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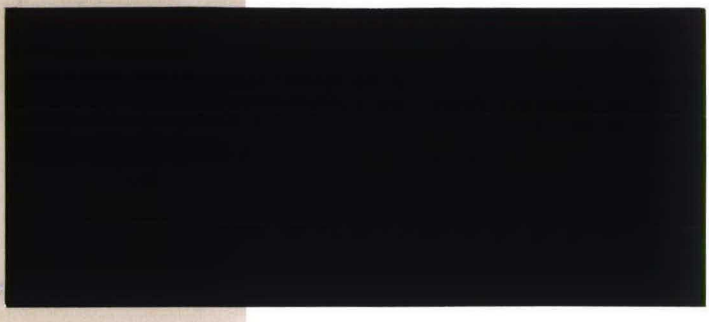

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EFFICIENCY WAGES, MARK-UP PRICING AND EFFECTIVE DEMAND

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*EFFICIENCY WAGES, MARK-UP PRICING AND EFFECTIVE DEMAND**

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Abstract

The combination of an efficiency wage approach with the explicit consideration of pricing and product market conditions leads to the existence of a unique NAIRU. The value of the NAIRU can be influenced by a variety of supply side policies but aggregate demand policies may also play a role. The effort function will be related to workers' wage aspirations and if wage aspirations depend on past outcomes of the distributional struggle then an important element of hysteresis is introduced into the system. Expansionary demand policies which increase employment will be associated with unanticipated inflation. Real wages will fall below the negotiated level and this may cause a gradual shift in wage aspirations and in the effort function.

The existence of class conflict is central to all neo-Marxian Theories of distribution. Workers strive to raise real wages while capitalists aim to maximise profits, and the outcome is determined by the relative strength of the two classes. A Keynesian perspective, however, raises important objections to this neo-Marxian story. Bargaining between workers and capitalists may determine the nominal wage rate and this determination will, in general, depend on the expected price level. But expectations will not always be realized and for a closed economy it may be illegitimate to assume that real wages are determined in the labour market. If there is imperfect competition and constant labour productivity then firms may apply a constant mark-up and the real wage rate becomes invariant with respect to variations in nominal wages. And if there is atomistic competition and diminishing returns to labour then the real wage rate is inversely related to the level of output and aggregate effective demand will determine real wages.

It is the purpose of this paper to examine these Keynesian objections. Section 1 describes how the strength of workers vis-à-vis capitalists may exert a direct influence on the negotiated real wage. Section 2 considers the implications of combining a neo-Marxian distribution theory with mark-up pricing. The role of effective demand in the neo-Marxian theory and the possibility of using aggregate demand policies to influence the long term behaviour of the economy are analysed in section 3. The final section contains a few concluding remarks.

Section 1. Real Wages and Employment.

Distribution is an important area of conflict between workers and capitalists but it is not the only one. Equally important is the determination of the intensity of work. Having hired workers, firms face the problem of ensuring that work is actually being done. Labour power, the potential for work, needs to be transformed into labour and the firm may have only one real

sanction against a non-working worker: it can dismiss the worker, the threat of dismissal being effective if the worker suffers a non-neglible "cost of job loss". This conflict over work intensity may lead to a direct relation between the strength of workers and the real wage rate.

The endogenous determination of the intensity of work - or work effort - is at the heart of efficiency wage models.[1] As an illustration we may assume - following Bowles and Boyer (1988) - that effort, e, is an increasing function of the cost of job loss

$$(1) \qquad e = e(w_c).$$

The cost of job loss, in turn, is related to the unemployment rate (u), the wages paid in other firms (w_a), and the incomes of unemployed workers (w_u) and we may assume a simple linear form,

$$(2) \qquad w_c = w - (1-u)\, w_a - u \cdot w_u.$$

Finally, assume that output is given by a fixed coefficient production function

$$(3) \qquad q = \min (eL, K)$$

where L is the input of labour in hours and where the capital stock K is predetermined in the short run.

