MONETARY POLICY, EFFICIENCY WAGES, AND NOMINAL WAGE RIGIDITIES

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INTRODUCTION

Efficiency wage models have been used for several decades to explain equilibrium unemployment; see Salop [1979] and Shapiro and Stiglitz [1984]. Much of the work done on efficiency wages has been concerned with policies to reduce that level of unemployment. Tax and subsidy policies have been suggested; see Johnson and Layard [1986]. Monetary policies have also been suggested.

Monetary policy can lower unemployment and have other real effects when efficiency wages are combined with some nominal rigidity. In some models, including those of Gottfries and Westermark [1998], Stiglitz [1986], and Summers [1988], the rigidity causes a fixed nominal wage.[1] Thus a monetary expansion that raises prices must lower real wages; this can raise employment and output. But it is important to note that in each of these models, one effect, central to efficiency wage models, is assumed either nonexistent or small. When the size of that effect, as estimated in the literature, is taken into account, the above result is impossible. Instead, monetary expansions raise employment but lower output. Given this unrealistic result, one might conclude that at least in their current forms, efficiency wage models with nominal wage rigidities cannot be plausibly applied to monetary issues or used to justify monetary policy.

The central effect these models omit or undervalue is that of unemployment on worker efficiency or productivity. To understand this effect, consider a moral hazard or shirking model of efficiency wages. In such a model, the threat of firing causes workers to provide effort, not to shirk. If unemployment is high, it takes longer for a fired worker to find a new job. So, firing is a greater punishment and workers work harder to avoid it. In short, greater unemployment causes greater worker effort. That this is central to efficiency wage models can be seen from the title of the subfield's best-known work, "Equilibrium Unemployment as a Worker Discipline Device," by Shapiro and Stiglitz [1984].

Similar logic holds in efficiency wage models of turnover; see Calvo [1979]. In these models, high turnover means low efficiency, either due to hiring and training costs, or due to low-tenure workers being less productive. In these models, as in shirking models, high unemployment makes it more difficult to find a new job. Workers quit less often, turnover falls, and efficiency rises. Whether turnover or effort is the motivation, greater unemployment often raises efficiency in efficiency wage models.

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Once one takes this effect into account, monetary results change. Efficiency may fall with the monetary expansion for two reasons. It certainly falls when unemployment falls, as in the above paragraphs. It may also fall if the monetary expansion lowers real wages. If these effects are great enough, they dominate the rise in employment, causing a drop in output.

Which effects do dominate? Does output rise or fall with money in efficiency wage models? To answer these questions, this paper uses a general efficiency wage model similar to those of Gottfries and Westermark [1998], Stiglitz [1986], and Summers [1988]. As in those models, nominal wages are rigid in the short run when the money supply rises. The presence of these nominal wage rigidities has received support in recent empirical work; see Spencer [1998], Gamber and Joutz [1997], and Holmes and Hutton [1996].[2] With such rigidities, a monetary expansion lowers real wages, raises employment, and lowers efficiency. One can find a necessary and sufficient condition for output to fall. The condition is a simple comparison of two elasticities, both of which have been estimated in the literature. According to these estimates, the condition holds; output falls when the money supply rises.

It is crucial to note that this result does not imply that an increase in employment lowers output. It does imply that employment and output move in opposite directions when some government policy changes the real wage. This should not be surprising; such results are common in efficiency wage models. In Drazen [1986], Perri [1990], and Carter [1999b], employment falls and output rises in response to a minimum wage law. Tariffs may raise employment but lower output in the models of Brecher [1992] and Agell and Lundborg [1995]. In a model with endogenous monitoring, Shapiro and Stiglitz [1984, 441] show that policies that lower employment also increase efficiency so much that output rises. In Carter's [1995] efficiency wage model, any government policy that raises employment must also reduce output. The current analysis extends this familiar result to the analysis of monetary policy.

Below, a simple efficiency wage model is used to illustrate the crucial relationship between unemployment and efficiency. In this model, an increase in the money supply unambiguously lowers output. Later, a more general model is used, in which the output change is theoretically ambiguous. The ambiguity is resolved using published empirical results. Alternative efficiency wage models are also considered. The conclusions follow. The main conclusion is that current efficiency wage models with nominal wage rigidities may not be well-suited to realistic discussions of monetary policy.

