MONASH UNIVERSITY

NEO-NEUTRALITY OF MONEY UNDER NON-PERFECT COMPETITION : WHY DO ECONOMISTS FAIL TO SEE THE POSSIBILITY?

Yew-Kwang Ng

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Yew-Kwang Ng
Department of Economics
Monash University
Australia 3168

Abstract

Despite the demonstration that non-perfect competition makes money possibly non-neutral (Ng 1977, 1980, 1982, 1986, 1992), economists now (e.g. Dixon and Rankin 1994) still regard additional distortions or frictions, such as menu costs, as necessary, in combination with non-perfect competition, to make money non-neutral. This paper explains this inconsistency. Really, it has only been shown that a real equilibrium can still be an equilibrium even if money supply changes. However, a change in money supply may also shift the economy from one equilibrium to another. When such possibilities prevail, there exists ***an interfirm macroeconomic externality*** where the expansion by each firm benefits other firms ***apart from*** the familiar income multiplier effects. Some real-world factors making monetary non-neutrality more likely to prevail are briefly outlined. In particular, revenue maximization and average-cost pricing increases the likelihood. When the economy does not but is close to possessing a continuum of equilibria, a tax reduction as aggregate demand increases may make a higher real output sustainable as an equilibrium point. Moreover, the tax reduction may be self-financing.

1 Introduction

More than a decade ago, I showed that the introduction of non-perfect competition (subsuming monopolistic competition, oligopoly, and monopoly; in fact whenever the firm perceives the demand curve for its product as downward sloping) alone in a standard macroeconomic model with profit maximization, no time lags, no menu costs or any other transaction costs or frictions, could break the classical dichotomy between the real and the monetary sectors and make money possibly non-neutral (Ng 1977, 1980, 1982, 1986, 1992). My 1980 *Economic Journal* paper is regarded by Marris (1991, p.215) as one "which effectively started the modern movement" in providing an imperfect competition foundation of macroeconomics. However, in the subsequent mushrooming literature, economists virtually ignored this possible non-neutrality of money under imperfect competition. Thus, as late as 1994, Dixon and Rankin, in their survey of imperfect competition and macroeconomics, conclude that "Imperfect competition by itself does not create monetary non-neutrality ... It is the combination of imperfect competition with some other distortion which generates the potential for real effects" (p.178). In this paper, I explain this apparent inconsistency.

Basically, when economists assert that imperfect competition itself does not create non-neutrality of money, they have only shown that a real equilibrium under imperfect competition can still be an equilibrium even if money supply changes. However, they have not shown that a change in money supply (or any other factor causing a change in nominal aggregate demand) may not trigger a shift from one real equilibrium to another. Such a shift may not be relevant if the equilibrium is unique. However, the introduction of imperfect competition may make a model with a unique equilibrium into one with multiple or even a continuum of equilibria and hence make the above-mentioned shift relevant and make money possibly non-neutral even without any friction. This is explained in the next section with the help of only graphical illustrations of the profit maximization of the firm familiar to first-year undergraduates. The mathematical model in support of the graphical analysis is presented in the appendix where it may also be seen that general functional forms are used instead of the specific forms used by other investigators. If an economy has a continuum of equilibria, why does it remain at a low-level equilibrium? This is explained by the existence of the interfirm macroeconomic externality discussed in Section 3. The expansion by each firm towards a higher equilibrium position benefits other firms in the economy. The externality works through an increase in a firm's output and the resulting reduction in its price on the demand for other firm's products through an endogenous increase in real aggregate demand *before* the familiar income multiplier takes effect.[1] In Section 4, some real-world factors making monetary non-neutrality more likely to prevail are briefly outlined. In particular, revenue maximization and average-cost pricing increases the likelihood. When the economy does not but is close to possessing a continuum of equilibria, a tax reduction as aggregate demand increases may make a higher real output sustainable as an equilibrium point. Moreover, the tax reduction may be self-financing.

