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Author(s): Olivier Jean Blanchard and Nobuhiro Kiyotaki

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Monopolistic Competition and the Effects of Aggregate Demand

By OLIVIER JEAN BLANCHARD AND NOBUHIRO KIYOTAKI*

How important is monopolistic competition to an understanding of the effects of aggregate demand on output? We ask the question at three levels. Can monopolistic competition, by itself, explain why aggregate demand movements affect output? Can it, together with other imperfections, generate effects of aggregate demand in a way that perfect competition cannot? If so, can it give an accurate account of the response of the economy to aggregate demand movements? The answers are no, yes, and yes.

Monopolistic competition provides a convenient conceptual framework in which to think about price decisions, and appears to describe many markets more accurately than perfect competition. But, how important is monopolistic competition for macroeconomics? In particular, how important is monopolistic competition to an understanding of the effects of aggregate demand on economic activity? This is the question we analyze in this paper.

One can ask the question at three levels. First, using perfect competition as a benchmark, can monopolistic competition, by itself, explain why aggregate demand movements affect output? Second, can monopolistic competition, together with some other imperfection, generate effects of aggregate demand in a way that perfect competition cannot? Third, taking as given that aggregate demand movements affect output, can monopolistic competition give a more accurate account of the response of the economy to aggregate demand shocks? The paper analyzes these three questions in turn.

Section I builds a simple general equilibrium model, with goods, labor, and money, and monopolistic competition in both the goods and the labor markets. It then characterizes the equilibrium. Section II characterizes the inefficiency associated with monopolistic competition and shows that it is associated with an aggregate demand externality. It shows that this externality cannot, however, explain why pure aggregate demand movements affect output. In particular, it cannot explain why changes in nominal money have real effects. The answer to the first question is therefore negative. Section III studies the effects of "menu costs" when combined with monopolistic competition. It shows that small (second-order) costs of changing prices may lead to large (first-order) changes in output and welfare in response to changes in nominal money. It shows the close relation between this result and the aggregate demand externality identified in Section II. The answer to the second question is therefore positive. Section IV takes as given that prices and wages do not adjust to movements in nominal money, and draws the implications of monopolistic competition with fixed costs for the behavior of output, productivity, profits, and entry by new firms in response to fluctuations in aggregate demand. These implications fit the facts and our answer to the third question is positive. We conclude by discussing how the implications for entry may in turn help explain the lack of adjustment of prices and wages.

*Department of Economics, MIT, Cambridge MA 02139, and University of Wisconsin, Madison, WI 53706, respectively. We thank Andrew Abel, Laurence Ball, Russell Cooper, Rudiger Dornbusch, Stanley Fischer, Mark Gertler, Robert Hall, Andrew John, Kenneth Rogoff, Jeffrey Sachs, Lawrence Summers, Martin Weitzman, and two referees for discussions and suggestions. We thank the National Science Foundation and the Sloan Foundation for financial support.

Our paper is closely related to three recent strands of research, on general equilibrium implications of monopolistic competition (Oliver Hart, 1982, and Martin Weitzman, 1982, in particular), on "menu costs" or "near rationality" (N. Gregory Mankiw, 1985, George Akerlof and Janet Yellen, 1985a, b) and on "coordination failures" (Russell Cooper and Andrew John, 1985, in particular). We shall point out specific relations as we proceed. Our intent is in part to show their relation and macroeconomic implications in the specific context of monopolistic competition.

I. A Model of Monopolistic Competition

In developing a model of monopolistic competition, we make four main choices. Because we want to focus on both wage and price decisions, we construct a model with both households and firms, with separate labor and goods markets. Both labor and goods markets are monopolistically competitive. The assumption of monopolistic competition in both sets of markets is made for symmetry and transparency rather than for realism. For some purposes, however, the model that has both wage and price setters is not the simplest, and we also occasionally focus on a special case, that can be thought of as an economy of household-firms, each producing a differentiated good; in that case, there is only one set of price setters and the analysis is simplified.

The second choice follows from the need to avoid Say's Law, or the result that the supply of goods produced by the monopolistically competitive firms automatically generates its own demand. To avoid this, agents must have the choice between these goods and something else. In the standard macroeconomic model, the choice is between consumption and savings. In other models of monopolistic competition, the choice is between produced goods and a nonproduced good (Hart, for example). Here, we shall assume that the choice is between buying goods and holding money. This is most simply and crudely achieved by having real money balances in the utility function. Thus, money plays the role of the nonproduced

good and provides services.^{1,2} Money is also the numeraire, so that firms and workers quote prices and wages in terms of money; this plays no role in this and the next section, but will become important in Section III.

The third choice is to make assumptions about utility and technology that lead to demand and pricing relations, which are as close to traditional ones as possible, so as to allow an easy comparison with standard macroeconomic models. In effect, we follow Avinash Dixit and Joseph Stiglitz (1977) in adopting constant elasticity of substitution specifications in utility and production.³ These specifications lead to log-linear demand and pricing functions, and rule out potentially important nonlinearities as well as a potential source of multiple equilibria.⁴

Finally, the model is static and we leave the potentially important dynamic implications of monopolistic competition to future work.⁵

A. The Model

The economy is composed of m firms, each producing a specific good that is an imperfect substitute for the other goods, and n consumer-workers, households for short,

¹A Clower Constraint would lead to similar results. Developing an explicitly intertemporal model to justify why money is positively valued did not seem worth the additional complexity in this context.

²There are, however, differences between money and a standard nonproduced good that arise from the fact that real, not nominal, money balances enter utility; we shall point out these differences as we go along.

³The main alternative to product diversification à la Dixit-Stiglitz, is geographic dispersion. This is the approach followed by Weitzman.

⁴Our assumptions imply a constant elasticity of demand, and a constant markup of price over marginal cost. Some recent work on the implications of imperfect competition for macroeconomics has precisely focused on why markups may not be constant, either because of changes in elasticity of demand, or of changes in the degree of collusion between firms. See, for example, Stiglitz (1984), Julio Rotemberg and Garth Saloner (1986), and Mark Bils (1985).

⁵Kiyotaki (1985b) studies the implications of monopolistic competition for investment and the likelihood of multiple equilibria.

each of them selling a type of labor which is an imperfect substitute for the other types. As a result, each firm and each worker has some monopoly power.⁶ We now describe the problem faced by each firm and each household.

Firms are indexed by i , $i = 1, \dots, m$. Each firm i has the following technology:

$$(1) \quad Y_i = \left(\sum_{j=1}^n N_{ij}^{(\sigma-1)/\sigma} \right)^{(\sigma/(\sigma-1))(1/\alpha)},$$

where Y_i denotes the output of firm i . N_{ij} denotes the quantity of labor of type j used in the production of output i . There are n different types of labor, indexed j , $j = 1, \dots, n$. The production function is a CES production function, with all inputs entering symmetrically. Introducing fixed costs would not affect the analysis of the first three sections where we assume the number of firms to be fixed; we shall, for simplicity, introduce them only in the last section where they matter.

The two parameters characterizing the technology are α and σ . The parameter σ is the elasticity of substitution of inputs in production. The parameter α is the inverse of the degree of returns to scale; $\alpha - 1$ is the elasticity of marginal cost with respect to output, elasticity of marginal cost for short in what follows. To guarantee the existence of an equilibrium, we restrict σ to be strictly greater than unity, and α to be equal to or greater than unity.