A SIMPLE EFFICIENCY WAGE MODEL

The purpose of this section is to show how a monetary expansion unambiguously lowers output in a simple efficiency wage model. To begin, assume that many identical, atomistic firms produce one homogenous good using one factor of production, labor. The demand for the good is a function of the real money supply, as in Equation (1). Equation (1) may be viewed as a simplification of standard money demand functions.

(1) $$Q = Q_D(M/P) .$$

Q is the quantity of the homogenous good and P is its price. M is the nominal money supply.

The firms pay efficiency wages. Equation (2) is the profit function. Equation (3) is the efficiency function.

$$\pi_i = PQ_i(e_iL_i) - W_iL_i \ , \tag{2}$$

$$e_i = e_i([W_i/P],\ L_E)\ ,\ \varepsilon_W > 0;\ \ \varepsilon_L < 0\ . \tag{3}$$

π_i, Q_i, e_i, W_i, and L_i denote firm i's profit, output, worker efficiency, nominal wage, and level of employment. L_E is the economy-wide level of employment, the sum of all the firms' L_i's. Normalizing the labor force to one, L_E equals the employment rate, one minus the unemployment rate. The ε_i's are the elasticities of e_i with respect to its two arguments.

In Equation (2), firm output is a function of e_iL_i, as is commonly assumed in efficiency wage models. Equation (3) shows efficiency to be increasing in the firm's real wage and decreasing in the economy-wide employment rate.[3] Efficiency is a general term, dependent on effort in shirking models, turnover in turnover models, and morale, fairness, and so forth in other efficiency wage models. Equation (3) is therefore consistent with many motivations for efficiency wages.

In the absence of any rigidities, firm i chooses L_i and W_i to maximize profit. The first order conditions are:

$$(\partial\pi_i/\partial L_i) = PQ_{Li}e_i - W_i = 0\ , \tag{4}$$

$$(\partial\pi_i/\partial W_i) = [Q_{Li}(\partial e_i/\partial[W_i/P]) - 1]L_i = 0\ , \tag{5}$$

where Q_{Li} is the derivative of Q_i with respect to firm i's effective labor, e_iL_i. Combining Equations (4) and (5), one can find the familiar Solow [1979] condition, $\varepsilon_W = 1$. This condition shows that firms choose wages to minimize the real effective cost of labor, which is the real wage per unit of efficiency, $(W_i/P)/e_i$.

This model can be used to study the effects of a change in the money supply. If there is no nominal rigidity, money has no real effects. But assume the wage is rigid in the short run. This could be because of a coordination problem, as in Stiglitz [1986] and Summers [1988], or it could be because of long-term contracts, as in Gottfries and Westermark [1998]. The reason is not important.[4] While the wage is fixed in the short run, continue to assume that it is perfectly flexible in the long run. It is important to understand what this implies about the Solow condition. The Solow condition holds when firms are free to choose the optimal wage. With wages perfectly flexible in the long run, the Solow condition holds in long run equilibrium. With short-run nominal rigidity, it need not hold continuously; see below.

Now, starting from a point of long-run equilibrium, let M increase. To solve for the short-run results, begin by taking the derivatives of Equations (1), (3), and (4). These are shown as Equations (6a), (6b), and (6c), respectively. Note that since all firms are identical, e_i, W_i, and Q_{Li} are identical for all i and subscripts are dropped. One might think of e, W, and Q_L economy-wide variables, each in equilibrium equal to the corresponding firm-level variable. Equation (6d) is the derivative of the economy's production function, $Q = Q(eL_E)$.

(6a) $$Q^* = \eta_D(M^* - P^*) \,,$$

(6b) $$e^* = \varepsilon_W(W^* - P^*) + \varepsilon_L L_E^* \,,$$

(6c) $$P^* + \eta_{QL}(e^* + L_E^*) + e^* - W^* = 0 \,,$$

(6d) $$Q^* = \Theta_L(e^* + L_E^*) \,,$$

where * denotes a proportional change ($P^* = dP/P$). Since all firms are identical and since the number of firms is constant, $L_E^* = L_i^*$. η_D is the elasticity of Q with respect to M/P in Equation (1), the demand equation; $\eta_D > 0$. η_{QL} is the elasticity of Q_L with respect to eL_E; $\eta_{QL} < 0$ by a second order condition. Θ_L is the share of labor in production, WL_E/PQ. Using Equation (4), $\Theta_L = Q_L eL_E/Q$.

