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A NEAR-RATIONAL MODEL OF THE BUSINESS CYCLE, WITH WAGE AND PRICE INERTIA*

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This paper presents a model in which insignificantly suboptimal behavior causes aggregate demand shocks to have significant real effects. The individual loss to agents with inertial price-wage behavior is second-order in terms of the parameter describing the shock, while the effect on real economic variables is first-order. Thus, significant changes in business activity can be generated by anticipated money supply changes provided that some agents are willing to engage in nonmaximizing behavior which results in small losses.

I. INTRODUCTION

This paper offers an explanation of why changes in the nominal supply of money are not neutral in the short run. It shows that aggregate demand shocks can cause significant changes in output and employment if agents adjust wages and prices in ways which are "insignificantly" suboptimal from their individual standpoints. Alternatively, very small transaction costs of decision making or changing prices could account for large fluctuations in real economic activity.

The argument proceeds in six steps.

1. The property of nonneutrality is shown to be important for business cycle theory.

2. The concept of near-rationality is introduced. Near-rational behavior is nonmaximizing behavior in which the gains

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from maximizing rather than nonmaximizing are small in a well-defined sense.

3. It is argued that in a wide class of models—those models in which objective functions are differentiable with respect to agents' own wages or prices—the cost of inertial money wage and price behavior as opposed to maximizing behavior, is small when a long-run equilibrium with full maximization has been perturbed by a shock. If wages and prices were initially at an optimum, the loss from failure to adjust them will be smaller, by an order of magnitude, than the shock.

4. The economic meaning of objective functions differentiable in agents' own prices and wages will be explained. Profit functions do *not* have this property when there is perfect competition in the labor and product markets. But in a wide class of models, including those with imperfect competition, objective functions *do* have this property.

5. Some intuition will be provided to explain why nonmaximizing behavior that results in only second-order losses to the individual nonmaximizers will nevertheless have first-order effects on real variables.

6. An example will be presented of a model in which inertial price and wage behavior causes first-order changes in real activity but imposes only insignificant losses on nonmaximizing agents. In this model the typical firm's profits are a continuous, differentiable function of the price it charges and the wage it offers. The model assumes imperfect competition in the product market and a relationship between wages and labor productivity leading to "efficiency wage" payments in the labor market. It will be argued that the assumption of efficiency wages is appealing because it rationalizes one important stylized view of the economy—the dual labor market—and because it provides a coherent explanation of persistent involuntary unemployment.

The Need for a Model without Money Neutrality

As is well-known, *anticipated* changes in aggregate demand cause no fluctuations in employment or output in neoclassical models with market clearing (see Sargent [1973]). The insensitivity of employment and output to aggregate demand shifts generalizes, however, beyond such neoclassical models. As long as a model postulates behavior that is rational—i.e., derived from maximization of objective functions that depend only on real variables—there is no reason why anticipated demand shocks should have any effect on real output. Thus, recent models in which involuntary unemployment can be rationalized as a result of staggered or implicit contracts, imperfect information, labor turnover, or efficiency wages still leave unanswered the question of how changes in the money supply, unless unanticipated, can affect real output.

In the Keynesian model, changes in aggregate demand cause fluctuations in real output because of agents' inertia in changing money wages and prices. There is abundant empirical evidence for the phenomenon of wage and price sluggishness (see, for example, the discussion in Okun [1981]). Nevertheless, the reasons why prices and wages do not adjust quickly to changes in aggregate demand remain mysterious. In the standard Keynesian model with competitive markets, there are substantial gains to be made by agents who do adjust wages and prices quickly; so inertial behavior, in that model, is both irrational and costly. In partial answer to this problem, the new classical macroeconomics has proposed models in which money is neutral with full information but is nonneutral insofar as unanticipated money shocks fool agents who are imperfectly informed about wage and price distributions. The applicability of this model has been the subject of considerable debate. This paper suggests an alternative.