The firm maximizes profits. Nominal profits for firm i are given by

$$(2) \quad V_i = P_i Y_i - \sum_{j=1}^n W_j N_{ij},$$

where P_i denotes the nominal output price

of firm i , and W_j denotes the nominal wage associated with labor type j . The firm maximizes (2) subject to the production function (1). It takes as given nominal wages and the prices of the other outputs. It also faces a downward-sloping demand schedule for its product, that will be derived below as a result of utility maximization by households. We assume that the number of firms is large enough that taking other prices as given is equivalent to taking the price level as given.

Households are indexed by j , $j = 1, \dots, n$. Household j supplies labor of type j . It derives utility from leisure, consumption, and real money balances. Its utility function is given by

$$(3) \quad U_j = (m^{1/(1-\theta)} C_j)^\gamma (M_j'/P)^{1-\gamma} - N_j^\beta,$$

$$\text{where } C_j = \left(\sum_{i=1}^m C_{ij}^{(\theta-1)/\theta} \right)^{(\theta/(\theta-1))}$$

$$\text{and } P = \left(\frac{1}{m} \sum_{i=1}^m P_i^{1-\theta} \right)^{1/(1-\theta)}.$$

The first term in utility is a consumption index (basket) that gives the effect of the consumption of goods on utility. C_{ij} denotes the consumption of good i by household j , and C_j is a CES function of the C_{ij} s. All types of consumption goods enter utility symmetrically. The parameter θ is the elasticity of substitution between goods in utility. To guarantee existence of an equilibrium, θ is restricted to be greater than unity. The constant in front of C_j , that depends on θ and on the number of products m , is a convenient normalization with the implication that an increase in the number of products does not affect marginal utility after optimization.

The second term gives the effect of real money balances on utility. γ is a parameter between zero and one. Nominal money balances are deflated by the nominal price index associated with C_j . We shall refer to P as the price level.

The third term in utility gives the disutility from work, N_j is the amount of labor supplied by household j . The term $\beta - 1$ is the

⁶Since in equilibrium each labor supplier sells some of his (her) labor to all firms, it is more appropriate to think of labor suppliers as craft unions, or syndicates as in Hart, rather than individual workers. However, since we want to analyze labor supply and consumption decisions simultaneously, we shall continue to refer to labor suppliers as "consumer-workers" or "households."

elasticity of marginal disutility of labor; β is assumed to be equal to or greater than unity.^{7,8}

Households maximize utility subject to a budget constraint. Each household takes prices and other wages as given. Again we assume that n is large enough that taking other wages as given is equivalent to taking the nominal wage level as given. It also faces a downward-sloping demand schedule for its type of labor, which will be derived as the result of profit maximization by firms. The budget constraint is given by

$$(4) \quad \sum_{i=1}^m P_i C_{ij} + M'_j = W_j N_j + M_j + \sum_{i=1}^m V_{ij},$$

where M_j denotes the initial endowment of money, and V_{ij} is the share of profits of firm i going to household j .

B. The Equilibrium

The derivation of the equilibrium is given in the Appendix. The equilibrium can be characterized by a relation between real money balances and aggregate demand, a pair of demand functions for goods and labor and by a pair of price and wage rules.

The relation between real money balances and real aggregate consumption expenditures, which we shall call aggregate demand for short, is given by

$$(5) \quad Y = K(M/P)$$

where

$$(6) \quad Y \equiv \left(\sum_{j=1}^n \sum_{i=1}^m P_i C_{ij} \right) / P$$

⁷The assumption that utility is homogeneous of degree one in consumption and real money balances, as well as additively separable in consumption and real money balances on the one hand, and leisure, on the other, eliminates income effects on labor supply. Under these assumptions, competitive labor supply would just be a function of the real wage, using the price index defined in the text. It also implies that utility is linear in income and this facilitates welfare evaluations.

⁸For reasons that will be clear below, we exclude the case where both α and β are equal to unity.

and

$$P \equiv \left((1/m) \sum_{i=1}^m P_i^{1-\theta} \right)^{1/(1-\theta)}.$$

The demand functions for goods and labor are given by

$$(7) \quad Y_i = \sum_{j=1}^n C_{ij} = K_c Y (P_i/P)^{-\theta} \quad i=1, \dots, m$$

$$(8) \quad N_j = \sum_{i=1}^m N_{ij} = K_n Y^\alpha (W_j/W)^{-\sigma} \quad j=1, \dots, n$$

where the wage index W is given by

$$(9) \quad W = \left(\frac{1}{n} \sum_{j=1}^n W_j^{1-\sigma} \right)^{1/(1-\sigma)}.$$

The price and wage rules are given by

$$(10) \quad (P_i/P) = [(\theta/(\theta-1)) K_p \times (W/P) Y^{\alpha-1}]^{1/(1+\theta(\alpha-1))} \quad i=1, \dots, m$$

$$(11) \quad (W_j/W) = [(\sigma/(\sigma-1)) K_w \times (P/W) Y^{\alpha(\beta-1)}]^{1/(1+\sigma(\beta-1))} \quad j=1, \dots, n$$

The letters K , K_c , K_n , K_p , and K_w are constants that depend on the parameters of the technology and the utility function as well as the number of firms and households.

We interpret these equations, starting with the relation between real money balances and aggregate demand. First-order conditions for households imply that desired real money balances are proportional to consumption expenditures. Aggregating over households and using the fact that, in equilibrium, desired money is equal to actual money gives equation (5).

The demand for each type of good relative to aggregate demand is a function of the ratio of its nominal price to the nominal price index, the price level, with elasticity $(-\theta)$. The demand for labor by firms is a derived demand for labor; it depends on the demand for goods. The demand for each type of labor is a function of the ratio of its nominal wage to the nominal wage index, with elasticity $(-\sigma)$.

We now consider the *price rule*. Given the price level, each firm is a monopolist and decides about its real (or relative) price P_i/P . An increase in the real wage (W/P) shifts the marginal cost curve upward, leading to an increase in the relative price. An increase in aggregate demand shifts the demand curve for each product upward; if the firm operates under decreasing returns, the marginal cost curve is upward sloping and the relative price increases. Under constant returns, the shift in demand has no effect on the relative price.

We finally consider the *wage rule*, equation (11). We can think of households as solving their utility-maximization problem in two steps. They first solve for the allocation of their wealth, including labor income, between consumption of the different products and real money balances. After this step, the assumption that utility is linearly homogeneous in consumption and real money balances implies that utility is linear in wealth, thus linear in labor income. The next step is to solve for the level of labor supply and the nominal wage. Given that utility is linear in labor income, we can think of households as monopolists maximizing the surplus from supplying labor. Formally, if μ denotes the constant marginal utility of real wealth, households solve in the second step:

$$\max \mu(W_j/P)N_j - N_j^\beta;$$

$$N_j = K_n Y^\alpha (W_j/W)^{-\sigma}.$$

The real wage relevant for worker j is W_j/P , which we can write as the product $(W_j/W)(W/P)$. The demand for labor of type j is a function of the relative wage (W_j/W) as well as of aggregate demand.

An increase in the aggregate real wage (W/P) leads household j to increase its labor supply, thus to decrease its relative wage (W_j/W) . An increase in aggregate demand leads, if β is strictly greater than unity, to an increase in the relative wage. If β is equal to unity, if the marginal disutility of labor is constant, workers supply more labor at the same relative wage, in response to an increase in aggregate demand.

C. Symmetric Equilibrium

Equilibrium and symmetry, both across firms and across households, implies that all relative prices and all relative wages must be equal to unity. Thus, using $P_i = P$ for all i and $W_j = W$ for all j , and substituting in equations (10) and (11) gives

$$(12) \quad (P/W) = (\theta/(\theta-1))K_p Y^{\alpha-1};$$

$$(13) \quad (W/P) = (\sigma/(\sigma-1))K_w Y^{\alpha(\beta-1)}.$$

Equation (12), obtained from the individual price rules and the requirement that all prices be the same, gives the price wage ratio (P/W) as a function of output. If firms operate under strictly decreasing returns, the price wage ratio is an increasing function of the level of output. Equivalently, the real wage (W/P) consistent with firms' behavior is a decreasing function of output. We shall refer to equation (12) as the "aggregate price rule."