Setting $W^* = 0$, these can be solved for the short-run effects of a monetary shock. Note that since nominal wages are rigid in the short run, Equation (5) no longer holds; this means the Solow condition no longer holds.

(7a) $$P^* = M^*[Z/D] \,,$$

(7b) $$L_E^* = M^*[1 - \varepsilon_W(1 + \eta_{QL})]/D \,,$$

(7c) $$e^* = M^*[\varepsilon_W\eta_{QL} + \varepsilon_L]/D \,,$$

(7d) $$Q^* = M^*\Theta_L[1 - \varepsilon_W + \varepsilon_L]/D \,,$$

where $Z = -[\eta_{QL} + \varepsilon_L(1 + \eta_{QL})]$ and $D = \Theta_L(1 - \varepsilon_W + \varepsilon_L)/\eta_D + Z$. D and Z are both positive by stability conditions.[5] To analyze these results, remember that the economy is in long-run equilibrium before the shock. Thus, if the shock is small, the Solow condition still holds approximately and ε_W is still close to 1 (larger shocks are considered below). With that, one can sign all the results:

$$P^*,\ L_E^* > 0 > e^*,\ Q^*.$$

With the monetary shock, Equation (7a) shows that prices rise, lowering the real wage. From Equation (7b), this raises L_E; there are more jobs when the real wage is low. But from Equation (7c), this implies two negative effects on efficiency. As discussed above, both the rise in employment and the drop in real wages reduce efficiency.

The efficiency result may be seen as complementary to that of Schmidt [2000a]. He finds that monetary policy may have a negative effect on efficiency if it changes relative wages (if some real wages fall more than others). The current result is that even if there is no relative wage change, monetary policy can still lower efficiency.

With L_E rising but e falling, the change in output may seem ambiguous, but it is not. From Equation (7d), output falls if and only if $[1 - \varepsilon_W + \varepsilon_L] < 0$. At the point of long-run equilibrium, the Solow condition holds; $1 - \varepsilon_W = 0$. Since $\varepsilon_L < 0$, output falls.

To understand the intuition, remember that firms choose W to minimize the effective cost of labor, $(W/P)/e$. From the firm's first order conditions, $\partial[(W/P)/e]/\partial(W/P) = 0$, a drop in real wages also lowers e, leaving $(W/P)/e$ approximately constant. With the real effective cost of labor approximately constant, firms continue to demand approximately the same amount of effective labor; eL_E is approximately constant. Output must also be approximately constant, so far. But for output to be constant at a lower e, firms must raise employment. Once they do, L_E rises and so e falls; this effect is measured by ε_L. $(W/P)/e$ therefore rises. With a higher effective cost of labor, firms demand less labor input; eL_E falls. When firms employ a smaller amount of effective labor, output falls.

This analysis assumes that the Solow condition approximately holds. It does so as long as the real wage is in the neighborhood of the optimal firm-chosen wage. But as the monetary shock pushes the real wage lower, ε_W rises.[6] From Equation (7d), the larger is ε_W, the more output falls with a rise in the money supply, all else equal. The negative effect on Q is thus reinforced. The intuition here is that as the wage is forced further and further from the cost-minimizing level, costs rise more and more. This induces firms to produce less and less.

There are other perverse implications here. First, since the price increase lowers output, the aggregate supply curve must be downward sloping. In many models, aggregate supply is upward sloping because higher prices cause lower real wages, greater employment, and greater output. Here, since the output result is reversed, the slope of the aggregate supply curve is also reversed.[7]

Second, profits behave in a counterintuitive way. In other models, a positive monetary shock lowers real wages and, since wages are a cost to the firm, lowers costs and raises profits. Here, the lower nominal wages actually raise labor costs and so lower profits. For intuition, remember that the efficiency wage is chosen to maximize profits; it is therefore no surprise that a shift from that wage lowers profits.[8]

In summary, a positive monetary shock lowers real wages and so raises employment. Lower wages and higher employment both reduce labor efficiency. Because of the Solow condition, this drop in efficiency dominates the rise in employment; output falls. Also, profits fall and the aggregate supply curve is downward sloping. The next section shows that these results also hold in a general efficiency wage model.

