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PRICE DECISIONS AND EMPLOYMENT EQUILIBRIUM

By José Encarnación, Jr.*

Instead of expected profit maximization, this paper assumes a safety-first objective so that the firm will set a higher price for its product if cost or demand is higher, which has macroeconomic implications. With all firms in the economy as price setters, there is an equilibrium of prices which entails an employment equilibrium, and vice versa. The model developed can account for increasing unemployment with inflation, and allows for procyclical real wages.

1. Introduction

Observation shows that the usual practice of imperfectly competitive firms facing demand uncertainty is to set prices on their products. This paper explores some possibilities of a model where the price decision maximizes the probability of satisfactory profits. The model yields the proposition, which has interesting macroeconomic implications, that a firm will set a higher price if cost or demand is higher. This seems intuitively plausible and consistent with casual observation, though under the usual assumption of expected profit maximization, price does not necessarily rise with costs, and more remarkable, it does not necessarily rise with demand either.

Assuming that all firms in the economy are similar price setters, a stable equilibrium of prices and aggregate employment can be defined where prices and employment remain stationary so long as cost and demand parameters do not change. An exogenous increase in demand means, in the usual case, a new equilibrium with higher prices and employment. More interesting, an exogenous increase in costs leads to more unemployment with inflation, a puzzle of recent years.

2. The Price Decision

Consider a firm whose differentiated product is subject to

*Professor of Economics, University of the Philippines. Thanks are due Ruperto Alonzo, Emmanuel de Dios, Paul Encarnación, Manuel Montes, Filologo Pante, Jr., and Eli Remolona for helpful discussions and comments.

uncertain demand[1] dependent on a demand parameter θ. The cost of producing output y is $C(y, \gamma)$ where γ is a cost parameter. The firm is to decide on a price p to be maintained unless there is a change in θ or γ. Then, when the random quantity demanded x is known in the current period, the firm chooses[2] y to maximize profit $py - C(y, \gamma)$. Defining y^+ as that value of y where marginal cost $C_y = p$ and C_y is increasing, current profit is maximized by simply putting

$$(1) \qquad y = \begin{cases} x & \text{if } x \leqq y^+ \\ y^+ & \text{if } x > y^+ \end{cases}$$

Our assumption about the choice of p is that the firm maximizes the probability

$$(2) \quad \Pr\{py - C(y, \gamma) \geqq A \mid \theta\}$$

where A = const is an acceptable return, y obeying (1). This objective function follows the Hall and Hitch (1939) finding that some satisfactory rate of profit is an important parameter in business decision-making, and the Cramér-Roy safety-first principle (Roy (1952)) of minimizing the probability of a "disaster", viewing the latter as a subsatisfactory return. It seems plausible that a firm's managers will want to maximize (2), taking A as stockholders' expectation of a "reasonable" return, and Mao's (1970) empirical investigation lends support to this idea.

Let $f(x \mid p, \theta)$ be the density of x given p and θ, and write

$$(3) \quad \pi(p, q, \theta) = \int_q^\infty f(x \mid p, \theta)\, dx \qquad (p, q > 0)$$

so $\pi_p \leqq 0$, $\pi_q \leqq 0$. Putting $\pi(p, q, \theta) = \alpha \; (0 < \alpha < 1)$ defines what

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[1]Such uncertainty may result from the kind of consumer behavior described by Hildenbrand (1971) and from random differences in the timing of purchases by different households, fluctuations in income, etc.

[2]Cf. Kirman and Sobel (1974) who assume instantaneous production to meet current demand. The holding of inventories is an attractive feature of their model, but they assume price adjustment every period which seems contrary to observed behavior. Benassy (1976) also assumes instantaneous production and price adjustment every period. However, as Levitan and Shubik (1971) have argued, one expects the imperfectly competitive firm to quote a steady price if market conditions are stationary except for random elements in demand.