2 Non-neutrality under Non-perfect Competition without other Frictions

Since the price, output, and employment decisions are made by business firms in a modern economy, with consumers and input-suppliers affecting these related decisions only indirectly through their effects on the demand and cost functions of firms, it makes sense to concentrate on the microeconomics at the firm level as the foundation for the macro analysis. On the other hand, since we are only interested here on the aggregate variables ignoring distributional and relative changes, it makes sense to concentrate on only one representative firm producing a single product. For simplicity, we assume a no-government closed economy. Partly for simplicity and mainly to show that our result is unrelated to complicating factors such as time lags, menu and other transaction costs, money illusion, etc., all such factors are assumed absent.

In the case of perfect competition, the firm is facing a horizontal demand curve for its product. Given either output determinacy at the firm level and/or the existence of some fixed costs, the short-run marginal cost curve of the firm must be upward sloping, as illustrated in Figure 1. The equilibrium output is at q where the MC curve cuts the demand curve. Given the production or cost function, the equilibrium output can change only if the price changes. However, with the full response of costs to prices (absence of money illusions, lags, etc.), the MC curve responds by the full extent as the price line, leaving the equilibrium output unchanged. A change in money supply in such a model can thus only change the price level without affecting output. For example, an increase in nominal aggregate demand shift the demand curve from d to d'. However, since this means that the price level increases from p to p', the MC curve also moves up from MC to MC', leaving the equilibrium output unchanged at q. (The introduction of such factors as time lags may mean that the MC curve may not move up fully immediately, making the output level possibly increasing somewhat in the short term. However, unless there are other sustaining factors, such output levels are not sustainable.) We thus have the neutrality of money and the classical dichotomy between the money and the real sectors. (This dichotomy and the neutrality of money need not be exactly equivalent in more complicated models.) However, this classical dichotomy can be broken simply by the introduction of non-perfect competition.

