuations in the state variables and hence to changes in aggregate demand, price or employment. This strategy will also be profit maximizing for each single firm, provided the fluctuations in demand are not too large. If there is a large sustained change in demand, particularly an increase in demand, then each firm will see gains from adjusting the wage path.

In comparing the two strategies S and $\hat{S}$ there may be general equilibrium effects on aggregate demand.[2] This does not affect the force of the results obtained because any single decision-making firm must surely ignore the impact of its own actions on aggregate demand.

V. EMPLOYMENT STRATEGIES

Employment strategies are much harder to analyse than wage strategies and I shall have a lot less to say about this topic. It is important to observe, however, that, while the firm

[1] The worker is shown in (21) as paying no mobility cost if he quits and is unemployed (apart from his loss of wage income of course). We could modify this. For example he might still incur search costs—some fraction of C_τ^t.

[2] The difference between S and $\hat{S}$ in terms of these effects on demand is only distributional in any case.

may smooth employment fluctuations to some extent, setting a non-stochastic level of employment does not in general maximize expected profits.

Consider the M firm economy of Section IV and suppose we knew the profit-maximizing path of output for this economy. Now compare two strategies $\tilde{S}$ and $\hat{S}$. Strategy $\hat{S}$, as defined previously, has a constant wage path but variations in employment. Strategy $\tilde{S}$ has both wage and employment constant. In both cases let the firms produce the profit-maximizing path of output. Hence with $\tilde{S}$ the firm is hoarding labour beyond its instantaneous production needs. Expected utility with $\hat{S}$ is simply (16) which I restate:

$$\hat{V} = \sum_{t}^{T} (1+\rho)^{-t} E(q_t U(\hat{v}) + (1-q_t) U(v_u)). \qquad \ldots(27)$$

With strategy $\tilde{S}$ we have:

$$\tilde{V} = \sum_{t}^{T} (1+\rho)^{-t} U(\tilde{v}). \qquad \ldots(28)$$

Choose $\tilde{v}$ so that these two are equal.

$$\sum_{t}^{T} (1+\rho)^{-t} \{E(q_t) U(\hat{v}) + (1-E(q_t)) U(v_u) - U(\tilde{v})\} = 0. \qquad \ldots(29)$$

The difference in the firm's expected profits between these two strategies is given by:

$$E(\Pi \mid \hat{S}) - E(\Pi \mid \tilde{S}) = \sum_{t}^{T} (1+r)^{-t} (\tilde{v} - \hat{v} E(q_t)) N. \qquad \ldots(30)$$

The important parameters are the path of output, the value of v_u and the concavity of $U(v_t)$. If the profit-maximizing path of output were to keep output constant then clearly keeping employment constant would be profit-maximizing. There is no theory here of the determination of the optimal price-output strategy but observation suggests variations in output are the rule. The level of v_u is the value of workers' income and leisure in periods of unemployment. If $v_u > 0$ we can certainly find paths of L_t (and hence q_t), where $L_t < N$ for some t, which satisfy equation (29) and for which (30) is positive. This means that this model will certainly predict fluctuations in employment following fluctuations in aggregate output.

Although the optimal employment strategy would have to be determined simultaneously with the optimal price-output strategy we can still see how some of the parameters would be likely to influence the result. As v_u changes the cost of unemployment changes. Government policies have a considerable impact on this. The taxation of wage income and the payment of unemployment compensation operate to lower the cost of employment variations.[1] Even without the government, however, v_u would be non-zero. A worker might find work outside the sector we are considering, perhaps within the household sector. The utility of leisure is important, particularly when the length of lay-off is not too great. The value of leisure is not independent of income; if unemployment implies starvation, leisure is worth little. In a relatively affluent economy, however, the utility of avoiding forty hours on the production line is considerable.

Although it is clear that there will be a positive probability of unemployment implied in the strategy set by the firm, it is also likely that the firm does hoard labour beyond its immediate production needs. This would reduce the probability of lay-off and be consistent with the risk-reducing role of the firm. Labour hoarding is a phenomenon that has been noted and is consistent with the observation that productivity per man increases in an upturn despite the forces which one would expect to lead to decreasing returns.[2]

[1] In principle the government has realized the incentive effect of its policies and imposes a penalty, in terms of higher social insurance contributions, for firms that have a high variance of employment. The penalties are not very effective, however, and only somewhat offset the incentive to employment variation provided by the tax on earned income and subsidy to unemployment. Feldstein [1] discusses the incentive effects of such policies in some detail.

[2] The income-smoothing motive for hoarding labour would reinforce the factors discussed by Oi [6] to explain the same phenomenon.