A GENERAL EFFICIENCY WAGE MODEL

The previous section highlights the crucial effect of employment on efficiency in a simple model. To make the model more general, this section modifies the efficiency equation, Equation (3). Equation (8a) is the more general equation to be used in this section. Most efficiency wage models include relationships that are special cases of Equation (8a).

(8a) $$e_i = e_i([W_i/P], [W_A/P], L_E), \varepsilon_W > 0; \varepsilon_A < 0; \varepsilon_L < 0 .$$

W_A is the average wage paid in other firms; ε_A is the elasticity of e with respect to W_A/P. In Equation (8a), higher wages paid elsewhere in the economy cause efficiency to drop. One can see the logic of this in a shirking or turnover model. In a turnover model, high wages elsewhere make workers more likely to move elsewhere. This raises turnover and so lowers efficiency. Similarly, in a shirking model, unemployment is not as bad if potential jobs are higher paying. Firing is less of a punishment, therefore; workers work less hard. Effort and efficiency fall.

Since all firms are identical, $W_A = W_i$ in equilibrium. Using that, the total derivative of Equation (8a) is Equation (8b).

(8b) $$e^* = (W^* - P^*)(\varepsilon_W + \varepsilon_A) + \varepsilon_L L_E^* .$$

Holding $W^* = 0$, one can now solve Equations (6a), (6c), (6d), and (8b) for the short-run effects of M on P, L_E, e, and Q.

(9a) $$P^* = M^*[Z/D_2] ,$$

(9b) $$L_E^* = M^*[1 - (\varepsilon_W + \varepsilon_A)(1 + \eta_{QL})]/D_2 ,$$

(9c) $$e^* = M^*[(\varepsilon_W + \varepsilon_A)\eta_{QL} + \varepsilon_L]/D_2 ,$$

(9d) $$Q^* = M^*\Theta_L(1 - \varepsilon_W - \varepsilon_A + \varepsilon_L)/D_2 ,$$

where $D_2 = Z + \Theta_L(1 - \varepsilon_W - \varepsilon_A + \varepsilon_L)/\eta_D$ and Z is as defined in the previous section. As above, D_2 and Z are both positive because of stability conditions. Now, using Equation (9d) and the Solow condition, $(dQ/dM) < 0$ if and only if $(\varepsilon_L - \varepsilon_A) < 0$. This is the condition for output to fall when the money supply rises. Since both ε_L and ε_A are negative, the condition can be restated as in Condition (10).

(10) $$dQ/dM < 0 \text{ iff } |\varepsilon_L| > |\varepsilon_A| .$$

Does this condition hold? Published empirical work consistently suggests that it does. Campbell [1993], Cappelli and Chauvin [1991], Green and Weisskopf [1990], and Huang et al. [1998] each estimate versions of the efficiency wage model. Each article provides some evidence that $|\varepsilon_L| > |\varepsilon_A|$. Consider each of these articles in turn.[9]

Campbell [1993] assumes that efficiency is a function of the quit rate. He estimates an equation in which the quit rate is an exponential function of the wage, the alternative wage, the unemployment rate, and other variables. This gives estimates of the elasticity of quits with respect to the alternative wage and with respect to unemployment (which can be easily transformed into an elasticity with respect to the employment rate). From his estimates, the effect of the employment rate on quits is 13 to 26 times as large as the effect of the alternative wage. $|\varepsilon_L|$ is far greater than $|\varepsilon_A|$ on these estimates.

Cappelli and Chauvin [1991] assume a moral hazard or shirking version of the efficiency wage model. In their estimated equation, the rate of disciplinary dismissals is a function of the wage premium, the unemployment rate, and other variables. The wage in their interplant, intrafirm study is the same across plants; thus, the wage premium term captures only the effect of the alternative wage. By their results, one can find that the elasticity of dismissals with respect to the employment rate is 10 to 250 percent greater than the elasticity with respect to the alternative wage (see estimations (1) and (2) in Cappelli and Chauvin [1991, 782]). Again, this means $|\varepsilon_L| > |\varepsilon_A|$.