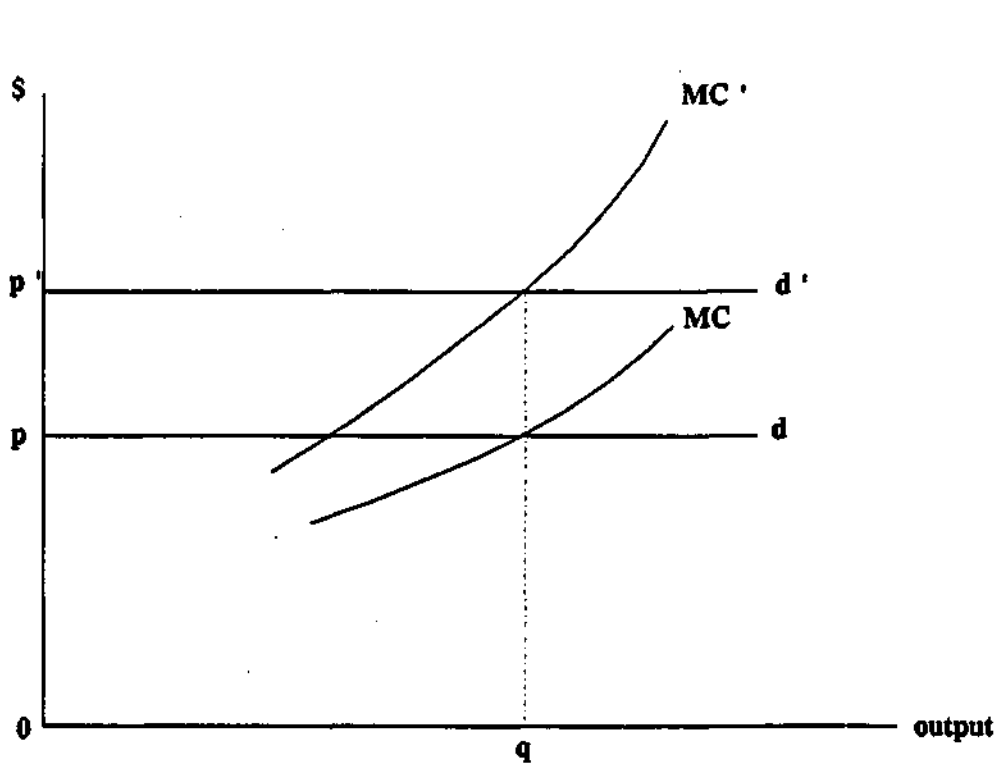

Figure 1

With non-perfect competition, the firm is facing a downward sloping demand curve, as illustrated in Figure 2. (Linearity in the demand and cost curves is not necessary for our argument. Ignore the dotted curves for the moment.) The initial equilibrium is at A where the MC curve cuts the MR curve. An increase in nominal aggregate demand may shift the demand curve to d' and hence the MR curve to MR'. (This is a proportional shift with no change in the price elasticity of demand at any given price, e.g. elasticity at B is the same as that at A.) If the MC curve is horizontal over the relevant range and does not shift, as illustrated in Figure 2, the new equilibrium is at B, with an increase in output and no change in price. (The absence of a price change is important since a change in the price of the representative firm means a change in the general price level which will shift the demand curve, making B no longer the final equilibrium point.) Alternatively (not illustrated), if the upward shift in the *MC* curve (a downward shift is not really possible) as aggregate output expands is offset by the downward sloping *MC* curve and/or the increase in the (absolute) demand elasticity (which lift *MR* at given price), we may still have an increase in real output with no change in price.

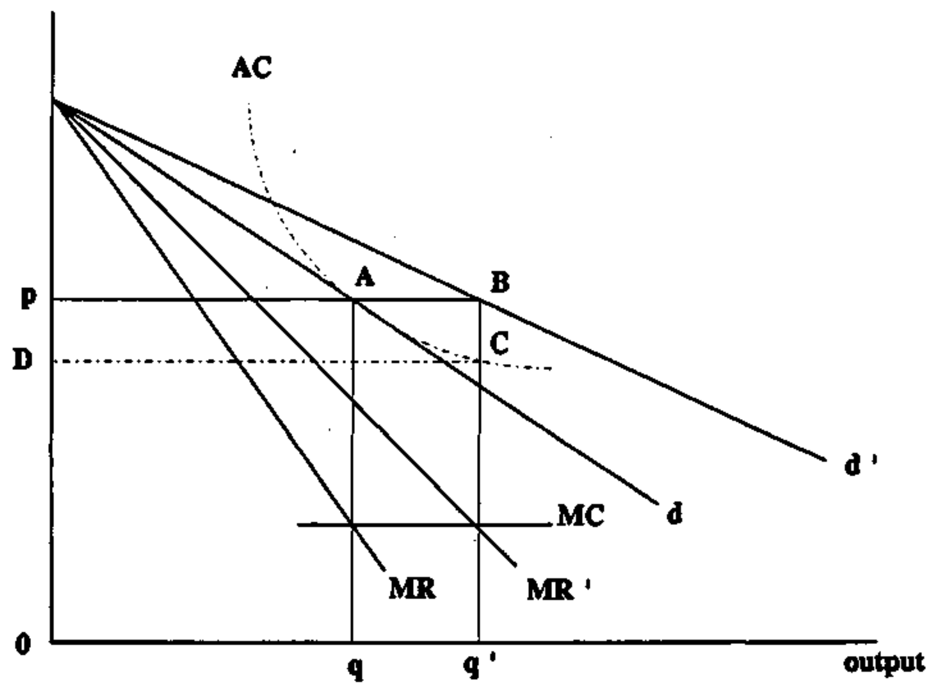

Figure 2

It may be thought that it is unlikely for the slope of the *MC* curve, the shift in the *MC* curve, and the change in *MR* (through a change in demand elasticity) to be at such a precise combination that the profit maximizing price remains exactly unchanged. However, for our non-traditional result to hold, we only need the resulting profit maximizing price not to increase. If it remains unchanged, we have the case of a continuum of equilibrium as illustrated in Figure 2 for a specific case. If the profit maximizing price decrease (due either to the *MC* curve being downward sloping or the demand curve become more elastic), the demand curve d' and the MC curve (which are drawn given the price level being equal to p) will both shift. The MC curve will shift vertically downward and the demand curve will both shift vertically downward (with the lower price level) and proportionately rightward (with a higher real aggregate demand, as the price level falls relative to the nominal aggregate demand). The combined shifts are such as to lead to further output expansions and price falls. Thus, if the responses of costs and demand elasticities are to lead to a fall in the price level, we have a cumulative expansion as aggregate demand increases, a case even more radical than a continuum of equilibria. We may refer to both cases as non-traditional.