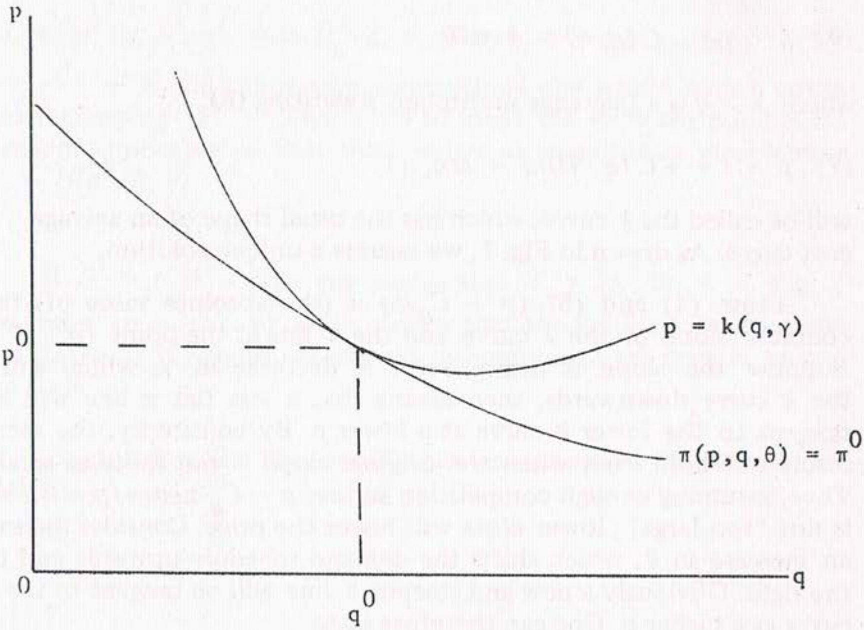

Figure 1

we will call a π line, a locus of points (p, q) for given θ such that $\Pr\{x \geqq q \mid p, \theta\} = \alpha$ (const). Fig. 1 shows one with a $\alpha = \pi^0$. The family of π lines corresponding to different values of α constitutes the stochastic demand schedule, which originates from a point on the p axis. The downward sloping π lines fan out toward the q axis so that at any given p, those to the left (with higher α) are steeper. An increase in θ shifts the originating point upwards and each π line rightwards, so $\pi_\theta > 0$.

In view of (1) maximizing (2) is equivalent to the problem of maximizing $\pi(p, q, \theta)$ subject to $pq - C(q, \gamma) \geqq A$. Solution values of the variables will be denoted by 0 superscripts — e.g. $\pi^0 = \pi(p^0, q^0, \theta)$ — which will usually be omitted however when the context is clear. We will take it that $0 < \pi^0 < 1$ so $\pi_p < 0$ and $\pi_q < 0$ in the solution, since the $\pi^0 = 0$ and $\pi^0 = 1$ cases are uninteresting. It is necessary then that

(4) $\pi_p + \lambda q = 0$

(5) $\pi_q + \lambda(p - C_q) = 0$

(6) $pq - C(q, \gamma) - A = 0$

where $\lambda > 0$ is a Lagrange multiplier. Rewriting (6),

(7) $p = (A + C(q, \gamma))/q = k(q, \gamma)$

will be called the k curve, which has the usual shape of an average cost curve. As drawn in Fig. 1, we assume a unique solution.

From (4) and (5), $(p - C_q)/q$ is (the absolute value of) the common slope of the k curve and the π line at the point (p^0, q^0). Suppose the slope is nearly zero. A decrease in γ, which shifts the k curve downwards, then means that a less flat π line will be tangent to the lower k curve at a lower p. By continuity, the same result will hold even when the original slope is not quite as small. Thus, assuming enough competition so that $p - C_q$ hence $(p - Cq)/q$ is not "too large", lower costs will lower the price. Consider instead an increase in θ, which shifts the demand schedule upwards and to the right. Obviously a new and steeper π line will be tangent to the k curve at a higher p. One can therefore state

Proposition 1. The firm will set a higher (lower) price if cost or demand is higher (lower).

We can then write $p = G(\theta, \gamma)$ $G_\theta > 0$, $G_\gamma > 0$, and for the mean value of output, $\bar{y} = h(p, \theta, \gamma)$ which has $h_p < 0$, $h_\theta > 0$, $h_\gamma \leqq 0$, γ appearing as an argument because $\bar{y}$ depends on y^+ which depends on $C(y, \gamma)$. (A higher γ that raises C_y lowers y^+, lowering $\bar{y}$). Normally, $h_p G_\theta + h_\theta > 0$ so that although a higher θ induces a higher p, the net result of a higher θ is a higher $\bar{y}$.