Near-Rational Behavior

The alternative explanation of nonneutrality offered in this paper is based on the idea that inertial wage-price behavior by firms may not, in fact, be very costly; it may be near-rational. Firms that behave suboptimally, adjusting prices and wages slowly, may suffer losses from failure to optimize, but those losses may be very small. Near-rational behavior is behavior that is perhaps suboptimal but that nevertheless imposes very small individual losses on its practitioners relative to the consequences of their first-best policy. Technically, *very small* is defined as being second-order in terms of the policy shocks that create a disturbance from a long-run, fully maximizing equilibrium. This paper argues that inertial wage and price behavior which is near-rational, in the sense that it causes only second-order losses to its practitioners, can nevertheless cause first-order changes in real activity. As a result, changes in the money supply can cause first-order changes in employment and output if agents are near-rational. In sum, this paper argues that a small amount of nonmaximizing behavior can cause a significant business cycle in response to money supply shocks that would be neutral in the absence of such inertial behavior.

The Crucial Requirement for the Near-Rationality of Inertial Behavior: Differentiability of Objective Functions in Agents' Own Wages and Prices

Consider a shock that perturbs an equilibrium in which all agents are maximizing. Sticky wage and price behavior will be near-rational for any agent whose objective function is differentiable as a function of *his own wages and prices*. The error in wages or prices caused by inertial behavior will result in losses to the agent that are second-order in terms of the policy shock, since at the equilibrium prior to the shock, the agent chose prices (wages) so that the marginal benefits of higher prices (wages) was just offset by the marginal costs. An error in wages and prices therefore has a second-order effect on the value of the objective function. This is just an application of the envelope theorem (see Varian [1978]).

The Assumption of Differentiability

The condition that the objective function is differentiable in an *agent's own wages and prices* requires explanation. This assumption does not hold in a competitive model. Consider firms' profits in a competitive model. In this model a firm that individually pays a wage lower than the market wage can hire no labor. At the market wage, labor availability jumps discontinuously and consequently so do profits. With the firm's own wage higher than the market-clearing, profits decline proportionately with the excess of the wage over the market-clearing level. Accordingly, profit as a function of the firm's wage is not differentiable at the optimum wage, which is the market-clearing wage. A similar story is true with regard to prices. If the firm charges a price above the market-clearing level, a competitive firm has no sales. Profits jump discontinuously when a firm's own price falls to the market-clearing level because the firm can then have all the sales it wants. And at prices lower than the market-clearing level, profits decline proportionately to the gap between the market-clearing price and the firm's own price. In the competitive model lower prices or higher wages than the market-clearing levels confer no benefits on the firm.

In contrast, there are many models of price and wage setting in which profits are a differentiable function of the firm's own price or wage. In models with imperfect information by buyers, monopoly or oligopoly in the product market, or monopolistic competition with differentiated products, a firm's profits vary *differentiably* with its own price because its sales do not fall to zero as its price departs marginally from the prices charged by other firms. In these models, price reductions by firms result in marginal benefits due to increased sales, as well as the marginal cost of less revenue per unit of output sold.

Similarly, there are models of the labor market in which profits are a differentiable function of the firm's own wage offer. This occurs in models where workers have imperfect information, which confers at least temporary monopsony power on firms, and in monopsonistic and oligopsonistic labor markets.[1] In most models of staggered contracts, the profit function is differentiable with respect to the *timing* of wage changes. Finally, in the efficiency wage model of unemployment, as will be presently described, profits are a differentiable function of wages because the higher labor costs per employee that result from higher wage offers are at least partially offset by a reduction in labor cost due to increased productivity.

Thus, there is a wide class of models in which firms' profits are a differentiable function of wage and price variables. In any such model inertial wage or price-setting behavior in response to a shock, starting from a long-run equilibrium with full maximization, will impose only small losses on nonmaximizing agents.