For non-perfectly competitive firms, non-upward sloping MC curves are quite prevalent. Also, for an economy with union power, it is also quite likely that the MC curves of firms may not shift up as aggregate output and employment expand over certain ranges. Suppose that a representative union chooses wage-rate to maximise the expected utility of an average worker which depends on the real wage-rate and the probability of employment. It can then be shown that, before full employment, unions maximise by leaving their wage demand unchanged as aggregate demand changes, shifting the demand-for-labour curve horizontally in or out. This is illustrated in Figure 3 where I and II are the indifference curves of the union. An increase in aggregate demand shifts the demand-for-labour curve from d_L to d_L', with an increase in employment but with the optimal wage-rate W^* unchanged. This would also be the result if the unions have the Dunlop (1944) objective function of maximizing the wage bill (wage-rate times employment), making their indifference curves rectangular hyperbola in Figure 3. Then, each indifference curve has (absolute) unit elasticity throughout the whole curve. At the point a where the demand-for-labour curve d_L is tangent to the indifference curve I, the elasticity of the curve d_L must also be unitary. Then, as it shift rightward proportionately (hence isoelastically at given W) as aggregate demand increases, the new demand-for-labour curve d_L' must also be of unitary elasticity at the point *b* on the same horizontal level as *a*. Hence. this new demand-for-labour curve d_L' must also be tangent to the higher indifference curve *II* (which is also of unit elasticity throughout the whole range) at this point *b*.