3. Equilibrium Prices in the Industry

The firm in Section 2 can be thought of as the ith firm in an n-firm industry, the index i suppressed in the notation there. Let now $p = (p_1, \ldots, p_n)$ and denote the vector of prices other than p_i by p_{-i}. The demand parameter θ^i depends on the prices set by other firms and on δ^i representing other factors affecting demand: $\theta^i = \theta^i(p_{-i}, \delta^i)$ and $\theta^i_j = \partial\theta^i/\partial p_j \gtreqless 0$, so $p^o_i = G^i(\theta^i\{p_{-i}, \delta^i\}, \gamma^i) = H^i(p; \delta^i, \gamma^i)$ with $H^i_j \gtreqless 0$. Given $\delta = (\delta^1, \ldots, \delta^n)$, $\gamma = (\gamma^1, \ldots, \gamma^n)$, and innocuous assumptions one would have a continuous mapping $p^0 = H(p; \delta, \gamma)$ to make the Brouwer fixed point theorem applicable so that there exists an equilibrium price vector $p^e = H(p^e; \delta, \gamma)$.

If $H^i_j > 0$ it is only reasonable that $H^i_{jj} = \partial H^i_j/\partial p_j < 0$. Fig. 2 illustrates $n = 2$, where it is clear that the equilibrium is unique and stable. It is easy to see that this generalizes to arbitrary n, so one can state

Proposition 2. The equilibrium of prices in the industry stable.

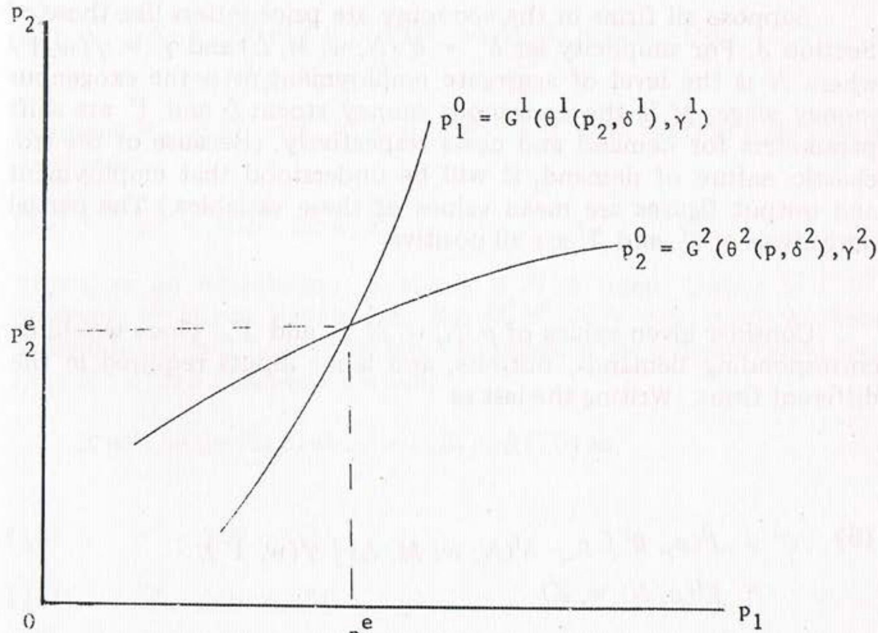

Figure 2

A lower γ^i shifting G^i "downwards" will decrease equilibrium prices, changes in prices spreading through the industry with each firm responding myopically only to its own cost and demand conditions. Firm i will then have a higher probability of satisfactory profits and other firms would have lower ones because of the shifts in demand. The better competitive position of the cost-reducing firm would thus be felt by other firms as a fall in the values of their objective functions, signalling their now weaker competitive position. This constrasts with the implications of expected profit maximization where, if the cost reduction only involves fixed costs, i would merely have larger expected profits at the same price, there would be no effect on the prices or expected profits of other firms, and they would get no signals that the market situation had changed.

4. Prices and Employment Equilibrium

Suppose all firms in the economy are price setters like those of Section 3. For simplicity let $\delta^i = \delta^i(N; w, M, \Delta)$ and $\gamma^i = \gamma^i(w, \Gamma)$ where N is the level of aggregate employment, w is the exogenous money wage, M is the exogenous money stock; Δ and Γ are shift parameters for demand and costs respectively. (Because of the stochastic nature of demand, it will be understood that employment and output figures are mean values of these variables.) The partial derivatives of δ^i and γ^i are all positive.