The firm wishes to minimise unit labour cost,

$$(4) \qquad \min \quad wL$$

$$\text{s.t.}$$

$$eL = q_0$$

$$e = e(w_c)$$

and the first order condition becomes

$$(5) \qquad e'(w_c) = \frac{e(w_c)}{w}$$

or

$$(6) \qquad w = \frac{e(w_c)}{e'(w_c)} \ .$$

In equilibrium all firms pay the same wage, $w = w_a$, and equation (6) defines a relation between w, w_u and u.[2] For any given value of w_u, we thus get a relation linking unemployment and the real wage. The relation looks like a labour supply curve but it is derived entirely from firms' cost minimisation. The relation describes how firms vary their wage offers as a function of the average rate of unemployment. Low employment - a small reserve army of labour - implies that workers are strong. The threat of dismissal loses its force and the level of effort declines. By raising real wages firms partly offset the erosion in discipline: higher real wages counteract the decline in the cost of job loss and hence in effort.

This link between employment and distribution can be used to examine the dynamic behaviour of the economy. A constant rate of utilisation of capital and a fixed coefficient production function imply that the rate of profit is proportional to the share of profit and the share of profits in income is given by

$$(7) \qquad \pi = \frac{pq - pwL}{pq} = 1 - w\frac{L}{q} = 1 - \frac{w}{e}$$

$$= h(w_u, u); \ h_1 < 0, \ h_2 > 0.$$

If accumulation depends on profits, the long run equilibrium rate of unemployment can now be determined. With a constant rate of capacity utilisation and fixed coefficients the growth of employment is equal to the rate of accumulation, and the change

in the employment rate (1-u) can be written

$$(8) \qquad (1\hat{-}u) = \hat{K} - n = \varphi(\pi) - n = \varphi(h(w_u,u)) - n = \psi(1-u);$$

$$\psi' < 0$$

where n is the growth rate of the total work force and w_u has been suppressed in the ψ-function on the assumption that it is kept constant.

Equation (8) describes a stable dynamic system:[3] the rate of employment will converge to its unique long run equilibrium value. The Marxian system has apparently generated a unique "natural rate of employment". But some workers are involuntarily unemployed. In fact, unemployment is essential to the functioning of the system: it is needed to provide firms with the means to extort effort from workers. [4]

Section 2. Mark-up pricing and Keynesian demand.

The previous section has focused on the labour market. It has been assumed that the firm takes into account the effect of wages on effort but there has been no consideration of the demand conditions facing the firm, and Keynesian aggregate demand problems have been ignored. These deficiences need to be remedied.

With respect to market conditions, I shall adopt a simple form of imperfect competition and assume that the conjectured demand curve has constant elasticity,

$$(9) \qquad p_i = p^{\varrho} B\, Y_i^{-\gamma} \quad ; \quad 0 \leq \varrho \leq 1, \quad 0 < \gamma < 1$$

where p_i and Y_i are the price and output of firm i, p denotes the average price level of rival firms, and B is a multiplicative constant.

This specification implies that a profit maximising firm applies a fixed mark-up to marginal cost,

(10) $p_i = m \cdot c_i$

where $m = 1/(1-\gamma)$ and c_i represents the firm's marginal cost. If firms are identical all subscripts may be deleted and we get

(11) $p = mc.$

There are good reasons to expect that under imperfect competition firms will wish to maintain a cushion of excess capital capacity and the empirical evidence confirms this expectation. Since we have disregarded raw-materials and intermediate inputs and adopted a fixed coefficient production function, marginal cost is therefore equal to unit wage cost and from equation (1) we get

(12) $c = p\ w/e = p\ w/e(w_c)$

where p is a price index for consumption goods (assumed equal to the average price level) and w and w_c denote the real wage and the real cost of job loss, respectively.

Firms minimise unit costs taking into account the dependence of effort on wages, and the value of $w/e(w_c)$ is determined as in section 1 by w_u and u,

(13) $w/e(w_c) = \mu(u,w_u).$

Substituting equation (13) into (12) and rearranging , we get

(14) $p = \mu(u,w_u) \cdot c$

Equations (11) and (14) define two relations between price and marginal cost. The value of μ is determined by the properties of the effort function and m is derived from the conjectured elasticity of demand. If u and w_u are arbitrarily given there is no necessary link between the values of μ and m and, in general, the model will be overdetermined.