First-Order Consequences of Sticky Wages and Prices for Real Variables

It has now been seen that in a wide class of models, the effect of wage and price stickiness on agents' objective functions is second-order in terms of the magnitude of a shock starting from a long-run equilibrium in which all agents maximize. Nevertheless, such wage and price stickiness commonly has a first-order effect on equilibrium values of real variables following the shock. Al-

1. In an implicit contract model without severance pay and with money, it is possible to show the existence of near-rational contracts in which money is nonneutral. If firms alter their short-run hiring when the money supply changes on the false assumption that unemployment benefits are fixed in money terms rather than in real terms, their policies are near-rational. But the effect of these policies on equilibrium employment and output are first-order in states of the world where there was some unemployment in the long-run equilibrium prior to the money supply shock. Thus, changes in aggregate demand can have a first-order effect on equilibrium in implicit contract models, if contracts are near-rational.

though this property must be checked in any particular variant of the model proposed, there is a general intuition why it usually occurs.

If *all* agents maintain sticky prices following a change in the money supply by a fraction ε, there would be a change in real balances by the same fraction. The change in real balances would clearly be of the same order of magnitude as the shock; and in most models all other real variables would change by the same order of magnitude. The property that most real variables change by the same order of magnitude as the shock continues to hold, although the argument is more subtle, in models of short-run equilibrium when only a fraction of agents have sticky prices or wages while the remainder of agents maximize.

The Example Chosen

The next section presents a specific model that illustrates the proposition that near-rational wage and price stickiness can account for business cycle fluctuations. The model presented has three basic features. The first of these is sticky wage and price behavior. By that we mean that following a shock to a long-run equilibrium in which all agents exactly maximize, a fraction β of agents maintain the same nominal prices and wages, while the remaining agents are full maximizers.

The second feature of the model guarantees that *price* stickiness is a near-rational policy in response to a shock of a long-run equilibrium with full maximization. We assume that firms are monopolistic competitors with their sales dependent on the level of real aggregate demand and the firm's own price relative to the average prices charged by other firms. For simplicity, we assume that real aggregate demand is proportional to real balances. As the logic of the previous discussion should indicate, price stickiness in such a model is near-rational. Even with a market-clearing labor market, such price inertia suffices to explain how money supply changes could cause proportional changes in real variables.

It is the intent of this paper to present an example that shows not only how monetary nonneutrality can result from near-rational behavior, but also how equilibria can be characterized by involuntary unemployment. Involuntary unemployment occurs in our model because the productivity of workers is assumed to depend on the real wage they receive, inducing firms to set wages above the market-clearing level. Because such efficiency wage models may be unfamiliar, they will be briefly described, with some comments on why we consider them to be a realistic basis for a model of nonclearing labor markets.

Efficiency Wage Models of Unemployment

There is now a burgeoning literature[2] that explains involuntary unemployment in developed countries as the result of *efficiency wages*. According to the efficiency wage hypothesis, real wage cuts may harm productivity. If this is the case, each firm sets its wage to minimize labor cost per efficiency unit, rather than labor cost per worker. The wage that minimizes labor cost per efficiency unit is known as the efficiency wage. The firm hires labor up to the point where its marginal revenue product is equal to the real wage it has set. And it easily happens that the aggregate demand for labor, when each firm offers its efficiency wage, falls short of labor supply, so that there is involuntary unemployment.

There are three basic variants of this model (see Yellen [1984] for a survey). In one case, firms pay higher wages than the workers' reservation wages so that employees have an incentive not to shirk. In a second version, wages greater than market-clearing are offered so that workers have an incentive not to quit and turnover is reduced. In a third version, wages greater than market-clearing are paid to induce loyalty to the firm.

Although there are potential problems with these models (e.g., complicated contracts in some cases will be Pareto-superior and eliminate equilibrium unemployment; these models may exhibit countercyclical, rather than procyclical productivity), nevertheless, with modification, they have real promise as an explanation of involuntary unemployment. Furthermore, any model of the *dual labor market* must explain why primary-sector firms pay more than the market-clearing wage, and such an explanation can only come from an efficiency wage theory.