VI. OPTIMAL WAGE STRATEGIES AND THE CAPITAL MARKET

It has been shown in the preceding sections how, subject to some conditions, the present value of expected profits would be maximized by a policy of a non-stochastic wage path. The assumptions made about the relative risk-bearing abilities of workers and firms were strong.

Consider now a situation where firms consider the present value of expected profits but, instead of workers considering expected utility, they also consider the present expected value of their incomes. If workers are to be indifferent between strategies $\hat{S}$ and S as before then we have that:

$$\sum_{t}^{T}(1+r)^{-t}E\{q_t v_t+(1-q_t)v_u\} = \sum_{t}^{T}(1+r)^{-t}E\{q_t \hat{v}+(1-q_t)v_u\} \qquad \ldots(31)$$

or by rearranging and multiplying by N:

$$\sum_{t}^{T}(1+r)^{-t}E\{L_t v_t - L_t \hat{v}\} = 0. \qquad \ldots(32)$$

This means—comparing (32) with (14)—that the firm is also indifferent between $\hat{S}$ and S. Hence the strategy of the pre-announced wage path does not become worse than the other. The firm becomes indifferent between the two. This is at least suggestive that, given the asymmetry between workers and stockholders that I described in the introduction, then $\hat{S}$, the pre-announced wage strategy, will still show superiority even if the strict risk neutrality versus risk aversion dichotomy were relaxed.

Even a rich stockholder will not be able to hold a portfolio which is perfectly diversified. The capital market itself contains a measure of aversion to risk. If we are willing to operate in mean-variance space, we can plot the worker's indifference curve superimposed on the standard portfolio theory diagram.[1] (Figure 1). The slope of the RA line measures the increase in expected value of returns the market requires for an increase in standard deviation of the return. If the worker's indifference curve is steeper than the RA line at the point A then the optimum firm strategy will involve a strictly non-stochastic wage.

A more formal analysis seems to be extremely difficult. Since strategies S and $\hat{S}$ may involve variations in employment each worker still faces uncertainty of income even when the wage is certain. It is easy enough to find the indifference curve in the space of mean and variance of the worker's income, but when employment varies profit space and workers' income space are related only in a very awkward way.

Ideally one should also allow workers some costly or limited access to capital markets explicitly. Allowing workers to borrow and lend subject to a budget constraint could modify the optimal strategy, although this ability clearly does not eliminate risk, even though it can smooth out the consumption path.[2] In general, if firms actually set a stochastic wage path then workers would want to operate in the market for uncertain assets. The picture of millions of workers continuously taking positions in different assets immediately suggests the possibility of financial intermediation. The savings in transactions and information costs would be immense. One can therefore think of a firm which is setting a pre-announced non-stochastic wage path as providing a joint product—employment and intermediation—for its workers. The difference in profits between the two strategies is the return to the intermediation. The stockholder is willing to provide the intermediation service since he can adjust his portfolio in response to the increased risk. The firm does not set a wage strategy which pushes workers into capital market operations because it is more efficient for the stockholders to operate in the capital market.

[1] See, for example, Tobin [10].

[2] It is possible to apply essentially the same approach that is used in Section IV to prove Proposition 2 when workers borrow and lend, provided stochastic independence of the random variables is assumed. The algebra becomes extremely burdensome, however. The result holds even with no divergence between borrowing and lending rates.

There is the intriguing possibility that a third party—perhaps an agency or a labour union—might offer to provide the intermediation service instead of the firm. One may in fact observe examples of this where an agency contracts to supply labour and pays the workers a constant wage rate and receives a fluctuating margin from the firm actually using the workers in production. It would seem in most cases, however, that the firm is most advantageously placed to provide the intermediation. It will always have to have an administrative