Inflation may act as the accommodating variable and eliminate this overdeterminency in the short term. Assume, for instance, that at time t workers have full knowledge about the values at time t-ε of the price index, the rate of unemployment and the income of unemployed workers, but that they have no information about movements in these variables for the period between t-ε and t, and that expectations are static. The cost minimising wage rate is then given by

$$(15) \qquad W_t = p_{t-\varepsilon} \cdot w^*(w_{ut-\varepsilon}\ ,\ u_{t-\varepsilon})$$

where W is the nominal wage rate.

The introduction of incomplete information has invalidated the contemporaneous relation between costs and prices in equation (14). Instead, we now get

$$(16) \qquad c_t = p_{t-\varepsilon} \quad \mu(u_{t-\varepsilon},\ w_{u\ t-\varepsilon})$$

or

$$(17) \qquad p_{t-\varepsilon} = c_t \cdot \mu(u_{t-\varepsilon},\ w_{u\ t-\varepsilon})$$

Retaining the mark-up given by equation (11), it follows that

$$(18) \qquad \frac{p_t}{p_{t-\varepsilon}} = \frac{m}{\mu}\ .$$

The rate of inflation will thus be positive (negative) if $m > \mu$ ($m<\mu$).

The analysis can be augmented in the standard way to allow for non-static price expectations. Assume that workers expect prices at time t to be some multiple of the observed price index at time t-ε,

$$(19) \qquad p_t^e = \lambda p_{t-\varepsilon}.$$

We then get

$$(20) \qquad c_t = \lambda p_{t-\varepsilon}\, \mu(u_{t-\varepsilon},\, w_{u\ t-\varepsilon})$$

and

$$(21) \qquad \frac{p_t}{p_{t-\varepsilon}} = \lambda\frac{m}{\mu}\ .$$

Incomplete information and lags in the adjustment process may thus allow inflation to remove the overdeterminacy resulting from an inequality between μ and m in the short term. Inflation plays a similar role in Rowthorn (1977) and Marglin (1984). It is doubtful, however, whether inflation can remove the over-determinacy in the long term. Price expectations will change in the light of past experience and if the expectations parameter λ in equation (19) changes endogenously, the scene is set for accelerating inflation: a non-accelerating inflation rate requires that $\mu(u,w_u) = m$. For any given value of w_u we thus get a unique NAIRU, $u^* = u^*(m,w_u)$.

Is u^* a feasible long run equilibrium solution? The dynamic behaviour of u will - as in section 1 - depend on the rate of accumulation and the movements in capital utilization. If σ denotes the rate of utilization then

$$(22) \qquad \hat{(1-u)} = \hat{K} + \hat{\sigma} - n$$

and in a Keynesian framework $\hat{K}$ and $\hat{\sigma}$ are determined by the saving and investment functions. At a long run equilibrium we have $\hat{(1-u)} = \hat{\sigma} = 0$ and the equilibrium conditions can be written

$$(23a) \qquad \frac{S}{K} = \frac{I}{K}$$

$$(23b) \qquad \frac{I}{K} = n$$

A standard specification of the saving and investment functions

will include both capital utilisation and the profit share as independent variables. The profit share, however, is fully determined by the mark-up and in order to ensure a solution to (23a)-(23b) one needs to introduce another free variable. There are several possibilities. Marglin (1984) assumes that accumulation depends on the rate of inflation. Alternatively, saving and/or investment may depend on the rate of interest (Ambrosi (1988)) or it may be argued that fiscal and monetary policies influence saving and/or investment and that deviations from the NAIRU will induce policy changes (Rowthorn (1977)).

For present purposes the choice of accommodating variable is of no importance. The point is simply that an extra variable needs to be introduced in order to ensure the existence of a long run equilibrium but that once this has been done the rate of unemployment at the equilibrium will be fully determined by the mark-up and the effort function. We have included Keynesian elements in the analysis but the long run outcome appears to be completely independent of these Keynesian elements.[5)]

Section 3. Policy Implications.