Consider given values of p, N, w, M, Δ and Γ. There would be corresponding demands, outputs, and labor inputs required in the different firms. Writing the last as

$$(8)\quad \begin{aligned} N_i^o &= J^i(p_i, \theta^i\{p_{-i}\ \delta^i(N; w, M, \Delta)\}\ \gamma^i(w, \Gamma)) \\ &= K^i(p, N; w, Z) \end{aligned}$$

where $Z = (M, \Delta, \Gamma)$ is an abbreviation, and $N^0 = \Sigma N_i^0$, write

(9) $N^0 = K(p, N; w, Z)$.

Allowing N to vary, one expects that $0 < \partial N^0/\partial N < 1$ (one might say that $\partial N^0/\partial N$ is the employment version of the marginal propensity to spend). Assuming the conditions of the Brouwer theorem there is a unique fixed point

(10) $N^e = K(p, N^e; w, Z)$

which, as an equilibrium, is stable if p is held fixed. Unless $p = p^0$ however, N^e is not sustainable. For if $p \neq p^0$, some firm will change its price and N^e will have to be different. One might therefore call N^e a quasi-equilibrium.

Consider again the earlier given values of p, N, w, M, Δ, *and* Γ. Firms will choose

(11) $$p_i^o = G^i(\theta^i\{p_{-i}, \delta^i(N; w, M, \Delta)\}, \gamma^i(w, \Gamma))$$
$$= R^i(p, N; w, Z).$$

Assuming $R_j^i \gtreqless 0$ and $R_{jj}^i < 0$ if $R_j^i > 0$, as in Section 3 there is a fixed point

(12) $p^e = R(p^e, N; w, Z)$

which, as an equilibrium, is stable if N is fixed. Unless $N = N^0$ however, p^e is not sustainable. For if $N^0 > N$ say, more workers or man-hours will have to be hired to produce the outputs called for. Like N^e, p^e is a quasi-equilibrium.

It will be useful to rewrite (12) and (10) as

(13) $p^e = S(N; w, Z)$

(14) $N^e = L(p; w, Z)$

respectively. An equilibrium of prices and employment will then obtain only if $p = p^e$ and $N = N^e$. Denoting that equilibrium by

(p^*, N^*),

(13′) $p^* = S(N^*; w, Z)$

(14′) $N^* = L(p^*; w, Z)$.

This can be illustrated in a simple diagram by defining a price index for each p and p^e. Noting that the components of p^e increase with N in (13), an index for p^e is possible: all that is needed is for the index to be higher with larger N. Next, an arbitrary p determines a corresponding N^e in (14) which, upon substitution in (13), gives a corresponding p^e and its index. The latter can then be defined as the index of p so that all price vectors determining, by (14), the same N^e will have the same index.

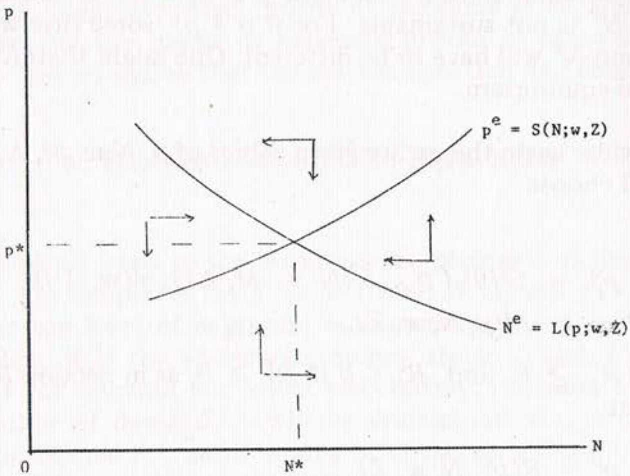

Figure 3

To avoid additional notation we will use the same symbol both for a price vector and its index, the context being clear. Thus in Fig. 3 the S curve (eq.(13)) is upward sloping as noted above. L (eq. (14)) is downward sloping because higher prices reduce demand. (In a diagram giving N^0 as a function only of N — see (9) — N^e is determined at the point where the N^0 curve crosses the 45^0 line. If p is higher the N^0 curve is shifted downwards making N^e lower.) The vertical arrows indicate that p will tend to p^e given N; the horizontal arrows show convergence of N to N^e given p. Although the approach to (p^*, N^*) from an arbitrary (p, N) could be cyclical and not monotonic, we can state

Proposition 3. The prices and employment equilibrium (p^*, N^*) is stable, given the money wage w and the money stock M.