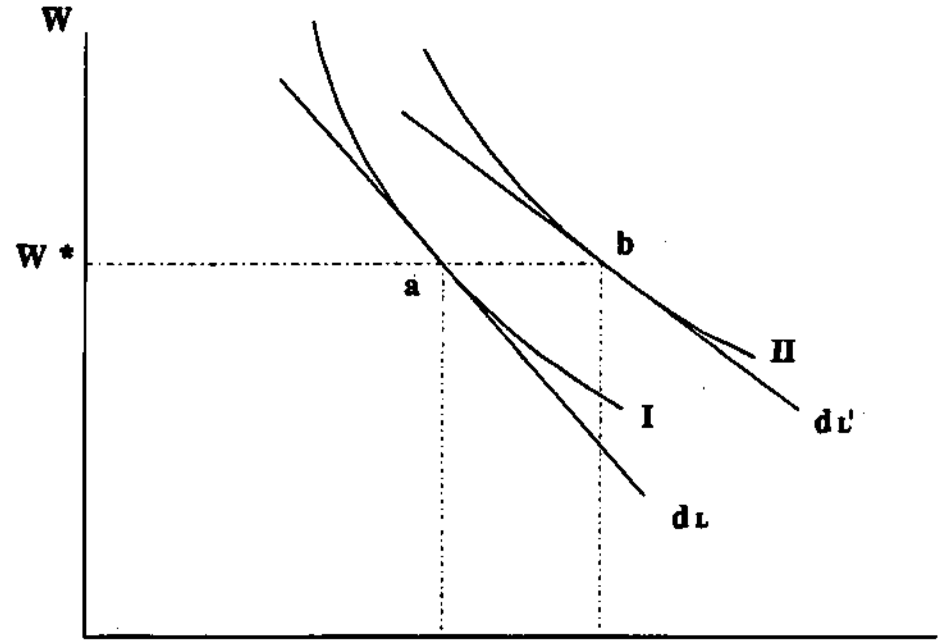

Figure 3

It is true that, for the case where a change in nominal aggregate demand may increase real output without affecting the price level (with Figure 2 illustrating a specific subcase of this case), we really have multiple or even a continuum of equilibria over the relevant range. However, this continuum of equilibria may precisely be the result of non-perfect competition in the following sense. With perfect competition, we must have a unique equilibrium under certain traditional assumptions such as no money illusion, no time lags, and the absence of indeterminacy at the firm level. Under the same traditional set of assumptions, the introduction of non-perfect competition alone (in the sense of not introducing menu costs or other transaction costs or distortions) may make a continuum of equilibria to prevail. It is true that this possibility depends on certain appropriate conditions regarding how costs respond to output (both the output at the firm level, referring to whether *MC* is upward or downward sloping; and the aggregate output at the economy level, referring to how *MC* shift, e.g. through changes in wage-rates, as aggregate output and employment change). However, the introduction of non-perfect competition also makes such conditions more likely to be fulfilled as horizontal or even downward-sloping *MC* curves and an increase in absolute demand elasticity becomes possible.

The demonstration of the possible continuum of equilibria and non-neutrality of money in a non-perfectly competitive economy is within a model with a given number of firms. It may thus be thought that if the long-run variation in the number of firms is taken into account, the possibility will no longer exist. However, allowing for free entry and exit of firms, I have shown (Ng 1986, Ch.4) that the possibility of a continuum of equilibria and non-neutrality of money still exists without considering any friction. Certain (more complicated than above) appropriate conditions regarding costs and demand elasticity are sufficient. In fact, since the entry of new firms as aggregate demand increases makes the absolute demand elasticity higher by increasing the degree of competition, the appropriate conditions for a continuum of equilibria are easier to satisfy in this respect. This is illustrated in Figure 4. The representative firm is initially at equilibrium at *A* where $MR=MC$ and $p=AC$. An increase in aggregate demand shift the demand curve to the right and makes it more elastic (competition effect), making it possible for the firm to reach a higher equilibrium point at *B* with no change in price, even if the cost curves shift upward as the aggregate output of the economy expands.