If the equilibrium rate of unemployment is independent of the Keynesian elements in the model then aggregate demand policies would appear to be ineffectual in the long run. In order to be successful in the long term, employment policies must influence the desired mark-up and/or the shape and position of the effort function.

An active anti-monopoly policy aimed at increasing competition may reduce m, and reductions in unemployment benefits and social security payments may reduce w_u and shift the μ-function downwards. These shifts in m and μ both raise the equilibrium rate of employment. Arguably, interventionist price and incomes policies could achieve similar effects and institutional reforms may also be used to shift the effort function. Employee share

ownership plans, for instance, have become increasingly popular in the US. The popularity may be partly explained by tax advantages but even The Economist (May 20 1989, p. 14) applauds this development arguing that "turning their employees into shareholders will make them work harder and smarter and so boost the company's productivity and profits to the benefit of all its shareholders".

Structural supply policies like these can undoubtedly be important for the long term development of the economy but how robust is the negative conclusion of ineffective demand policies? Is it plausible to assume that m and $\mu(.,.)$ are invariant with respect to the state of effective demand?

The mark-up is determined by the conjectured elasticity of demand and, as argued in Auerbach and Skott (1988), these conjectures may well change endogenously as firms revise their demand expectations in the light of experience: there is no reason to suppose that unanticipated changes in actual demand will be reflected exclusively in adjustments in the conjectured value of the multiplicative constant B in equation (9) with γ remaining unchanged. Since aggregate demand policies influence the demand conditions facing the representative firm they may therefore also affect the mark-up factor. Arguably, however, the effect of demand on the μ-function will be of greater interest. Let us assume, therefore, that m is given and consider the factors determining the shape and position of the effort function.

The dependence of effort on wages can be derived from a standard utility maximising framework where each worker's utility is given as a function of consumption, leisure and effort. In this case there is no reason to expect any influence of aggregate demand on the effort function.[6] But other interpretations of the effort function are possible. Rowthorn's (1977) specification of the "negotiated wage share" as well as the post-Keynesian and neo-

Marxian use of real wage targets (e.g. Arestis (1986), Sawyer (1986) are also consistent with the efficiency wage framework.

In Rowthorn's model the balance of power between workers and capitalists in the labour market determines the negotiated wage share. Unanticipated price changes, however, may cause the actual real wage to deviate from the negotiated wage. Workers, in Rowthorn's words, "may negotiate increases designed to give them a certain standard of living, and individual capitalists, having agreed on these wage payments, may then set prices so as to achieve a certain target rate of profit. For any individual capitalist, this need not imply a deliberate attempt to alter the level of real wages and vitiate what has been agreed in the wage bargain. Yet aggregating over the whole economy this may be the objective consequence of their individual and uncoordinated decisions". (p. 150).

In this respect the argument in section 2 mirrors Rowthorn's analysis. The efficiency wage represents the negotiated wage and the aggregated effects of mark-up pricing leads to unanticipated price changes and deviations from the efficiency wage.
How is the negotiated real wage to be determined in Rowthorn's framework? He argues that as labour "reserves are progressively exhausted or unemployment reduced, their bargaining position becomes stronger and workers become more confident and aggressive" and "workers use their greater power to extract higher wages from their employers" (p. 154).

But why should firms accept these wage claims? An obvious explanation is that they may find it in their own best interest to do so since rejection of the wage claim may raise unit labour costs even more: workers may threaten industrial action and a failure to raise wages may also increase unit costs in less dramatic ways as workers' dissatisfaction affects work intensity and labour turnover. The negotiated real wage thus is closely related to efficiency wage. But Rowthorn (p. 174) explicitly

rejects the standard framework of individual utility maximization. Instead, organised power, politics and ideology play important roles.