An exogenous increase in Δ raising general demand will shift L to the right and S upwards, so p^* will be higher in the new equilibrium. In the normal case where the induced S shift is relatively smaller, N^e will also be higher as in the standard Keynesian model. An exogenous increase in Γ raising costs, will shift S upwards and possibly L to the left (and only marginally), so N^* will be lower and p^* higher. A monotonic approach to the new equilibrium then means increasing unemployment with inflation. (Prices of imported inputs like oil would be reflected in Γ in a model with trade.)

And exogenous increase in M, like Δ, implies a higher p^*. It is not as clear, however, that N^* should also be higher.

5. Money Equilibrium

Since output and employment are one-to-one in the short term, we can write an employment version of the simple demand-for-money function as $g(p, N, r)$ with $g_p > 0, g_N > 0, g_r < 0$, where p may be the price vector or its index. Money equilibrium holds when $M = g(p, N, r)$ or, alternatively, $r = r(p, N, M)$. Going back to the second paragraph of Section 4, the given values of p, N, w, M, Δ and Γ there implicitly determine a value of r that satisfies money equilibrium for those values of p, N and M. In effect we can think of r as implicit in eqs. (8)-(14) so the equilibrium value of r is $r^* = r(p^*, N^*, M)$, and therefore $M = g(p^*, N^*, r^*)$ in the equilibrium.

6. Wages and the Level of Employment

There is no reason for N^* to equal full employment given the exogenously determined money wage. It has been a recurring question in the literature to what extent a rigid or sticky w prevents attainment of a full employment equilibrium. Suppose a lower w, which shifts L to the left and S downwards. The new p^* will be lower but, as Keynes had emphasized, the new N^* could be lower also. Letting w vary in (13') - (14'), some value of w would maximize N^* but that maximum may still fall short of full employment. There is no assurance therefore that there exists a "correct" w yielding full employment.

Suppose N^* is less than full employment. Let $w = 1$ by normalization so p is the reciprocal of the real wage in Fig. 3. A downward sloping labor supply curve can be drawn in, which cuts the S and L curves at points to the right of (p^*, N^*). As in the standard

Keynesian model, a sufficiently large increase in Δ can drive a new (p^*, N^*) northeast — in the normal case — until the new equilibrium lies on the labor supply curve, at which point there is full employment with a higher p^* hence a lower real wage. What is interesting if a possibility, a sufficiently large decrease in Γ would drive a new (p^*, N^*) southeast until the new equilibrium lies on the labor supply curve at a point where the full employment level would be higher and the real wage, instead of being lower, is higher than before.

We see then that the phenomenon of a rising real wage during the expansionary phase of the business cycle,[3] which would seem unrelated to the phenomenon of rising unemployment with inflation due to a higher Γ, is here only the other side of the same coin. A lower Γ (because of a cost-reducing innovation 'a la Schumpeter, a change in government policy that lowers costs, or a fall in the prices of imported inputs) has effects the opposite of an increase in Γ. A decrease implies more employment and lower prices relative to the money wage.

7. Concluding Remarks

On the hypothesis that the imperfectly competitive firm facing demand uncertainty sets a price on its product to maximize the probability of obtaining satisfactory profits, the firm will set a higher price when demand is higher and also when costs are higher. This implication has macroeconomic significance. Taking all firms in the economy as price setters responding only to their cost and demand conditions, there is an equilibrium of prices which implies an employment equilibrium at the macro level, and an employment equilibrium which implies an equilibrium of prices at the micro level. Even with a flexible money wage the prices and employment equilibrium need not be one of full employment, since firms hire only that number of workers whose output can be sold at equilibrium prices.[4] Given the money wage, a new equilibrium called for by an increase in general demand means more employment

3. Fischer (1988, p. 310) remarks that "the weight of the evidence by now is that the real wage is slightly procyclical." This is a difficulty for profit maximization models which imply a close link between the real wage and the marginal productivity of labor, as the latter is expected to decrease with more employment in the short term.

4. Since this fact holds true also for the long run, full employment is not assured even there. Hart (1982) gets a similar conclusion from his model.

and higher prices in the usual way. An exogenous increase in costs implies more unemployment and higher prices, the stagflation case; a decrease means greater employment at a higher level wage, in conformity with observed procyclical real wages.

In a less incomplete account than is given in this paper, one would have an explicit treatment of household decisions, which are in the background and reflected only in the demand schedules confronting firms. A more complete formulation would fill this lacuna, but it does not seem that the present discussion would need to be changed in its essentials.

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