II. A Model of Cyclical Unemployment

As motivated in the Introduction, this section constructs a model in which changes in the money supply will cause changes of the same order in the level of employment in near-rational

2. See, for example, Akerlof [1982]; Bowles [1981, 1983]; Calvo [1979]; Foster and Wan [1984]; Malcomson [1981]; Miyazaki [1984]; Salop [1979]; Schlicht [1978]; Shapiro and Stiglitz [1984]; Stoft [1982a, 1982b]; Weiss [1980]; and Weisskopf, Bowles, and Gordon [1983].

short-run equilibrium. As indicated earlier, the model is based on monopolistic competition and efficiency wage theory.

The Model

Assume a monopolistically competitive economy with a fixed number of identical firms. In the initial equilibrium each firm sets its price and wage to maximize profits, under the assumption that changes in its own price will have no effect on the prices charged by rivals or on the average price level. In this sense, each firm is a Bertrand maximizer. There are two different types of firms. One type, which is a fraction β of all firms, sets its price and wage according to a rule of thumb in the short run. The variables pertaining to such firms are denoted n, since these are *non*maximizing firms. The remaining fraction $(1 - \beta)$ of the total are short-run maximizers, as well as long-run maximizers. They set their price and wage at the levels that maximize profits, on the Bertrand assumption that the prices charged by competitors (and the average price level) will be unaffected by their decision. Variables relating to these firms are denoted m, since they are *maximizing* firms.

Accordingly, let the demand curve facing each firm be

$$X = (p/\bar{p})^{-\eta}\,(M/\bar{p}) \qquad \eta > 1, \tag{1}$$

where X = output of the firm, p = the price of the firm's output, $\bar{p}$ = the average price level, and M = the money supply per firm. The parameter η is chosen to be greater than one, so that each firm has increasing revenues as its own price falls. $\bar{p}$, the average price level, is given as the geometric mean of the prices charged by all firms. In long-run equilibrium all firms charge the same price, $p = \bar{p}$, and so the system of demand equations (1) is consistent with a quantity theory:

$$\bar{p}X = M. \tag{2}$$

Firms produce output according to the production function:

$$X = (eN)^{\alpha} \qquad 0 < \alpha < 1, \tag{3}$$

where e = average effort of laborers hired and N = number of laborers hired.

Effort e is assumed to depend on the real wage paid ω, according to the function, $e = e(\omega)$. $e(\omega)$ is assumed to be a function whose elasticity with respect to ω is less than one at high ω and is greater than one at low ω. An example of such a function is

$$e(\omega) = -a + b\omega^{\gamma} \qquad 0 < \gamma < 1, \qquad a > 0, \qquad b > 0. \tag{4}$$

In most efficiency wage theories, e realistically depends not only on ω but also on the unemployment rate and the wages paid by other firms. The dependence of e on unemployment plays an important role in these models: through this dependence, increases in the supply of labor cause more workers to be hired in equilibrium. An increase in labor supply, in the absence of any other repercussions, causes unemployment to rise. This rise in unemployment causes a rise in e, which in turn, causes firms to increase their demand for labor. (Other repercussions will also follow, as the equilibrium real wage and other things also change.) Our example omits the dependence of e on unemployment and other wages with the result that equilibrium employment is independent of labor supply. The peculiarity of this outcome should not be disturbing, since this is not an essential property of efficiency wage models. Our goal is to illustrate, in the simplest fashion, how first-order changes in welfare can occur because of inertial wage and price behavior whose individual cost is second-order. Since that property does not turn on the dependence of e on unemployment or other wages, and since such dependence considerably complicates the model, we have adopted the simpler assumption: $e = e(\omega)$.

Long-Run Equilibrium

The production function and demand function can be used to compute the profit function for each firm, which is revenue (price times output sold), net of factor costs (money wages times labor hired). The profits of each firm are accordingly

$$\Pi = p\left(\frac{p}{\bar{p}}\right)^{-\eta}\frac{M}{\bar{p}} - \left(\frac{p}{\bar{p}}\right)^{-\eta/\alpha}\left(\frac{M}{\bar{p}}\right)^{1/\alpha}\omega(e(\omega))^{-1}\,\bar{p}. \tag{5}$$

In long-run equilibrium each firm chooses the price of its own output and the wage paid its own workers, so as to maximize profits (provided that the demand for labor is less than the supply), on the assumption that the average price level $\bar{p}$ is unaffected by that decision.