Equation (13), obtained from the individual wage rules and the requirement that all wages be the same, gives the real wage (W/P) as a function of output. If β is strictly greater than unity, that is, if workers have increasing marginal disutility of work, an increase in output, that leads to an increase in the derived demand for labor, requires an increase in the real wage. The real wage consistent with households' behavior is an increasing function of output. We shall refer to equation (13) as the "aggregate wage rule."

Equations (12) and (13) give (W/P) and Y . The value of (M/P) follows from (5). The equilibrium is characterized graphically in Figure 1. As (12) and (13) are log-linear, we measure $\log(W/P)$ on the vertical axis

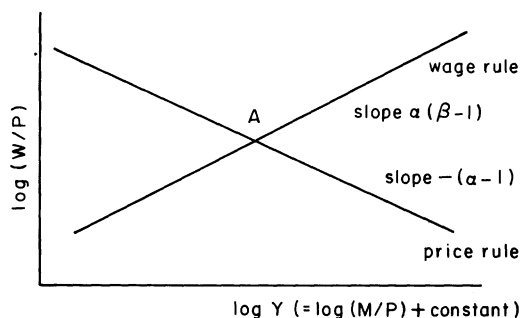


FIGURE 1. THE MONOPOLISTICALLY COMPETITIVE EQUILIBRIUM

and $\log(Y)$ (or $\log(M/P)$ as the two are linearly related) on the horizontal axis. If α and β are both strictly greater than unity, the aggregate wage rule is upward sloping, while the aggregate price rule is downward sloping. The equilibrium determines the real wage and output. Given output, we obtain the equilibrium level of real money balances and given nominal money, we finally obtain the price level.

Figure 1 looks like the characterization of equilibrium under perfect competition, with an upward-sloping labor supply curve and a downward-sloping labor demand. What is, therefore, the effect of monopolistic competition? Before turning to that issue, we briefly consider a special case of the model that will be convenient later.

D. A Convenient Special Case

In the special case of the model where the marginal utility of leisure is constant so that $\beta = 1$, the characterization of the equilibrium is much simpler. The relation between real money balance and aggregate demand is still given by equation (5). But, from equation (11) and symmetry, the real wage is constant, so that the price rules are now given by

$$(14) \quad P_i/P = k(M/P)^{(\alpha-1)/(1+\theta(\alpha-1))},$$

where k is an unimportant constant. Equations (5) and (14) characterize the equilibrium. The symmetric equilibrium is identical

to that in Figure 1, except for the fact that the aggregate wage rule is horizontal.

This special case is convenient as it allows to concentrate on the interactions between price setters rather than between both price and wage setters. The assumption of constant marginal utility of leisure is unattractive, but equations (5) and (14) admit an alternative interpretation: they can also be derived as the equations characterizing the equilibrium of an economy with many household-firms, each producing a differentiated good with a constant returns technology and increasing marginal disutility of work, and deriving utility from the consumption of all goods and money services.⁹ Under that interpretation, $(\alpha-1)$ stands for the elasticity of marginal utility of leisure.

II. Inefficiency and Externalities

A. Comparing Monopolistic Competition and Perfect Competition

To characterize the inefficiency associated with monopolistic competition, we first compare the equilibrium to the competitive equilibrium. The competitive equilibrium is derived under the same assumptions about tastes, technology, and the number of firms and households, but assuming that each firm (each household) takes its price (wage) as given when deciding about its output (labor).

The competitive equilibrium is very similar to the monopolistically competitive one. The demand functions for goods and labor are still given by equations (7) and (8). The price and wage rules are identical to equations (10) and (11), except for the absence of $\theta/(\theta-1)$ in the price rules and the absence of $\sigma/(\sigma-1)$ in the wage rules (the K 's are the same in both equilibria). The explanation is simple. The term $\theta/(\theta-1)$ is the excess of price over marginal cost, reflecting the degree of monopoly power of firms in the goods market; if firms act competitively, price is instead equal to marginal cost. The same explanation applies to households.

⁹Laurence Ball and David Romer (1987) derive the equilibrium for such an economy.

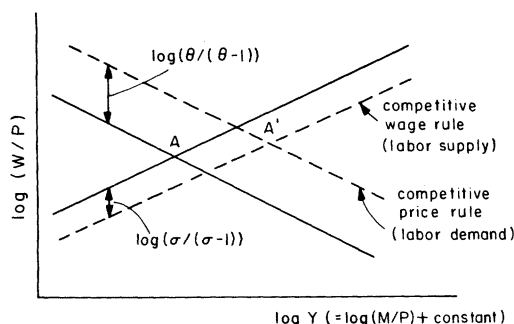


FIGURE 2. MONOPOLISTICALLY COMPETITIVE AND COMPETITIVE EQUILIBRIA

Again, symmetry requires in equilibrium all nominal and all wages to be the same; this gives equations identical to (12) and (13), but without the terms $\theta/(\theta-1)$ and $\sigma/(\sigma-1)$. The price wage ratio consistent with firms' behavior is lower in the competitive case by $\theta/(\theta-1)$ at any level of output; the real wage consistent with household's behavior is lower in the competitive case by $\sigma/(\sigma-1)$ at any level of output. The monopolistically competitive and competitive aggregate wage and price rules are drawn in Figure 2. Point A' gives the competitive equilibrium; point A gives the monopolistically competitive equilibrium.

The equilibrium level of real money balances is lower in the monopolistic equilibrium; the price level is higher. Employment and output are lower. What happens to the real wage is ambiguous and depends on the degrees of monopoly power in the goods and the labor markets. If, for example, there is monopolistic competition in the goods market but perfect competition in the labor market, then the real wage is unambiguously lower under monopolistic competition.

Denoting by R the ratio of output in the monopolistically competitive equilibrium to output in the competitive equilibrium, R is given by

$$R = \left(\frac{\sigma-1}{\sigma} \frac{\theta-1}{\theta} \right)^{1/(\alpha\beta-1)} < 1,$$

where R is an increasing function of σ and θ . The higher the elasticity of substitution

between goods or between types of labor, the closer is the economy to the competitive equilibrium. R is an increasing function of α and β . If α and β are both close to unity, R is small: the existence of monopoly power in either the goods or the labor markets can have a large effect on equilibrium output.¹⁰

B. Aggregate Demand Externalities

Under monopolistic competition, output of monopolistically produced goods is too low. We have shown above that this follows from the existence of monopoly power in price and wage setting. An alternative way of thinking about it is that it follows from an aggregate demand externality.

The argument is as follows. In the monopolistically competitive equilibrium, each price (wage) setter has, given other prices, no incentive to decrease its own price (wage) and increase its output (labor). Suppose however that all price setters decrease their prices simultaneously; this increases real money balances and aggregate demand. The increase in output reduces the initial distortion of underproduction and underemployment and increases social welfare.¹¹

We now make the argument more precise. By the definition of a monopolistically competitive equilibrium, no firm has an incentive to decrease its price, and no worker has an incentive to decrease its wage, given other prices and wages. Consider now a proportional decrease in all wages and all prices, $(dP_i/P_i) = (dW_j/W_j) < 0$, for all i and j ,

¹⁰Note that, as there are distortions in two sets of interrelated markets, the economy is operating inside its production frontier. This point is developed by Rotemberg (1982).