Green and Weisskopf [1990] do not estimate the alternative wage effect, but their results are still instructive. They run separate regressions for each of 100 industries, regressing efficiency on the unemployment rate. They find that for the average industry, efficiency rises by 6 percent when unemployment rises by 50 percent (p. 247). When unemployment rises 50 percent from, say, 6 percent to 9 percent, employment falls 3.2 percent from 94 percent to 91 percent. Since this raises efficiency by 6 percent, $|\varepsilon_L|$ is about 2. From the Solow condition, $|\varepsilon_W| = 1$. Thus, Green and Weisskopf's [1990] results are that $|\varepsilon_L| > |\varepsilon_W|$. It is reasonable to assume that the effect of a worker's own wage on efficiency is at least as great as the effect of alternative wages; that is, $|\varepsilon_W| > |\varepsilon_A|$. If so, Green and Weisskopf's [1990] results also support the condition in Equation (10).

Huang et al. [1998] also estimate the effects on productivity of the unemployment rate, wage premia, and other variables. From their conclusion, "a 10% increase in the unemployment rate is associated with a 1% increase in output" [Huang et al., 1998, 137]. Since unemployment averages 6 percent in their data set, this implies an $|\varepsilon_L|$ of 1.7, again greater than 1. Their estimated $|\varepsilon_A|$ ranges from 0.2 to 0.6 (p. 137).[10]

If one accepts the empirical evidence, Condition (10) holds.[11] So, the results in this general model are qualitatively identical to those of previous section's simple model. When M rises, employment rises. Efficiency falls because of the reduced real wages and the increased employment. Combining the effects, efficiency falls so much that output also falls. Also, profits fall and the aggregate supply curve is downward sloping.

The result that a monetary expansion raises employment but lowers output may seem counterintuitive, but it is consistent with many in the efficiency wage literature. As mentioned in the introduction, Agell and Lundborg [1995], Brecher [1992], Carter [1995, 1999b], Drazen [1986], Perri [1990], and Shapiro and Stiglitz [1984] present efficiency wage models in which employment and output move in opposite directions when some government policy changes the real wage. In the current model, the government policy is a monetary policy.

Given these results, the reader may wonder how other authors have found realistic results in monetary efficiency wage models with nominal wage rigidities. Stiglitz [1986], Summers [1988], and Gottfries and Westermark [1998] find the traditional result, that monetary expansions lower real wages and raise employment and output. To get the traditional result, each of these models must assume, contrary to empirical evidence, that the effect of employment on efficiency is zero, as in Stiglitz [1986] and Gottfries and Westermark [1998], or small, as in Summers [1988].[12] With these assumptions, Condition (10) cannot hold.

The value of the above analysis depends crucially on how general an efficiency function Equation (8a) really is. Of course, not all efficiency wage models include relationships that are special cases of Equation (8a), but many do. To see this, consider some of the better-known efficiency wage models. Start with the seminal paper of Shapiro and Stiglitz [1984]. In their paper, effort is an on/off variable, equal to e if the wage equals or exceeds the efficiency wage, equal to zero otherwise. Combining their Equations (5), (8), and (11), one can express the efficiency wage as a function of economy-wide wages (w_A in my notation), the employment level (L_E in my notation), and exogenous terms. Thus, the Shapiro-Stiglitz efficiency function is a special case of Equation (8a). In Shapiro and Stiglitz [1984], effort depends on the wage paid, which is the first argument in my Equation (8a), relative to the efficiency wage, which is a function of the two other arguments.

The efficiency function of Pisauro [1991] also shows effort as a function of wages in and out of the firm, the unemployment rate, and exogenous terms; see his Equation (9) and the equations that precede it. The same can be said of Stiglitz [1986][13] and Salop [1979]. Johnson and Layard [1986] in Chapter 16 of the *Handbook of Labor Economics* consider many theories of unemployment. Their efficiency wage models yield equations that are special cases of Equation (8a); see their pages 960 and 967.[14]

The analysis of this section suggests that, at least in their current forms, efficiency wage models with nominal wage rigidities may not be well-suited to discussions of monetary policy. What alternative forms are there? To answer this question, recognize that efficiency wage models used to analyze monetary policy, including the current one, are typically static, but the effects of monetary shocks likely have important dynamic elements. So, it may be useful to use a dynamic model. In the model of this paper, efficiency depends on the wages and the employment level. In a dynamic setting, it would also likely depend positively on expected wage growth and negatively on expected employment growth.[15] In a moral hazard or shirking model, wage growth makes a job more valuable in the future and so makes the worker work harder to avoid losing it today. Employment growth means more hiring and so a shorter expected unemployment spell if a worker is fired. This makes firing less of a punishment and therefore a worker has less incentive to work hard.