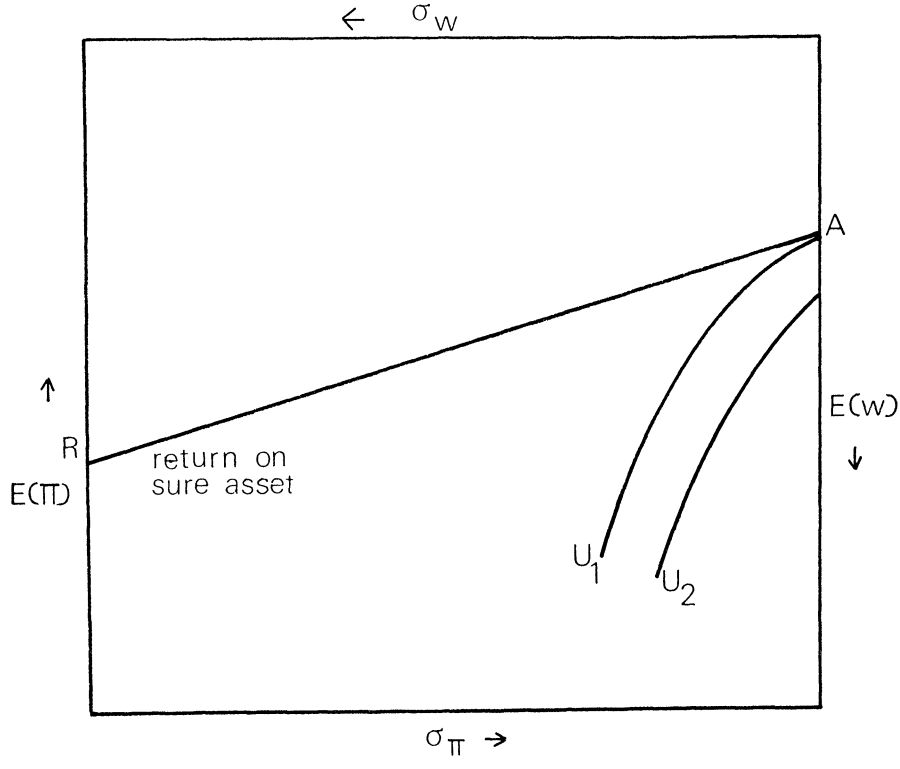

FIGURE 1

Market equilibrium with non-stochastic wage.

machinery to organize personnel matters. Its administrative costs are likely, in fact, to be minimized by a constant wage rate policy. A third party would incur the costs of an alternative administrative machinery to receive fluctuating wage payments from the firm and pay constant wage payments to workers. There is a return to the intermediation from the difference in expected profits between the alternative strategies but this does not necessarily mean that the firm has excess profits available to be bid away. If there are many competing firms then the strategy of paying a constant wage path will earn normal returns and any another strategy less than normal returns.

VII. CONCLUSIONS AND EXTENSIONS

It would be a mistake to overemphasise the strict results of Propositions 1 and 2. Changing some of the assumptions could easily modify the results. The important ideas are that firms set long-run wage and employment strategies, that these strategies embody a risk-reducing or insurance role for the firm and that employment fluctuations will be smoothed somewhat, but less than wage fluctuations. To specify clearly what sticky wages meant for the model a strictly non-stochastic (and in fact constant) wage strategy was used. A more general framework could lead to conclusions about smoothing of fluctuations, but this is harder to

specify formally.[1] Even without a more general formal framework, it is hoped that the ideas presented here can provide some insight into the rather vague but pervasive view that wages are sticky.

There are many questions unanswered and directions to go in. I have made some attempt to incorporate monopoly elements on both sides of the labour market. In particular, the fact that unions impose seniority rules on the laying-off process means that a majority are insulated from employment variations. By contrast, wage variations would affect all workers. A union working on a majority vote principle would, therefore, be willing to trade employment variations for higher wages in its bargaining. This factor would reinforce the wage-employment asymmetry described above. Introducing bargaining and unions changes the whole picture, however, and I mention it here only as a direction for further work. A more obvious extension of this paper is to look for some direct empirical evidence to support the ideas. In particular, to look for evidence to distinguish this model from other explanations of wage stickiness.[2] It is not necessary for there to be only one factor at work, though presumably some influences are more important than others.

Apart from a brief mention in Section IV, I have avoided the question of whether or not one can say that wage stickiness has caused or exacerbated unemployment. I have avoided the question because I do not know the answer. My feeling is that wage stickiness, or rather the underlying market imperfection, has exacerbated the unemployment. These are deep waters, however, and much more information is required. Specifically, a general equilibrium framework and a price adjustment specification under conditions of fluctuating aggregate demand are needed.

REFERENCES

[1] Feldstein, M. " Lowering the Permanent Rate of Unemployment ", a forthcoming publication of the Joint Economic Committee of the US Congress.

[2] Katona, G. *et al.* 1968 *Survey of Consumer Finances* (Ann Arbor, Mich.: Survey Research Center, Institute for Social Research, University of Michigan, 1969).

[3] Kuh, E. " Unemployment, Production Functions and Effective Demand ", *Journal of Political Economy*, **74** (June 1966).

[4] Lampmann, R. J. *The Share of Top Wealth-Holders in National Wealth 1922-56* (Princeton, N.J., Princeton University Press, 1962).

[5] Lucas R. E. Jr. " Capacity, Overtime and Empirical Production Functions ", *American Economic Review, Papers and Proceedings*, **60**, no. 2 (May 1970).