A simplified interpretation of Rowthorn's argument is outlined in figure 1. Given their price expectations, workers demand money wage, W^T. A wage rate at or above W^T leads to normal levels of work intensity while wage offers below W^T cause industrial unrest and low productivity. Firms minimise unit costs and with a discontinuity at W^T they accept the wage demand. But how is W^T to be determined? The expected price level, the size of the reserve army and the level of benefits may be important, but - rejecting the individual utility approach - the historically and socially conditioned wage aspirations also play a role. Algebraically, W^T can then be written as:

$$(24) \qquad W^T = p^e\varphi(u,w_u,x);\ \varphi_u < 0 \quad \varphi_w > 0 \quad \varphi_x > 0$$

where x represents the historical and ideological element in wage formation. To simplify, we may assume that real benefits $w_u = \bar{w}_u$ are constant and, by assumption, we have $W = W^T$ and $w = \bar{w}$ where $\bar{w}$ is the real wage rate associated with the price mark-up m and the normal productivity level $\bar{e}$.

Figure 1 about here

The difference between equation (24) and the earlier specifications in equations (14) and (15) is the appearance of the historical element x in (24). The evolution of x will be influenced by ideological and political factors which are exogenous to any simple economic model but there may also be important feedback effects from the economic variables. If, for instance, actual wages exceed the negotiated wage for a prolonged period then it seems inconceivable that the negotiated wage should remain fixed at the original level. Wage aspirations will be conditioned by past levels of the real wages and one would

expect x to change in response to discrepancies between the negotiated and the actual real wage.[7] We thus get a relation of the following form

$$(25) \qquad \dot{x} = g(w/w^T);\ g' > 0,\ g(1) = 0$$

Substituting equation (24) into (25) and using $(w,w_u) = (\bar{w},\bar{w}_u)$ we get the expression

$$(26) \qquad \dot{x} = g(\bar{w}/\varphi(u,\bar{w}_u,x)) = \psi(u,x);\ \psi_u > 0,\ \psi_x < 0$$

Equation (26) implies that wage aspirations (worker militancy) will adjust over time and that any given rate of unemployment can become a long run equilibrium. If unemployment is maintained at $u = u_0$ - through the use, for instance, of active demand policies - then x will converge to a value $x(u_0)$ such that $\bar{w} = \varphi(u_0,\bar{w}_u,x(u_0))$. The policy conclusions have been reversed: Keynesian policies can influence the long run equilibrium if one allows for an historical element in the formation of wage demands.

What are the consequences for inflation of expansionary Keynesian policies? Assume that initially the economy is in a position of long run equilibrium at $u = u_0$ but that the government wants to move to a new long run position at $u = u_1$, and hence a new equilibrium value of x, $x = x_1$, which solves $f(u_1, \bar{w}_u, x_1) = \bar{w}$. We have $W_t^T/p_t = \bar{w}$ and $W_t^T/p_t^e = w_t^T$ (where p_t^e is the expected price as of time t-1) and equation (25) can therefore be rewritten in terms of expected and actual prices,[8]

$$(27) \qquad \dot{x} = gp^e/p = \tilde{g}(\hat{p}^e - \hat{p})$$

Adjustment to the new equilibrium at x_1 implies

$$(28) \qquad x_1 - x_0 = \int \dot{x} = \int \tilde{g}(\hat{p}^e - \hat{p})$$

and the inflationary implications of this change in x and u clearly depend upon the formation of price expectations as well as on the precise specification of the g-function.

Consider first the simple case of static price expectations. We then have $p_t^e = p_{t-1}$ and hence

(29) $\hat{p}^e = 0$

The economy converges to a new equilibrium with $\dot{x} = 0$ and since $\dot{x} = \tilde{g}(\hat{p}^e - \hat{p}) = \tilde{g}(-\hat{p})$ it follows that the rate of inflation will converge to zero. Expansionary policies thus do not affect the long term inflation rate in this case. But if we modify the expectational hypothesis the conclusion changes. Assume, for instance, that expectations are static with respect to the rate of inflation, i.e.

(30) $\hat{p}_t^e = \hat{p}_{t-1}$

and hence

(31) $\dot{x} = \tilde{g}(\hat{p}^e - \hat{p}) = \tilde{g}(-\dot{\hat{p}})$

The equilibrium condition $\dot{x} = 0$ now implies $\dot{\hat{p}} = 0$. The rate of inflation will be stationary at the new equilibrium but the new equilibrium value $\hat{p}_1$ will (in general) be different from the initial inflation rate $\hat{p}_0$.