¹¹An alternative way of stating the argument is as follows: If starting from the monopolistically competitive equilibrium, a firm decreased its price, this would lead to a small decrease in the price level and thus to a small increase in aggregate demand. While the other firms and households would benefit from this increase in aggregate demand, the original firm cannot capture all of these benefits and thus has no incentive to decrease its price. We have chosen to present the argument in the text to facilitate comparison with the argument of Section III.

that leaves all relative prices unchanged but decreases the price level.

Consider first the change in the real value of firms.¹² At a given level of output and employment, the real value of each firm is unchanged. The decrease in the price level, however, increases real money balances and aggregate demand. This in turn shifts outward the demand curve faced by each firm and increases profit: an increase in demand at a given relative price increases profit as price exceeds marginal cost. Thus, the real value of each firm increases.

Consider then the effect of a proportional reduction of prices and wages on the utility of each household. Consider household j . We have seen that, once the household has chosen the allocation of his wealth between real money balances and consumption, we can write its utility as

$$U_j = \mu(I_j/P) - N_j^\beta,$$

where μ is the constant marginal utility of real wealth and I_j is the total wealth of the j th household. Using the budget constraint, we can express utility as

$$U_j = \left[\mu(W_j/P)N_j - N_j^\beta \right] \\ + \mu \sum_{i=1}^m V_{ij}/P + \mu(M_j/P).$$

Utility is the sum of three terms. The second is profit income in terms of utility; we have seen that each firm's profit goes up after an increase in aggregate demand. Thus, this term increases. The first term is the household's surplus from supplying labor. At a given level of employment N_j , the proportional change in wages and prices leaves this term unchanged. But the increase in aggregate demand and the implied derived increase in employment implies that this term increases: at a given real wage, an outward

shift in the demand for labor increases utility as the real wage initially exceeds the marginal utility of leisure. The third term is the real value of the money stock, which increases with the fall in the price level. Thus, utility unambiguously increases.¹³

The aggregate demand externality implies that underproduction is magnified through macroeconomic interactions. Consider the problem faced by an individual firm, with upward-sloping marginal cost and downward-sloping demand, taking as given other prices and aggregate demand. Because the marginal utility of wealth is constant under our assumptions, we can measure welfare by looking at the sum of consumers' and producers' surplus. If the firm acted competitively rather than as a monopolist, the price would be lower and the surplus would be larger. This is the familiar partial-equilibrium effect. But here, in addition, if all firms acted competitively and decreased their prices, aggregate demand would be higher and the demand curve facing each firm would shift to the right and welfare would be further increased. This is the additional general equilibrium effect present here.

Identifying the inefficiency associated with monopolistic competition as an aggregate demand externality does not, however, imply that movements in aggregate demand affect output. Aggregate demand changes associated with changes in the demand elasticities facing firms and workers will have real effects, and these effects are likely to be different under perfect and monopolistic competition. These are not, however, the effects we want to focus on. For that reason,

¹²What happens to the real value of firms is obviously of no direct relevance for welfare. This step is however required to characterize what happens to the utility of households below.

¹³Note that, if we were performing the same experiment in the neighborhood not of the monopolistically competitive but of the competitive equilibrium, the first two terms would be equal to zero. The third, however, would still be present. This is one of the implications of our use of real money as the nonproduced good. If real money enters utility, then the competitive equilibrium is not Pareto optimal, as a small decrease in the price level increases welfare. This inefficiency of the competitive equilibrium disappears if money is replaced by a nonproduced good, while the aggregate demand externality under monopolistic competition remains (see Kiyotaki, 1985a).

we shall concentrate on changes in nominal money. But then it is clear that, as equations (12) and (13) are homogeneous of degree zero in P , W , and M , nominal money is neutral, affecting all nominal prices and wages proportionately, and leaving output and employment unchanged. Thus something else is needed to obtain real effects of nominal money. We examine the effects of costs of price setting in the next section.

III. Menu Costs and Real Effects of Nominal Money

We now introduce small costs of setting prices, small "menu" costs. Akerlof and Yellen (1985a, b) and Mankiw have shown how such small costs can lead to large welfare effects in imperfectly competitive economies.¹⁴ We apply their argument to the specific context of monopolistic competition, derive welfare and output effects as explicit functions of the underlying parameters, and relate these effects to the externality identified earlier.

A. The Effects of Small Changes in Nominal Money

We start by considering the effects of a small change in nominal money, dM . The intuitive argument is the following.

At the initial nominal prices and wages, the change in nominal money leads to a change in aggregate demand, thus to a change in the demand facing each firm. If demand is satisfied, the change in output implies in turn a change in the derived demand for labor, thus a change in the demand facing each worker. Unless firms operate under constant returns, each firm wants to change its relative price. Unless workers have constant marginal utility of leisure, each worker wants to change his relative wage. The loss in value to a firm which does not adjust its relative price is, however, of second order;

the same is true of the utility of a worker who does not adjust his relative wage. Thus second-order menu costs may prevent firms and workers from adjusting relative prices and wages. The implication is that nominal prices and nominal wages do not adjust to the change in nominal money. The second part of the argument is to show that the change in real money balances has first-order effects on welfare; we show that it is indeed first order, and of the same sign as the change in money. The argument has very much the same structure as the aggregate demand externality argument of the previous section; this coincidence is not accidental and we return to it below.

The first part is a direct application of the envelope theorem. Consider firms first. Let V_i be the value of firm i . V_i is a function of P_i as well as of P , W , and M ($V_i = V_i(P_i, P, W, M)$). Let V_i^* be the maximized value of firm i , after maximization over P_i ; $V_i^* = V_i^*(P, W, M)$. The envelope theorem then says that

$$\begin{aligned} dV_i^*/dM &= \partial V_i/\partial M + (\partial V_i/\partial P_i)(dP_i/dM) \\ &= \partial V_i/\partial M. \end{aligned}$$

To a first order, the effect of a change in M on the value of the firm is the same whether or not it adjusts its price optimally in response to the change in M . Exactly the same argument applies to the utility of the household. Thus, second-order menu costs (larger than the second-order loss in utility or in value) will prevent each firm from changing its price given other prices and wages and each worker from changing its wage given other prices and wages. The implication is that all nominal prices and wages remain unchanged, and that the increase in nominal money implies a proportional increase in real money balances.

What remains to be shown is that the increase in real money balances has positive first-order effects on welfare. However, we have already shown in the previous section that the increase in real money balances, associated with the increase in aggregate demand and employment, raises firms' profits and the households' surpluses from supply-

¹⁴Akerlof and Yellen assume "near rationality" that is equivalent to rationality subject to second-order costs of taking decisions.

ing labor. Thus, it increases welfare in the neighborhood of the monopolistically competitive equilibrium.

There is clearly a close relation between the *aggregate demand externality* and the *menu cost argument* of this section. This relation is most simply shown in the special case where the marginal utility of leisure is constant, where there are no menu costs in wage setting and where we can concentrate on the interactions between price setters only. Equation (14), which gives the individual price rules in the absence of menu costs, can be rewritten as

$$(15) \quad P_i/M = k(P/M)^{[1 + (\theta - 1)(\alpha - 1)] / (1 + \theta(\alpha - 1))}$$

Figure 3 plots the price chosen by firm i as a function of the price level, both as ratios to nominal money. In the presence of monopoly power, the price rule has slope smaller than one. We also draw iso-profit loci, giving combinations of (P_i/M) and (P/M) that yield the same level of real profit for the firm.¹⁵ The symmetric monopolistically competitive equilibrium is given by the intersection of the price rule and the 45° line, point E . Point A gives the highest real profit point on the 45° line.