For notational convenience, denote the price level in the initial period as p_0; this is the average price level, the price of maximizing firms, and the price of nonmaximizing firms. With an initial money supply M_0, the first-order condition for profit maximization and the condition $p = \bar{p}$ yields an equilibrium price of

$$p_0 = k\bar{M}_0, \qquad \text{where } k = \left(\frac{\eta\omega^*}{\alpha(\eta - 1)e(\omega^*)}\right)^{\alpha/(1-\alpha)} \tag{6}$$

The real wage ω is chosen at the optimizing level ω^*, where the elasticity of effort with respect to the real wage is unity. (This is a standard result in such models [Solow, 1979] and represents the condition that the firm chooses the real wage that minimizes the unit cost of a labor efficiency unit.)

With this choice of real wage ω^*, the demand for labor is

$$N_0 = k^{-1/\alpha}/e(\omega^*). \tag{7}$$

The total supply of labor per firm $\bar{L}$ is assumed to exceed total labor demanded (which is the right-hand side of (7)). In this case, there will be unemployment, and the firm will be able to obtain all the labor it wants at its preferred real wage ω^*.

Assumptions Concerning Short-Run Equilibrium

This characterization of the initial (long-run) equilibrium lays the foundation for determining how much employment will change if there is a change in the money supply when some of the firms are nonmaximizers in the short run. Also to be calculated is the difference between the actual profits of a nonmaximizing firm and its expected profits if it were to continue setting its prices and wages in the Bertrand-maximizing fashion.

The description of short-run behavior follows. Suppose that the money supply changes by a fraction ε, so that $M = M_0(1 + \varepsilon)$. Suppose also that there are two groups of firms which behave differently in the short run. The m-firms, which are the short-run maximizers, set both the price of their output and the wage paid their workers at those levels that exactly maximize profits, on the assumption that the average price level is unaffected by their individual decisions. The n-firms, which follow a rule of thumb, continue to charge the same price for output and to pay the same money wage. This assumption corresponds to the common finding that money wages are sticky over the business cycle, and also that prices are a constant markup over normal average unit cost. (See Nordhaus and Godley [1972] and Nordhaus [1974] for such a model of pricing and further references; this behavior of wages corresponds to any standard Phillips curve.) An increase in the money supply induces the nonmaximizing firms to hire more labor—to an extent dependent on the reduction in the relative price of output, the increase in aggregate real balances, and the number of laborers needed to produce output according to the production function.

The Nature of Short-Run Equilibrium

The first key task, with respect to this short-run model, is to compute the difference between the profit of a typical nonmaximizing firm, and its profits if it were to abandon its rule-of-thumb behavior and adopt, instead, the Bertrand behavior of the maximizing firms. It will be shown that, for ε equal to zero, the derivative of this difference with respect to ε is zero. In this sense, the prospective loss in profits to the nonmaximizing firms, due to their *individual* nonmaximizing behavior is a second-order effect. The second key task is to calculate the derivative, with respect to ε, of the ratio between the total employment and initial employment. This derivative is positive for ε equal to zero.

In short-run equilibrium the key endogenous variables are determined by (8) to (12):

$$p^n = p_0 \tag{8}$$

$$\omega^m = \omega^* \tag{9}$$

$$p^m = p_0(1 + \varepsilon)^\theta, \tag{10}$$

where

$$\theta = \frac{(1 - \alpha)/\alpha}{\beta(\eta/\alpha - \eta + 1) + (1 - \beta)((1 - \alpha)/\alpha)} \leqslant 1$$

$$\bar{p} = p_0 (1 + \varepsilon)^{(1-\beta)\theta} \tag{11}$$

$$\omega^n = \omega^*(1 + \varepsilon)^{-(1-\beta)\theta}. \tag{12}$$

$p^n = p_0$: it is obvious, by assumption, that $p^n = p_0$.