The value of $\hat{p}_1$ is fully determined and path-independent if $\tilde{g}$ is linear. We then have

(32) $x_1 - x_0 = \int \tilde{g}(-\dot{\hat{p}}) = \int -\alpha\dot{\hat{p}}$

or

(33) $\hat{p}_1 = \hat{p}_0 + (x_0 - x_1)/\alpha$

The equilibrium values of x and u are directly related and equation (33) therefore implies a Phillips relation between the long run equilibrium values of inflation and unemployment. This stable Phillips curve evaporates as soon as one introduces non-linearities in the $\tilde{g}$-function. If, for instance, $\tilde{g}$ is cubic then

$$(34) \qquad x_1 - x_0 = \int - \alpha(\dot{\hat{p}})^3$$

and

$$(35) \qquad \hat{p}_1 - \hat{p}_0 = \int \dot{\hat{p}}$$

It follows that the relation between $\hat{p}_1$ and x_1 (and hence between $\hat{p}_1$ and $u_1 = u_1(x_1)$) will be path-dependent. If the government wants to minimise the inflationary consequences of the desired reduction in u (and x), then the cubic specification in (34) implies that it should apply a short sharp shock: a large expansion of demand - taking the unemployment rate temporarily below the desired long term value - will imply high values of $\dot{\hat{p}}$ and these affect militancy more strongly than inflation. If, for instance, u_t is fixed such that $\dot{\hat{p}}_t = \delta$ during the transition from x_0 to x_1 then the length of the transitional period is given by $T = (x_0 - x_1)/\alpha\delta^3$ and the inflationary impact of the policy is $\hat{p}_1 - \hat{p}_0 = T \cdot \delta = (x_0 - x_1)/\alpha\delta^2$.

The policy conclusions are reversed if $\tilde{g}'$ is decreasing as a function of $|-\dot{\hat{p}}|$ rather than increasing as in the cubic example. If unanticipated inflation have a less than proportional effect on militancy then the inflationary consequences are minimised by adopting a slow and gradual policy. Although the introduction of a feedback effect from realised wage rates to future wage aspirations leaves room for Keynesian demand policies, it is therefore not possible to derive precise policy conclusions without detailed knowledge of the functional forms.

Section 4.

The efficiency wage approach can provide a formal explanation of the direct influence of unemployment on the negotiated real wage but price expectations will not be realized unless the negotiated real wage happens to be compatible with firms' pricing policies. The explicit consideration of pricing and product market conditions in a neo-Marxian framework thus leads to the existence of a unique NAIRU. The value of the NAIRU can be influenced by a variety of supply side policies but in this paper I have argued that aggregate demand policies may also play a role. If wage aspirations depend on past outcomes of the distributional struggle then an important element of hysteresis is introduced into the system. Expansionary demand policies which increase employment will be associated with unanticipated inflation. Real wages will fall below the negotiated level and this may cause a gradual downward shift in the schedule of wage demands.

The argument in favour of induced shifts in wage aspirations does seem plausible but the significance of these shifts depends critically on the speed with which they occur and a priori reasoning has little to say on this issue. It should be noted also that there may be anti-Keynesian feedback effects from the rate of employment on workers' militancy and wage demands: low unemployment may cause a gradual increase in militancy. This effect is at the heart of Goodwin's (1967) formalisation of Marx's theory and it has been used in numerous extensions of Goodwin's analysis. This anti-Keynesian feedback may help to explain the long term movements in unemployment, inflation and industrial conflict over the postwar period (see Desai (1984) and Skott (1990)) and it may well be of greater empirical importance than the hysterises effects analysed in this paper.

Footnotes.

1. See Bowles (1985) and Green (1988) for a discussion of the relationship between Marxian conceptions of production and the efficiency wage literature.

2. In the simple case when $e = (w_c)^{\gamma}$ we get

$$w = \frac{u}{u-\gamma} \cdot w_u.$$

3. The present specification of the rate of accumulation represents a generalisation of Goodwin's (1967) analysis. Unlike Goodwin, however, it is assumed that the rate of unemployment determines the share of wages in income (not the change in the share of wages) and this accounts for the qualitative difference in the dynamic behaviour of the two systems.