The aggregate demand externality argument can then be stated as follows. Consider a *small proportional decrease of prices*, keeping nominal money constant. The equilibrium moves from point E to a point like E' along the 45° line. The profit of each firm rises with the increase in aggregate demand. However, in the absence of coordination, no firm has an incentive to reduce prices away from the equilibrium point E .

The menu cost argument considers instead a *small increase in nominal money*. At the initial set of prices, real money balances would increase and the economy would move from point E to a point like point E' . But,

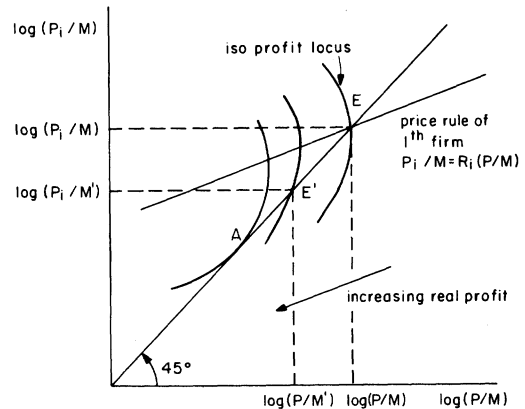


FIGURE 3. AGGREGATE DEMAND EXTERNALITIES AND MENU COSTS

absent menu costs, each firm would find in its interest to increase its price until the economy had returned to point E . In the presence of menu costs, however, these menu costs, if large enough, can prevent this movement back to E , so that the economy remains at E' and all firms end up with higher real profits. (A similar argument, although slightly more complicated, holds for the general model. We shall not present it here.)

It is also important to note the *specific role played by money* in this section. The presence of an aggregate demand externality does not depend on the nature of the nonproduced good, or on the nature of the numeraire. The results of this section depend on money being the nonproduced good and the numeraire. That money is the numeraire implies that, given menu costs, unchanged prices and wages mean unchanged nominal prices and wages. That money is the nonproduced goods implies that, as the government can vary the amount of nominal money, it can, if nominal prices and wages do not adjust, change the amount of real money balances, the real quantity of the nonproduced good.

B. The Effects of Larger Changes in Nominal Money

For larger changes in money, the private opportunity costs of not adjusting prices in

¹⁵ The figure assumes decreasing returns to scale. Note also that, as firms take the price level as given when choosing their own price, iso-profit loci are vertical along the price rule.

response to the change in money (private costs, for short) are no longer negligible and depend on the parameters of the model. We now investigate this dependence.

The *private costs* faced by a firm depends on the size of the demand shifts as well as on the two parameters α and θ . As we have seen, these costs are of second order in response to a change in aggregate demand, thus roughly proportional to the square of the change in aggregate demand. More precisely, define $L(\Delta; \alpha, \theta)$ to be the private opportunity cost to a firm expressed as a proportion of initial revenues, associated with not adjusting its price in response to a change of 100 $\Delta\%$ in aggregate demand, when all other firms and households keep their prices and wages unchanged. Then, by simple computation, we get

$$L(\Delta; \alpha, \theta) = \left\{ [(\alpha - 1)^2(\theta - 1)] / [2(1 + \theta(\alpha - 1))] \right\} \Delta^2 + O(\Delta^2),$$

where $O(\Delta^2)$ is of third order.

The closer α is to one, that is, the closer to constant returns to scale, the smaller the private cost. In the limit, if α is equal to one, then private costs of not adjusting prices are equal to zero as the optimal response of a monopolist to a multiplicative shift in iso-elastic demand under constant marginal cost is to leave the price unchanged. Thus private costs are an increasing function of α . They are also an increasing function of θ ; the higher the elasticity of demand with respect to price, the higher the private costs of not adjusting prices.

Exactly the same analysis applies to workers. The two important parameters for them are β and σ . If we define the function L in the same way as above, the private opportunity cost to a worker (measured in terms of consumption and expressed as a proportion of initial consumption), associated with not adjusting the wage in response to a change of 100 $\Delta\%$ in aggregate demand, when all other firms and households keep their prices and wages unchanged, is given by

$$[(\theta - 1)/\theta\alpha] L((1 + \Delta)^\alpha - 1; \beta, \sigma),$$

where $(\theta - 1)/\theta\alpha$ is the initial share of wage income in GNP.

If β is close to unity, that is, if the elasticity of the marginal disutility of labor is close to unity, private costs of not adjusting wages are small; in the limit, if marginal disutility of labor is constant, private costs are equal to zero. If σ is very large, if different types of labor are close substitutes, private costs of not adjusting wages are high.

Table 1, Part a, gives the size of menu costs as a proportion of the firm's revenues (GNP produced by the firm) that are just sufficient to prevent a firm from adjusting its price in response to a change in demand; Table 1, Part b, gives the size of menu costs as a proportion of initial consumption (GNP consumed by the worker) that are just sufficient to prevent a worker from adjusting his (her) wage.

Thus, given the unit elasticity of aggregate demand with respect to real money balances and the assumption that all other prices have not changed, Part a of Table 1 gives the private costs associated with not changing prices in the face of 5 and 10 percent changes in demand to the firm. The main conclusion is that very small menu costs, say less than .08 percent of revenues, may be sufficient to prevent adjustment of prices. Results are qualitatively similar for workers. Part b of Table 1 gives the private costs of not changing wages in response to changes of +5 and +10 percent in the demand for goods. It assumes that α is equal to 1.1, so that changes in the derived demand for labor are of 5.5 and 11 percent approximately. We expect β to be higher than α so that Part b of Table 1 looks at values of β between 1.2 and 1.6. For values of β close to unity, required menu costs are again very small; as β increases however, required menu costs become non-negligible: for $\beta = 1.6$ and a 11 percent change in demand, they reach .45 percent of initial consumption, a number which is no longer negligible.

The more relevant comparison, however, at least from the point of view of welfare, is between private costs and *welfare effects*, that is, the change in utility resulting from the changes in output, employment, and real money that are implied by a change in nomi-

TABLE 1—CHANGE IN AGGREGATE DEMAND AND MENU COSTS

(a): Loss in value to a firm from not adjusting prices (as a proportion of initial revenues) ^a				(b): Loss in utility (in terms of consumption) to a worker from not adjusting wages (as a proportion of initial consumption) ^{a,b}			
α	θ	$M_1/M_0 =$		β	σ	$M_1/M_0 =$	
		1.05	1.10			1.05	1.10
1.0	5	.000	.000	1.2	5	.025	.100
1.1	5	.003	.013	1.4	5	.066	.265
1.1	2	.001	.004	1.4	2	.027	.111
	20	.008	.031		20	.105	.418
1.3	5	.018	.071	1.6	5	.112	.451

Note: M_0 is the initial level of nominal money, M_1 the level after the change.

^a Shown in percent.

^b $\theta = 5$; $\alpha = 1.1$.

TABLE 2—MENU COSTS AND WELFARE EFFECTS

α	β	$M_1/M_0 = 1.05$			$M_1/M_0 = 1.10$		
		Menu Costs ^a	Welfare Effects ^a	Ratio	Menu Costs ^a	Welfare Effects ^a	Ratio
1.1 ($\theta = \sigma = 5$)	1.2	.03	1.79	60	.11	3.54	32
	1.4	.07	1.83	26	.28	3.60	13
	1.6	.11	1.91	17	.46	3.72	8
1.2	1.2	.04	1.82	45	.15	3.57	24
	1.4	.08	1.87	24	.33	3.67	11
	1.6	.13	1.98	15	.53	3.85	7
1.1 ($\theta = \sigma = 10$)	1.2	.03	.94	31	.11	1.86	17
	1.4	.06	1.02	17	.23	1.93	8
	1.6	.09	1.11	12	.36	2.05	6
1.2	1.2	.04	.99	25	.16	1.87	12
	1.4	.07	1.07	16	.29	2.01	7
	1.6	.11	1.27	12	.44	2.24	5

^a Shown in percent.

nal money at given prices and wages. Welfare effects depend on the size of the change in nominal money as well as on the parameters α , β , θ , and σ ; the dependence is a complex one and we shall not analyze it here in detail. Table 2 gives numerical examples. It gives the required menu costs and welfare effects associated with two different changes in nominal money, 5 and 10 percent, and different values of the structural parameters.