$\omega^m = \omega^*$: setting the derivative of the profit function (5) with respect to ω equal to zero yields the optimizing condition that the elasticity of effort, with respect to the real wage ω^m be unity. It follows that, in equilibrium, ω^m is unchanged from its long-run value of ω^*.

$p^m = p_0(1 + \varepsilon)^\theta$: setting the derivative of the profit function with respect to p^m equal to zero, with $\omega = \omega^*$, yields the optimizing p^m as a function of $\bar{p}$ and M. Remembering that $\bar{p}$ is a geometric mean of prices, so that $\bar{p} = (p^n)^\beta(p^m)^{1-\beta}$, and setting $p^n = p_0$ and $M = \overline{M}_0(1 + \varepsilon)$ yields $p^m = p_0(1 + \varepsilon)^\theta$.

$\bar{p} = p_0(1 + \varepsilon)^{(1-\beta)\theta}$: this follows directly from the definition of $\bar{p} = (p^n)^{\beta}(p^m)^{1-\beta}$ and the values of $p^n = p_0, p^m = p_0(1 + \varepsilon)^{\theta}$.

$\omega^n = \omega^*(1 + \varepsilon)^{-(1-\beta)\theta}$: the money wage paid by the nonmaximizing firm is unchanged at its initial value w_0. The real wage is, accordingly, $w_0/\bar{p}$, which can be rewritten as the product $(w_0/p_0)(p_0/\bar{p})$. The first term of this product is ω^*, and the second is $(1 + \varepsilon)^{-(1-\beta)\theta}$.

Calculation of p^n, ω^m, p^m, $\bar{p}$, and ω^n

Each of these will be explained in turn.

Now, consider the position of nonmaximizing firms. Their actual profits Π^n in the short-run equilibrium are given by the profit function (5), evaluated with $p^n = p_0$, $\bar{p} = p_0\,(1 + \varepsilon)^{(1-\beta)\theta}$, $\omega^n = \omega^*(1 + \varepsilon)^{-(1-\beta)\theta}$, and $M = \overline{M}_0\,(1 + \varepsilon)$. Whether or not it is reasonable for these firms to follow rule-of-thumb behavior, we assume, depends upon the difference between their maximum expected profits and their actual profits. The optimum price for any nonmaximizing firm to charge, on the assumption of constant $\bar{p}$, is just the price being charged by the maximizing firms, which is $p^m = p_0\,(1 + \varepsilon)^{\theta}$. The maximum expected profits of any nonmaximizing firm are thus identical with the actual profits Π^m being earned by the typical maximizing firm. Π^m is found by substituting $p^m = p^m(\varepsilon) = p_0(1 + \varepsilon)^{\theta}$, $\bar{p} = p_0(1 + \varepsilon)^{(1-\beta)\theta}$, $\omega^m = \omega^*$, and $M = \overline{M}_0(1 + \varepsilon)$ into the profit function (5). Accordingly, Π^n and Π^m can be written, respectively, as functions of ε:

$$\Pi^n = (p_0)^{1-\eta}f(\varepsilon) - (p_0)^{-\eta/\alpha}g(\varepsilon)h(\varepsilon)\omega^*[e(h(\varepsilon)\omega^*)]^{-1} \tag{13}$$

$$\Pi^m = (p^m(\varepsilon))^{1-\eta}f(\varepsilon) - (p^m(\varepsilon))^{-\eta/\alpha}g(\varepsilon)\omega^*(e(\omega^*))^{-1}. \tag{14}$$

The precise functional forms of $f(\varepsilon)$ and $g(\varepsilon)$ are unimportant. What is crucial is their similar role in the Π^n and Π^m functions. They can be calculated explicitly by substituting $p_0(1 + \varepsilon)^{(1-\beta)\theta}$ and $M_0\,(1 + \varepsilon)$ for $\bar{p}$ and M, respectively, into the profit function (5). Similarly, $h(\varepsilon)$ can be found as $(1 + \varepsilon)^{-(1-\beta)\theta}$, since $\omega^n = \omega^*(1 + \varepsilon)^{-(1-\beta)\theta}$. $h(\varepsilon)$ has the property that $h(0) = 1$.