4. An equilibrium $u^* \in]0,1[$ exists if $\Psi(0) > 0$ and $\Psi(1) < 0$. If the first inequality is violated then $u^* = 1$. Violation of the second inequality implies that the assumption of full capacity utilisation must be abandoned: in this case the rate of accumulation exceeds the growth rate of the labour force even at full employment. Real wages, however, go to infinity as $u \to u_0 > 0$ and as gross profits become negative, firms will cease production and net accumulation will (on any reasonable specification) become negative. Strong theoretical reasons thus support the second inequality.

5. Bowles and Boyer (1988) analyse a model which includes both efficiency wages and separate saving and investment functions. They do not, however, consider the pricing decisions (the market conditions of individual firms) and allow the mark-up to vary freely. Shifts in the saving and investment functions therefore influence the equilibrium rate of unemployment in their model.

6. What matters, however, is firms' conjectured relationship between wages and effort and if firms have imperfect information then these conjectures may be revised as a result of shocks to the economy. An aggregate demand shock, for instance, may lead to an increase in all wage rates and prices but firms and/or workers may not realize instantaneously that relative real wages are unchanged.

7. A similar argument is used in the Keynesian literature on wage relativities. Workers have views about what constitutes a fair wage structure and deviations from fairness cause wage claims to escalate. Fairness, however, is hard to achieve since, as argued by Hicks (1974), "[n] system of wages, when it is called into question, will ever be found to be fair" (p. 65). In order to reduce conflict over relativities it therefore becomes important that "the system of wages should be well established, so that it has the sanction of custom. It then becomes what is expected; and (admittedly on a low level of fairness) what is expected is fair" (Hicks (1974, p. 65)). See also Wood (1978), Paldam (1989) and Skott (1990).

8. The second equality in (29) uses a first order approximation. We have

$$\begin{aligned} p_t^e/p_t &= \exp\,(\log p_t^e/p_{t-1} - \log p_t/p_{t-1}) \\ &\approx \exp\,[(p_t^e-p_{t-1})/p_{t-1} - (p_t-p_{t-1})/p_{t-1}] \\ &= \exp\,(\hat{p}^e - \hat{p}\,) \end{aligned}$$

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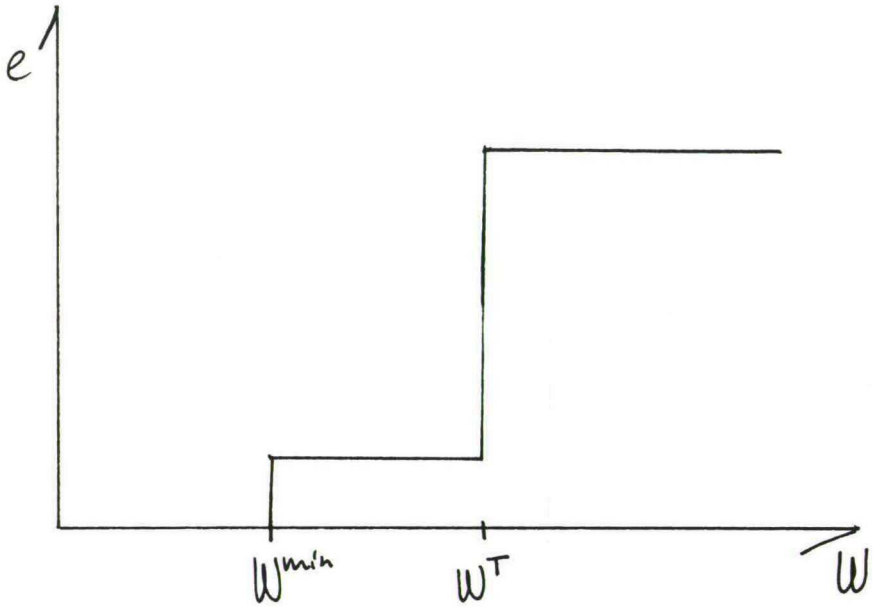

Figure 1.

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