To sketch out briefly possible implications of a dynamic model, assume that there is no long-run effect of money on real wages or employment. Then, when a positive monetary shock temporarily lowers real wages and raises employment, it also raises expected wage growth and lowers expected employment growth. Both of these effects raise efficiency. If these effects are strong enough, one might find that expansionary monetary policy raises output. Of course, the development and estimation of such a dynamic model is beyond the scope of this paper.

CONCLUSION

Several efficiency wage models have been used to analyze monetary policy. In some of these, including those of Stiglitz [1984], Summers [1988], and Gottfries and Westermark [1998], rigidities in the labor market keep nominal wages constant. So, a rise in the money supply lowers real wages. This raises employment and output. Crucially, each of these papers assumes that the effect of employment on productivity is small or nonexistent.

The current paper uses a general efficiency wage model to reanalyze the effects of monetary policy. Here, a rise in the money supply raises employment but lowers output. This happens because efficiency or productivity falls when the money supply rises. Following Stiglitz [1984], Summers [1988], and Gottfries and Westermark [1998], the monetary shock raises prices and so lowers real wages. Low wages and the resulting high employment both reduce efficiency. Firing becomes less of a punishment because the current job pays less, and because fired workers can more easily find new jobs. Thus, workers work less hard and productivity falls. With lower productivity but more employment, the effect on output is ambiguous. The ambiguity is resolved using published empirical results. Using these to parameterize the model, output falls when the money supply rises.

This result, although perhaps surprising, is consistent with many results in the efficiency wage literature. In many models, employment and output move in opposite directions when some government policy changes the real wage. This holds in analyses of minimum wage laws, employment subsidies and taxes, tariffs, and other policies. The current analysis extends this familiar microeconomic result to the study of monetary policy.

Thus, to the extent that efficiency wages are important in causing nominal rigidities in labor markets, monetary expansions lower output. Also, profits fall and the aggregate supply curve is downward sloping. Of course, the conclusion to be drawn is not that monetary expansions really are contractionary. Instead, one might conclude that, at least in their current forms, efficiency wage models with nominal wage rigidities may not be well-suited to discussions of monetary policy. Alternative models may be more useful.

NOTES

I thank three anonymous referees whose comments added significant value to this paper.

1. In Summers [1988], small misperceptions regarding wages in other firms can cause a coordination problem, leading to fixed wages. A coordination problem also keeps nominal wages fixed in Stiglitz [1986]. Gottfries and Westermark [1998] show that in a turnover model of efficiency wages, it may be optimal to fix long-term contracts in nominal terms. In other efficiency wage models, goods market rigidities cause the non-neutrality; see Ball and Romer [1990].
2. Spencer [1998] finds that, in response to aggregate demand shocks, nominal wages adjust slower than do prices. So, as Gamber and Joutz [1997] find, real wages fall with positive shocks to aggregate demand. These results are consistent with the efficiency wage models discussed here. Holmes and Hutton [1996] also provide partial support for these models.
3. Expressing efficiency as a decreasing function of the employment rate instead of as an increasing function of the unemployment rate simplifies the presentation below. Of course, the two formulations are equivalent.
4. It may seem implausible that firms are rational enough to choose optimal wages yet are incapable of adjusting wages in the face of a monetary shock. There are several explanations for this, the specifics of the explanation depending on the model used. As one example, in Stiglitz [1986], the quit rate at a firm depends on that firm's wage relative to wages at other firms. In the model, every profit-maximizing firm rationally seeks to pay the same wage as does every other firm. This leads to slow adjustment of wages after a shock; no firm wants to be the first to change. Of course, if firms set wages in real terms instead of nominal terms, money would still be neutral. Real wages would be constant when the prices change. But there are plausible reasons firms would set wages in nominal terms. See Niehans [1978, 121] and McCallum [1986, 409-410] who argue that minimizing transactions and other costs requires that the medium of exchange and the unit of account be the same.
5. One condition is that as each firm increases its L_i, holding W_i/P constant, $\partial\pi_i/\partial L_i$ becomes negative. Using Equations (4) and (6b), this implies that $Z > 0$. The second condition is that as the prices of goods rise, the demand for goods, from Equation (1), falls relative to the supply of goods, solvable from Equations (6b), (6c), and (6d). This implies that $D > 0$.
6. This is from a stability condition. The condition is that, keeping L_i at profit-maximizing levels, $\partial\pi_i/\partial W_i$ falls when all firms raise wages. To see this, note that, using Equation (4), Equation (5) can be rewritten as $\partial\pi_i/\partial W_i = (\varepsilon_W - 1)L_i = 0$. By inspection, $\partial\pi_i/\partial W_i$ falls from 0 when real wages rise if and only if $\partial\varepsilon_W/\partial(W_i/P) < 0$.
7. Whatever the slope, the relevant stability condition is still $D > 0$; see Note 5.
8. Using Equations (2), (7a), (7b), and (7d), one can find that the change in real profits in the economy is
$$(\pi/P)' = -M^*wL_E\eta_{QL}[1 - \varepsilon_W + \varepsilon_L]/PD.$$
9. Many papers that empirically test the efficiency wage hypothesis are not useful in the current context. Some, such as Rebitzer [1987], do not estimate the effect of the alternative wage (ε_A). Some, such as Wadhwani and Wall [1991], measure the effect of a composite variable, W_i/W_A. This does not allow one to find ε_A as distinct from $-\varepsilon_W$. A similar problem arises with the use of Schmidt's [2000a; 2000b] results.
10. The results of Campbell [1993], Cappelli and Chauvin [1991], and Green and Weisskopf [1990] are discussed in more detail in Carter [1999a, 599-601].