Π^n and Π^m are not very different. Their first and second terms have the common factors $f(\varepsilon)$ and $g(\varepsilon)$, respectively. The derivative of Π^m, with respect to p^m, is zero, since that variable is chosen to maximize that function. And the derivative of Π^m with respect to ω is equal to zero for $\omega = \omega^*$. These properties are useful in showing that the derivative of the difference between Π^m and Π^n with respect to ε vanishes for $\varepsilon = 0$.

The derivative of $\Pi^m - \Pi^n$ with respect to ε can be grouped into four separate terms, each one corresponding to one set of curly brackets in (15):

$$
\begin{aligned}
\frac{d(\Pi^m - \Pi^n)}{d\varepsilon} = {} & \left\{ (1 - \eta)\,(p^m(\varepsilon))^{-\eta} f(\varepsilon) + \left(\frac{\eta}{\alpha}\right) \right. \\
& \left. \times\ (p^m(\varepsilon))^{-\eta/\alpha - 1} g\,(\varepsilon)\omega^*(e(\omega^*))^{-1} \right\} \frac{dp^m}{d\varepsilon} \\
& + \{\omega^*[e(h(\varepsilon)\omega^*)]^{-1} - h(\varepsilon)\omega^{*2}e'(h(\varepsilon)\omega^*) \\
& \times\ [e(h(\varepsilon)\omega^*)]^{-2}\} \cdot \frac{dh}{d\varepsilon}(p_0)^{-\eta/\alpha} g(\varepsilon) \\
& + \{(p^m(\varepsilon))^{1-\eta} f'\,(\varepsilon) - (p^m(\varepsilon))^{-\eta/\alpha}\omega^*[e(\omega^*)]^{-1} g'\,(\varepsilon)\} \\
& - \{(p_0)^{1-\eta} f'\,(\varepsilon) - (p_0)^{-\eta/\alpha} h(\varepsilon)\omega^*[e(h(\varepsilon)\omega^*)]^{-1} g'\,(\varepsilon)\}.
\end{aligned} \tag{15}
$$

The first term in curly brackets in (15) is zero because of the first-order condition for p^m as the maximand of the profit function Π^m. The second term in curly brackets vanishes for ε equal to zero, since $h(0) = 1$, and since ω^* has been chosen to maximize profits. (This causes $\omega^* e'(\omega^*)[e(\omega^*)]^{-1}$ to equal unity.) Thus, the first two terms in curly brackets in (15) are zero for ε equal zero because of the optimizing choice of the respective variables, p and ω. The third and fourth terms in curly brackets cancel for ε equal to zero, because $p^m(0) = p_0$ and $h(0) = 1$. These terms reflect the common effect of ε on Π^m and Π^n. Since all four terms in curly brackets either vanish or cancel for ε equal zero, it follows that

$$
\left. \frac{d(\Pi^m - \Pi^n)}{d\varepsilon} \right|_{\varepsilon = 0} = 0. \tag{16}
$$

This is a key result of this paper. It says that the loss to the nonmaximizers over their maximum possible profits in this model is second order with respect to ε. It also follows trivially that this loss in percentage terms is equal to zero for ε equal zero and has a derivative of zero.

Employment

The elasticity of total employment, with respect to changes in the money supply is not zero. For ε equal zero, this elasticity can be calculated as

$$\frac{d(N/N_0)}{d\varepsilon} = \frac{1}{\alpha}(1 - (1 - \beta)\theta) + \beta(1 - \beta)\theta. \tag{17}$$

Two comments are in order about (17). First, since θ is less than one, an increase in the money supply causes an increase in employment. Also, since $\theta = 1$ for $\beta = 0$, the elasticity of employment with respect to changes in the money supply vanishes as the fraction of nonmaximizers approaches zero. Such a result should be expected, since as β approaches zero, the model approaches one of monetary neutrality.