For each of the two changes in money, the first column gives the minimum value of menu costs, expressed as a proportion of GNP, that prevents adjustment of nominal prices and wages; this value is the sum of menu costs required to prevent firms from

adjusting their prices and workers from adjusting their wages, given other wages and prices. The second column gives the welfare effects of an increase in nominal money at unchanged prices and wages, expressed in terms of consumption, again as a proportion of GNP. The third gives the ratio of welfare effects to menu costs.

Welfare effects turn out not to be much affected by the specific values of the parameters, at least for the range of values we consider in the table. Thus, the ratio of welfare effects to menu cost has the same qualitative behavior as that of the ratio of output movements to menu costs. It is largest for values of α , β , θ , and σ close to unity,

and decreases as these parameters increase. In the table, it varies from 60 for low values of α , β , θ and σ to 5 for high values of these parameters.

C. Strategic Complementarities and Multiple Equilibria

We have shown that, if menu costs were sufficiently large, there was an equilibrium where, in response to an increase in nominal money, nominal prices and wages remained unchanged and nominal money had real effects. What we have not shown, however, is that this was the only equilibrium. It turns out that, if the condition that Cooper and John have called "strategic complementarity" is satisfied, there exists a range of menu costs for which the equilibrium is not unique. This has been shown by Julio Rotemberg and Garth Saloner (1986a, b) and, in the context of this model, by Laurence Ball and David Romer (1987). We give a brief sketch of their argument but refer the reader to those papers for details.

To discuss the existence and the role of strategic complementarity in this context, it is again easiest to study the special case where the marginal utility of leisure is constant and where there are no menu costs in nominal wage setting, so that real wage is constant and we can concentrate on the interactions between price setters. Following Cooper and John's definition, strategic complementarity corresponds then to the case where an increase in the price level leads a firm, absent menu costs, to increase its own nominal price. Strategic substitutability corresponds to the case where an increase in the price level leads the firm instead to decrease its nominal price.

In the special case we are considering, the price that each firm would choose, absent menu costs, is given by equation (14). An increase in P has two effects on P_i . At a given level of aggregate demand, the firm wants to keep the same relative price, and increase P_i in proportion to P . But an increase in the price level also decreases real money balances and aggregate demand, leading the firm to want a decrease in its relative price. The net effect is, in our con-

text, unambiguous: the relative price effect dominates the aggregate demand effect, so that an increase in P leads to an increase in P_i , although less than one for one. Thus, the model exhibits strategic complementarity. This is not, however, a robust feature of the model: if the elasticity of aggregate demand with respect to real money balances exceeded one, the aggregate demand effect could dominate the relative price effect; an increase in P could lead the firm to decrease rather than increase P_i and the model would exhibit instead strategic substitutability. It is clear that the results derived above on the inefficiency of the monopolistically competitive equilibrium, the existence of an aggregate demand externality and the role of menu costs do not depend on whether the model exhibits strategic complementarity or substitutability. But, if the model exhibits strategic complementarity however, the equilibrium with menu costs may not be unique.

Consider what a particular firm should do after an increase in nominal money. If other firms do adjust their prices, and if prices are strategic complements, the firm's optimal price, P_i , increases because of both the increase in M and the increase in P . If, instead, other firms do not adjust their prices, so that the price level does not change, the optimal price P_i increases, but by less. Put another way, the larger the proportion of firms which do not adjust their prices, the lower the opportunity cost to a firm of not adjusting its price. Thus, for some values of the menu costs, there will be two equilibria, one in which all firms adjust, making it costly for a given firm not to adjust, and the other in which no firm adjusts, making it less costly for a given firm not to adjust.

Strategic complementarity can therefore lead to multiple equilibria in the context of monopolistic competition with menu costs.¹⁶ These equilibria are associated with different levels of welfare, and to the extent that the economy ends at a low welfare equilibrium,

¹⁶Strategic complementarity turns out to play an important role in dynamic models with menu costs. See the surveys by Blanchard (1987) and Rotemberg (1987).

this can be seen as a "coordination failure," the term used by Cooper and John.

D. Demand Determination of Output

We have until now assumed that increases in real money balances at constant prices and wages led to increases in output and employment. When analyzing the effects of small changes in money, this assumption was clearly warranted; in the initial equilibrium, as price exceeds marginal cost, firms will always be willing to satisfy a small increase in demand at the existing price. The same is true of workers: as the real wage initially exceeds the marginal disutility of labor, workers will willingly accommodate a small increase in demand for their type of labor. When we consider larger changes in money, this may no longer be the case. Even if firms do not adjust their price, they have the option of either accommodating or rationing demand; they will resort to the second option if marginal cost exceeds price. The same analysis applies to workers. From standard monopoly theory, we know that firms and workers will accommodate relative increases in demand, respectively, of

$$(\theta/(\theta - 1))^{1/(\alpha - 1)}$$

and $(\sigma/(\sigma - 1))^{1/(\beta - 1)}$.

This raises the question of whether, assuming menu costs to be large enough, an increase in demand can increase output all the way to its competitive level. The answer is provided in Figure 4. This figure replicates Figure 2 and draws the aggregate price and wage rules under competitive and monopolistically competitive conditions. Point *A* is the monopolistic competitive equilibrium and *A'* the competitive one. Along the monopolistically competitive price rule, price exceeds marginal cost; thus firms will satisfy demand, at a given price wage ratio, until marginal cost equals price, that is, until they reach the competitive locus. In our case, firms will supply up to point *B*. The shaded area *F* is the set of output-real wage at which firms will ration rather than supply.

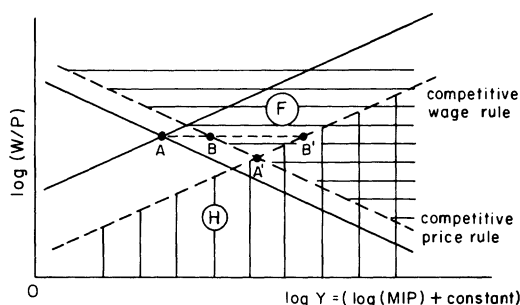


FIGURE 4. DEMAND DETERMINATION OF OUTPUT

By a similar argument, workers will supply up to point *B'*. The shaded area *H* is the set of real wage combinations where workers do not satisfy labor demand. The figure makes it clear that an increase in nominal money will increase output and employment. It also makes clear that, no matter how large menu costs are, it is impossible, unless the competitive and monopolistically competitive real wages are equal, to attain the competitive equilibrium through an increase in nominal money.

What happens, therefore, as demand increases depends on both menu costs and supply constraints. If menu costs are large, supply constraints will come into effect first. If menu costs are small, a more likely case, prices and wages adjust before supply constraints come into effect.

IV. Fixed Costs and Aggregate Demand Movements

Until now, we have taken the number of firms as given and fixed costs have played no role in our analysis. Both the aggregate demand externality and the menu costs arguments hold, irrespective of the presence of fixed costs.