11. To see the intuition that supports $|\varepsilon_L| > |\varepsilon_A|$, note that this condition means that a, say, 5 percent change in employment has a bigger impact on worker efficiency than does a 5 percent change in wages paid by other firms. In a shirking model, the greater is the welfare of the unemployed relative to the employed, the less threatening is being fired, and so the less hard workers work to avoid firing. Similarly, in a turnover model, the greater the relative welfare of the unemployed, the more quits. So, Condition (10)'s holding means that a 5 percent change in employment has a greater impact on the relative welfare of the unemployed than does a 5 percent change in wages.

    To see why it likely does, perform a thought experiment. Suppose that the unemployment rate is 8 percent and wages are $10. Now, consider two possible changes. In case A, unemployment falls to 3.4 percent (employment rises by 5 percent) while wages are constant. In case B, wages rise to $10.50 (a 5 percent increase) while unemployment is constant. Which has the greater impact on the welfare of the unemployed? The employment change greatly increases the worker's chance of finding a job. The wage change is only of marginal benefit, and only then if the worker can find a job. So, the employment change likely has a greater impact on the relative welfare of the unemployed. That means that Condition (10) holds.
12. In Stiglitz's [1986] turnover model, workers may quit firm *i* to work at firm *j* if $W_j > W_i$; employment levels are irrelevant. In the Gottfries and Westermark [1998] discrete-time model, workers make their quit decisions before any monetary shock occurs. Firms make hiring decisions after monetary shocks. So in the short run, shocks can raise employment but can have no impact on quits or efficiency. In both of these models, $\varepsilon_L = 0$ by assumption.

    There are, to the author's knowledge, no efficiency wage models with rigid wages that avoid this basic problem. Realistic results occur only with unrealistic assumptions.
13. Stiglitz [1986] reviews several efficiency wage theories, including models based on nutrition, turnover, heterogeneous workers, monitoring costs, and sociological theories of fairness. From his page 187, "Though the five theories differ in a number of important respects, they have a common mathematical structure: the net productivity of a worker at the *i*th firm is a function of the wage paid by the firm, w_i, the wage paid by other firms, w, and the unemployment rate (or, more generally, the expected duration in the unemployment pool)." Except for the parenthetical reference to unemployment duration as a substitute for the unemployment rate, Stiglitz's "common mathematical structure" is Equation (8a).
14. Of course, there are many efficiency wage models in which the efficiency functions are not special cases of Equation (8a). Efficiency may depend on monitoring intensity [Brecher, 1992] or employment security [Carter and De Lancey, 1997] when those are firm choice variables. It may depend on the ratio of the actual wage relative to the workers' perception of a fair wage, which may in turn depend on profits [Palley, 1994] or the returns to other factors [Agell and Lundborg, 1995]. None of these models have been used to analyze monetary policy and it is indeed unclear that any of them would yield more realistic results.
15. See Kimball [1994], who presents a dynamic version of the Shapiro-Stiglitz efficiency wage model. His model is real; there is no role for money.

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