Simulations

We did some simulations of the preceding model of unemployment for various values of the elasticity of output with respect to labor input (α), the elasticity of demand for each firm (η), and the fraction of nonmaximizers (β). The parameters of the wage-effort function, a, b, and γ, were chosen equal to 1.0, 2.0 and 0.5, respectively, so that $\omega^*[e(\omega^*)]^{-1}$ would conveniently equal one.[3]

For each set of parameter values, Table I reports the percentage difference between the profits of maximizers and nonmaximizers for changes in the money supply, which, respectively, produce 5 percent and 10 percent increases in employment. For 5 percent changes in employment, all values but one, even for values of η (the elasticity of demand) as large as 100, are less than 1 percent. For changes in employment of 10 percent, these differences are mainly below 1 percent for low values of η, and, at the maximum value in the table, for $\alpha = 0.75$, $\eta = 100$, and $\beta = 0.25$, only reaches 5.05 percent. Although this loss in profits is extreme in the table, it is not beyond the bounds of possibility. Quite conceivably, over the course of the business cycle, a quarter of all firms could fail to correct a policy that caused a 5 percent loss in profits.

III. CONCLUSION

In conclusion, a model has been presented in which changes in aggregate demand cause significant changes in equilibrium output. This model meets Lucas' criterion that there are "no \$500

3. Another choice of the a, b, γ parameters showed negligible differences from the results reported in Table I.

TABLE I

PERCENTAGE LOSS IN PROFITS DUE TO NONMAXIMIZING BEHAVIOR FOR DIFFERENT PERCENTAGE CHANGES IN EMPLOYMENT, ELASTICITY OF OUTPUT WITH RESPECT TO LABOR INPUT (α), ELASTICITY OF DEMAND (η), AND PROPORTION OF NONMAXIMIZERS (β)

	5% Change in employment			10% Change in employment		
	β = 0.25	β = 0.5	β = 0.75	β = 0.25	β = 0.5	β = 0.75
α = 0.25						
η = 1.5	0.084	0.023	0.011	0.309	0.088	0.043
η = 3.0	0.220	0.059	0.028	0.808	0.226	0.107
η = 5.0	0.298	0.079	0.036	1.090	0.303	0.142
η = 20.0	0.408	0.107	0.049	1.496	0.410	0.189
η = 100.0	0.443	0.116	0.052	1.623	0.442	0.203
α = 0.5						
η = 1.5	0.088	0.024	0.012	0.330	0.092	0.045
η = 3.0	0.295	0.080	0.038	1.109	0.306	0.146
η = 5.0	0.459	0.122	0.057	1.726	0.471	0.222
η = 20.0	0.768	0.201	0.091	2.892	0.774	0.356
η = 100.0	0.888	0.231	0.104	3.343	0.889	0.405
α = 0.75						
η = 1.5	0.046	0.012	0.006	0.175	0.045	0.021
η = 3.0	0.207	0.054	0.025	0.796	0.209	0.097
η = 5.0	0.397	0.103	0.048	1.533	0.402	0.186
η = 20.0	0.974	0.251	0.114	3.769	0.979	0.447
η = 100.0	1.304	0.334	0.151	5.046	1.304	0.591

$a = 1.0$, $b = 2.0$, $\gamma = 0.5$.

bills lying on the sidewalk." There is a class of maximizers in this model who are ready to take advantage of *any* profitable opportunity; and those agents who are not maximizing can make at most only small gains from altering their behavior.

The model presented also satisfies the condition that there is involuntary unemployment. This occurs because of the assumption that wages are determined in excess of market-clearing according to the efficiency wage criterion of minimization of cost per labor efficiency unit.

As the introduction may have made clear, the basic method applied in this paper to show the short-run nonneutrality of money should be applicable in a wide range of models, of which the monopolistic-competition, efficiency-wage model of the last section was only one example.

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