In this section, we want to study further the effects of aggregate demand on activity, taking as given that, because of menu costs, such movements in aggregate demand affect output. It is then essential to introduce fixed costs, as they have important implications for productivity, profitability, and the potential for entry by new firms in response to

movements in output induced by aggregate demand.

A. Fixed Costs and the General Equilibrium

To introduce fixed costs, we change the specification of the production function to

$$(1') \quad Y_i + F = \left(\sum_{j=1}^n N_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)},$$

where F can be interpreted as being in terms of the firm's own output, or as overhead labor requiring all types of labor in the same proportions as regular production.¹⁷ For convenience, we also assume that, apart from the fixed cost, firms operate under constant returns to scale, so that $\alpha = 1$.

Given this specification of fixed costs, equations characterizing equilibrium are very similar to equations (5) to (13). The relation between real money balances and aggregate demand is unchanged. The demand functions for goods are still given by equation (7), while in the demand functions for labor, equation (8), Y is replaced by $(Y + mF)$. The price rules are still given by equation (10), which becomes under the assumption that α is equal to unity:

$$(10') \quad (P_i/P) = (\theta/(\theta-1))K_p(W/P) \\ i = 1, \dots, m.$$

The wage rules are given by equation (11) where Y is replaced by $(Y + mF)$.

Equations (12) and (13) which give the aggregate price and wage rules become

$$(12') \quad (P/W) = (\theta/(\theta-1))K_p$$

$$(13') \quad (W/P) = (\sigma/(\sigma-1))K_w$$

$$(Y + mF)^{\beta-1}.$$

¹⁷An alternative is to assume that fixed costs for a given firm are in the form of other goods. A convenient assumption is to assume that the fixed cost is a CES function of all goods, with elasticity of substitution θ . This assumption insures that the demand functions for goods still have elasticity θ .

Together they determine as before equilibrium aggregate output and real wages. From the assumption of constant returns in this section, the markup, or its inverse the real wage, is independent of the level of demand and is determined by (12'). Given the real wage, (13') determines the level of output.

We can now go further and determine the equilibrium number of firms. For a given number of firms, m , the real profit of each firm after profit maximization is given by

$$(16) \quad V_i/P = K_v(1/m)(W/P)^{1-\theta}Y \\ - K_p(W/P)F,$$

where K_v and K_p depend on the structural parameters but not on the number of firms. An increase in m has two effects on the profit of each firm. Given Y and (W/P) , it decreases the sales of each firm and decreases profit: this effect is captured by the term $(1/m)$ in (16). But it also affects the equilibrium value of Y ; while the constants K_p and K_w in (12') and (13') do not depend on m , the level of employment associated with a given level of output increases with aggregate fixed costs and therefore with m . This leads to a lower equilibrium value of Y ; given the assumption of constant returns, and given that K_p is independent of m , the value of (W/P) is unaffected by m ; lower aggregate output in turn decreases profit.

Assuming that entry takes place until profit is equal to zero, equations (12') to (16) and the zero-profit condition determine the equilibrium number of firms. We shall assume in what follows that the number of firms is initially given by zero-profit conditions but is going to be fixed in the short run.

B. Movements in Aggregate Demand, Profit, and Entry

Aggregate demand depends on real money balances, the ratio of nominal money to the price level. Under constant returns with a fixed markup of prices on wages, aggregate demand is therefore a function of the ratio of nominal money to the nominal wage,

money in wage units. We now consider the effects of movements in (M/W) . This may be due to a movement in nominal money, with no adjustment in nominal wages because of menu costs as in the previous section. Or it may be due to a change in the nominal wage given nominal money; the reason need not concern us in this section. Movements in (M/W) lead to one for one movements in aggregate demand and employment.

The first obvious implication of fixed costs is that productivity, given by $(Y/(Y + mF))$, varies procyclically. We focus on a related implication, the procyclical behavior of profit. From equation (16), profit is, given that nominal wages and prices are fixed, an increasing function of output. If profit was initially equal to zero, it becomes negative with a decrease in (M/W) , positive with an increase in (M/W) . Both procyclical productivity and profitability seem to be in accordance with the facts.

Procyclical profitability has interesting implications for entry. Keeping the number of firms constant, we examine the return to entry as a function of aggregate demand.¹⁸ Consider the effects of a decrease in nominal money in wage units and the associated reduction in output. Existing firms make negative profits and thus, if a potential entrant has to pay the prevailing wage, it will not want to enter. We can go further and derive the shadow wage, say W^* , which would make a potential entrant indifferent to entry, as a function of (M/W) . Going back to equation (5), (12'), and (16), given M and the aggregate nominal wage W , if a firm can pay its workers W^* , it will make profits of

$$\begin{aligned} & \left[K(K_v/m)((\theta-1)/\theta K_p)^{\theta-2} \right] \\ & \times (W^*/W)^{1-\theta} (M/W) \\ & - [(\theta-1)/\theta](W^*/W)F]. \end{aligned}$$

¹⁸An alternative would be to determine the equilibrium number of firms as a function of the level of aggregate demand. This is the route pursued by Robert Solow (1984).

For a potential entrant to be indifferent to entry, this expression has to be equal to zero. Assuming zero profit for the potential entrant, we can derive the elasticity of the relative wage (W^*/W) to the money stock in wage units (M/W) . Denoting it by η , we have

$$\eta = (1/\theta).$$

Equivalently the elasticity of the shadow nominal wage to the aggregate nominal wage is given by $1 - (1/\theta)$.¹⁹ Thus, the higher are aggregate nominal wages, the more difficult is entry, the lower the relative wage a new entrant can offer to its workers. This result depends on both the presence of monopolistic competition and fixed costs. Fixed costs imply that when higher nominal wages decrease aggregate demand, the profit of all firms can be negative; the fact that products are imperfect substitutes implies that new entrants face downward-sloping demands and cannot capture all of demand by simply undercutting the prices of existing firms.

This result has two implications. In the previous section, we showed that, if the number of firms was given, menu costs could lead firms not to change prices in response to changes in nominal money. We see that, with respect to decreases in money, allowing for entry will not change the result. More generally (and stepping outside our model) this result implies that if nominal wages are too high, perhaps because of union push, and lead to unemployment, new firms will not want to enter, even if they can pay wages to the unemployed that are far below those paid to the employed.²⁰ Absent fixed costs,

¹⁹As θ is greater than unity, the elasticity of the shadow wage with respect to the aggregate wage is positive. If we had, however, formalized fixed costs in terms of a basket of goods, the sign of the elasticity would depend on whether θ is greater or smaller than 2. The difference comes from the fact that, in our case, a decrease in the shadow wage decreases the fixed cost whereas, under this alternative assumption, it does not.

²⁰We are indebted to Larry Summers for suggesting this argument.

entry would occur and unemployment subsides.²¹

V. Conclusion

The results of this paper are tantalizingly close to those of traditional Keynesian models: under monopolistic competition, output is too low, because of an aggregate demand externality. This externality, together with small menu costs, implies that movements in demand can affect output and welfare. In particular, increases in nominal money can increase both output and welfare. In the presence of fixed costs, output, productivity, and profitability move in the same direction.

We believe these results to be important to the understanding of macroeconomic fluctuations; we want to point out the obvious limitations of the analysis as it stands.

The scope for small menu costs to lead to large output effects in our model depends critically on the elasticity of labor supply with respect to the real wage being large enough (on $(\beta - 1)$ being small). Evidence on individual labor supply suggests however a small elasticity. Thus the "menu cost" approach runs into the same problem as the imperfect information approach to output fluctuations; neither can easily generate large fluctuations in output in response to demand if the real wage elasticity of labor supply is low. As in the imperfect information case, the theory may be rescued by the distinction between temporary and permanent changes in demand. Another possibility is that unions have a flatter labor supply than individuals, or do not represent the whole labor force. More likely, the assumption that labor markets operate as spot markets (competitive or monopolistically competitive) will have to be abandoned.²²

The analysis of this paper is purely static. There are two main issues involved in ex-

tending the model to look at the dynamic effects of aggregate demand on output in the presence of menu costs.