[6] Oi, W. Y. " Labor as a Quasi-Fixed Factor of Production ", *Journal of Political Economy*, **70** (December 1962).

[7] Phelps, E. S. *et al.* *Microeconomic Foundations of Inflation and Employment Theory* (New York: W. W. Norton, 1970).

[8] Projector, D. *et al.* *Survey of Financial Characteristics of Consumers* (Washington, D.C.: Board of Governors of the Federal Reserve System, 1966).

[9] Stigler, G. J. " Inflation in the Labor Market ", *Journal of Political Economy, Supplement*, **5**, part 2 (October 1962).

[10] Tobin, J. " Liquidity Preference as Behavior Toward Risk ", *Review of Economic Studies*, **25** (February 1958).

[1] One might use reduction of variance as a criterion, but this is approximate at best and runs into awkward covariance problems when employment and wages vary.

[2] Notably the contributions in the Phelps volume [7]. Professor Alchian has told me that some UCLA students are collecting data which may help, although I think they are more concerned with price setting behaviour. Historical data on the real wage rate and a discussion of wage rigidity can be found in Kuh [3].

[Footnotes]

[3] **Capacity, Overtime, and Empirical Production Functions**
Robert E. Lucas, Jr.
The American Economic Review, Vol. 60, No. 2, Papers and Proceedings of the Eighty-second Annual Meeting of the American Economic Association. (May, 1970), pp. 23-27.
Stable URL:
http://links.jstor.org/sici?sici=0002-8282%28197005%2960%3A2%3C23%3ACOAEPF%3E2.0.CO%3B2-S

[4] **Labor as a Quasi-Fixed Factor**
Walter Y. Oi
The Journal of Political Economy, Vol. 70, No. 6. (Dec., 1962), pp. 538-555.
Stable URL:
http://links.jstor.org/sici?sici=0022-3808%28196212%2970%3A6%3C538%3ALAAQF%3E2.0.CO%3B2-L

[2] **Labor as a Quasi-Fixed Factor**
Walter Y. Oi
The Journal of Political Economy, Vol. 70, No. 6. (Dec., 1962), pp. 538-555.
Stable URL:
http://links.jstor.org/sici?sici=0022-3808%28196212%2970%3A6%3C538%3ALAAQF%3E2.0.CO%3B2-L

[1] **Liquidity Preference as Behavior Towards Risk**
J. Tobin
The Review of Economic Studies, Vol. 25, No. 2. (Feb., 1958), pp. 65-86.
Stable URL:
http://links.jstor.org/sici?sici=0034-6527%28195802%2925%3A2%3C65%3ALPABTR%3E2.0.CO%3B2-8

[2] **Unemployment, Production Functions, and Effective Demand**
Edwin Kuh
The Journal of Political Economy, Vol. 74, No. 3. (Jun., 1966), pp. 238-249.
Stable URL:
http://links.jstor.org/sici?sici=0022-3808%28196606%2974%3A3%3C238%3AUPFAED%3E2.0.CO%3B2-9

References

[3] **Unemployment, Production Functions, and Effective Demand**
Edwin Kuh
The Journal of Political Economy, Vol. 74, No. 3. (Jun., 1966), pp. 238-249.
Stable URL:
http://links.jstor.org/sici?sici=0022-3808%28196606%2974%3A3%3C238%3AUPFAED%3E2.0.CO%3B2-9

[5] **Capacity, Overtime, and Empirical Production Functions**
Robert E. Lucas, Jr.
The American Economic Review, Vol. 60, No. 2, Papers and Proceedings of the Eighty-second Annual Meeting of the American Economic Association. (May, 1970), pp. 23-27.
Stable URL:
http://links.jstor.org/sici?sici=0002-8282%28197005%2960%3A2%3C23%3ACOAEPF%3E2.0.CO%3B2-S

[6] **Labor as a Quasi-Fixed Factor**
Walter Y. Oi
The Journal of Political Economy, Vol. 70, No. 6. (Dec., 1962), pp. 538-555.
Stable URL:
http://links.jstor.org/sici?sici=0022-3808%28196212%2970%3A6%3C538%3ALAAQF%3E2.0.CO%3B2-L

[10] **Liquidity Preference as Behavior Towards Risk**
J. Tobin
The Review of Economic Studies, Vol. 25, No. 2. (Feb., 1958), pp. 65-86.
Stable URL:
http://links.jstor.org/sici?sici=0034-6527%28195802%2925%3A2%3C65%3ALPABTR%3E2.0.CO%3B2-8