The first is that we have assumed all prices to be initially equal and set optimally. In a dynamic economy and in the presence of menu costs, such a degenerate price distribution is unlikely. But, if prices are initially not all equal or optimal, it is no longer obvious that even a small change in nominal money will leave all prices unaffected. It is no longer obvious that money, or aggregate demand in general, will have large effects on output.

The second is that, even if nominal money has large effects on output, it must be the case that money is sometimes unanticipatedly high, sometimes unanticipatedly low. When money is high, output increases and so does welfare to a first order. When money is low, output decreases and so does welfare, again to a first order. These welfare effects would appear to cancel out to a first order. It is therefore no longer obvious that, even if menu costs lead to large output fluctuations, the welfare loss of those fluctuations exceeds the menu costs which generate them.

Fortunately, all these issues are the subject of active research. Recent developments are reviewed in Blanchard and Rotemberg.

APPENDIX

This Appendix derives the market equilibrium conditions (5) to (11) given in the text. It proceeds in three steps. The first derives the demand functions of each type of labor and each type of product by solving part of the maximization problems of firms and households. These functions hold whether or not prices and wages are set by workers and firms at their profit or utility maximizing level. The second derives price rules from firms' profit maximization and wage rules from workers' utility maximization. The third characterizes market equilibrium.

A. *Demands for Product and Labor Types*

(a) *Demand for product of type i.* In order to maximize utility, each household

²¹This is our interpretation of Weitzman's argument that increasing returns are a necessary condition for unemployment to persist.

²²This is indeed the direction taken by Akerlof and Yellen (1985b) who formalize the goods market as monopolistically competitive and the labor market using the "efficiency wage" hypothesis.

chooses the optimal composition of consumption and money holdings for a given level of total wealth I , and product prices:

$$\max_{C_{ij}, M'_j} \Lambda_j = \left(\sum_{i=1}^m C_{ij}^{(\theta-1)/\theta} \right)^{\theta\gamma/(\theta-1)} \\ \times m^{\gamma/(1-\theta)} (M'_j/P)^{1-\gamma}$$

subject to $\sum_{i=1}^m P_i C_{ij} + M'_j = I_j.$

Solving this maximization problem gives

$$(A1) \quad C_{ij} = (P_i/P)^{-\theta} (\gamma I_j/mP)$$

$$(A2) \quad M'_j = (1-\gamma)I_j$$

$$(A3) \quad \Lambda_j = \mu I_j/P$$

where

$$(A4) \quad P = \left((1/m) \sum_{i=1}^m P_i^{1-\theta} \right)^{1/(1-\theta)} \quad \text{and} \\ \mu = \gamma^\gamma (1-\gamma)^{1-\gamma},$$

μ can be interpreted as the marginal utility of real wealth.

The demand for product of type i is therefore given by

$$(A5) \quad Y_i = \sum_{j=1}^n C_{ij} = (P_i/P)^{-\theta} (Y/m),$$

where

$$(A6) \quad Y = \left(\sum_j \sum_i P_i C_{ij} \right) / P = (\gamma/P) \sum_{j=1}^n I_j.$$

Y denotes real aggregate consumption expenditures of households and will be referred to as "aggregate demand." Equation (A5) is equation (7) in the text. Note also that equations (A1), (A2), (A5), and (A6) imply the following relation between aggregate demand and aggregate desired real mo-

ney balances:

$$(A7) \quad Y = (\gamma/(1-\gamma)) M'/P$$

where $M' = \sum_{j=1}^n M'_j.$

(b) *Demand for labor of type j .* In order to maximize profit, each firm minimizes its production cost for a given level of output and wages:

$$\min_{N_{ij}} \sum_{j=1}^n W_j N_{ij}$$

subject to $\left(\sum_{j=1}^n N_{ij}^{(\sigma-1)/\sigma} \right)^{(\sigma/(\sigma-1))^{1/\alpha}} = Y_i.$

Solving this minimization problem gives

$$N_{ij} = (n^{\sigma/(1-\sigma)}) (W_j/W)^{-\sigma} Y_i^\alpha$$

and

$$(A8) \quad \sum_{j=1}^n W_j N_{ij} = n^{\sigma/(1-\sigma)} W Y_i^\alpha$$

where

$$(A9) \quad W = \left((1/n) \sum_{j=1}^n W_j^{1-\sigma} \right)^{1/(1-\sigma)}.$$

The demand for labor of type j is therefore given by

$$(A10) \quad N_j = \sum_{i=1}^m N_{ij} = (W_j/W)^{-\sigma} N/n,$$

where

$$(A11) \quad N \equiv \left(\sum_i \sum_j W_j N_{ij} \right) / W \\ = n^{1/(1-\sigma)} \sum_{i=1}^m Y_i^\alpha.$$

N can be interpreted as the aggregate labor demand index.

B. Price and Wage Rules

(a) Taking as given wages and the price level, each firm chooses its price and output so as to maximize profit:

$$(A12) \quad V_i = P_i Y_i - \sum_{j=1}^n W_j N_{ij},$$

subject to the cost function (A8) and the demand function for its product (A5). Solving the above maximization problem gives

$$(A13) \quad P_i/P = [((\theta/(\theta-1))n^{1/(1-\sigma)}\alpha m^{1-\alpha}) \\ \times (W/P)Y^{\alpha-1}]^{1/(1+\theta(\alpha-1))}.$$

Equation (A13) implies that the price is equal to $\theta/(\theta-1)$ times the marginal cost. Equation (A13) is equation (10) in the text.

(b) Taking as given prices and other wages, each household chooses its wage and labor supply so as to maximize utility. Using (A3),

$$(A14) \quad U_j = \mu I_j/P - N_j^\beta$$

subject to the demand for its type of labor (A10) and the budget constraint:

$$(A15) \quad I_j = W_j N_j + \sum_{i=1}^m V_{ij} + M_j.$$

Solving this maximization problem gives

$$(A16) \quad W_j/W = [((\sigma/(\sigma-1))(\beta/\mu)n^{1-\beta}) \\ \times (P/W)N^{\beta-1}]^{1/(1+\sigma(\beta-1))}$$

Equation (A16) implies that the real wage, in terms of utility, is equal to $\sigma/(\sigma-1)$ times the marginal disutility of labor.

C. Market Equilibrium

In equilibrium, desired real money balances must be equal to actual balances. Thus $M = M'$. Replacing in (A7) gives

$$(A17) \quad Y = (\gamma/(1-\gamma))M/P.$$

This gives equation (5) in the text.

Replacing the Y_i 's in (A11) by their value from (A5) gives

$$(A18) \quad N = [n^{1/(1-\sigma)}m^{-\alpha}] \\ \times \left(\sum_{i=1}^m (P_i/P)^{-\alpha\theta} \right) Y^\alpha.$$

If all firms choose the same (not necessarily optimal) price, this reduces to

$$(A19) \quad N = [n^{1/(1-\sigma)}m^{1-\alpha}]Y^\alpha.$$

Substituting N from equation (A19) into (A10) gives the demand function for labor j , equation (8) in the text. Note that the demand functions for goods and labor, and the relation between aggregate demand and real money balances, have been derived without use of the price and wage rules and therefore hold whether or not wages and prices are set optimally.

Substituting N from equation (A19) into equation (A16) gives the wage rule, equation (11) in the text. This completes the derivation.

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