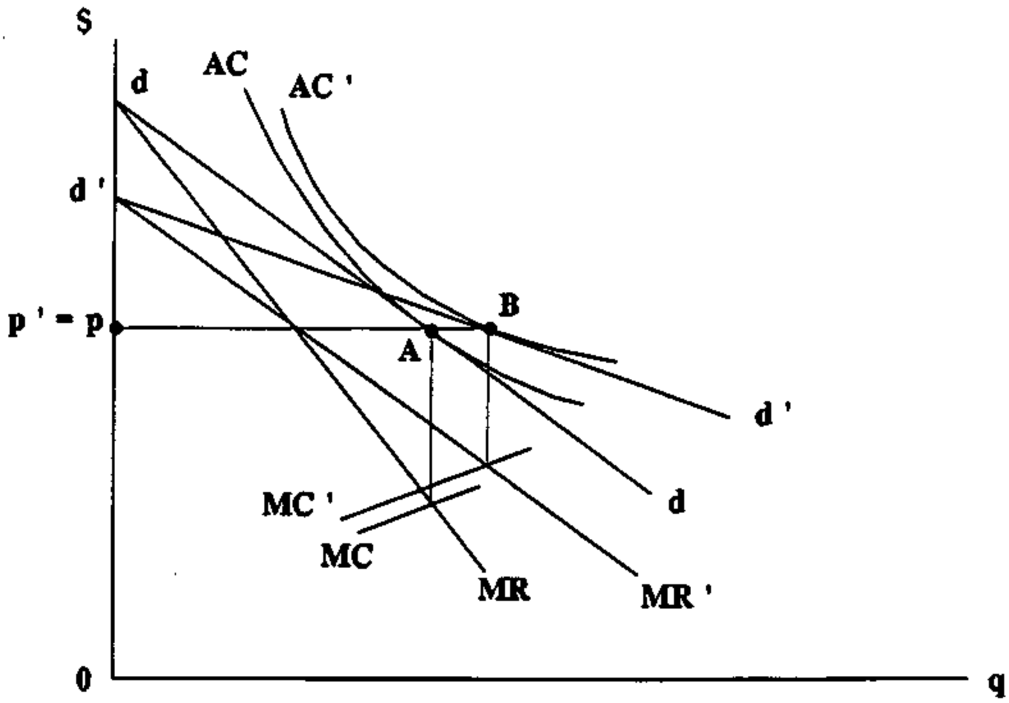

Figure 4

3 A Continuum of Equilibria and the Interfirm Macroeconomic Externality

For the case where a continuum of equilibria exists as illustrated in Figure 2 and Figure 4 above, a change in (even just nominal) aggregate demand may trigger a shift from one real equilibrium point to another. However, such a change in real output is not necessarily the case whenever aggregate demand changes. If firms expect that an increase in nominal aggregate demand (such as effected by an increase in money supply) will lead to a proportionate increase in the price level, then an increase in nominal aggregate demand will in fact increase only the price level without affecting real output, as illustrated in Figure 5. As both nominal aggregate demand and the price level are expected to increase by the same percentage (33 1/3% in Figure 5), each firm's demand curve shifts vertically upward by the same percentage from *d* to *d'* since quantity demanded is homogeneous of degree zero in all prices and nominal demand. Correspondingly, the *MR* curve also shifts vertically upward proportionately to *MR'*, intersecting the new *MC'* (if costs respond fully, i.e. proportionately, to the increase in the price level) at an unchanged output level.

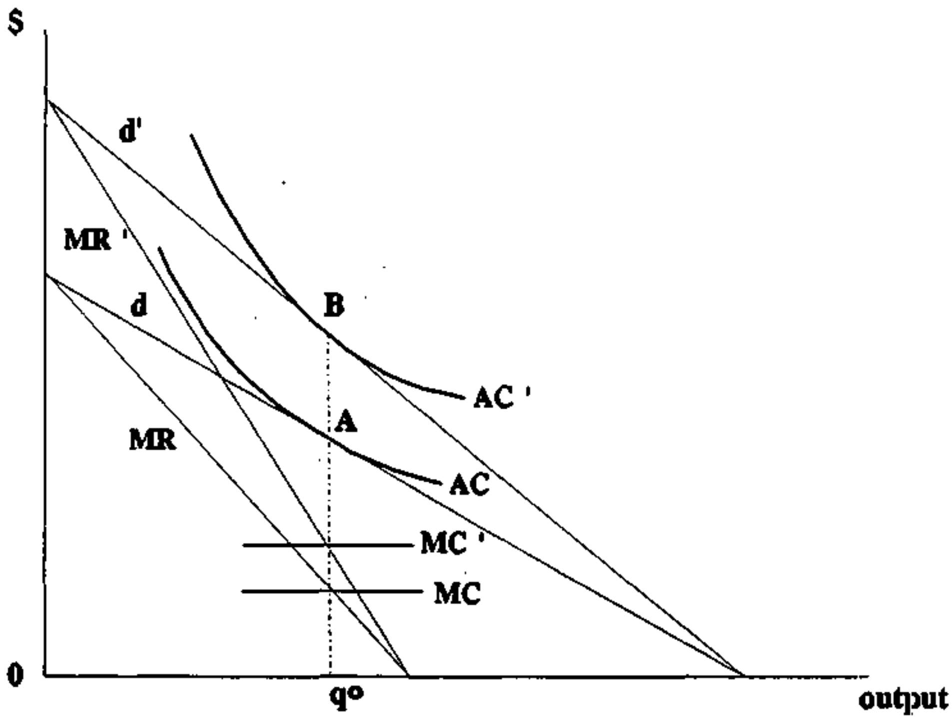

Figure 5

Thus, even for situations where there is a continuum of equilibria, the original equilibrium point may remain unchanged as nominal aggregate demand changes. In such situations, a change in nominal aggregate demand will change the price level by the same proportion and leave the real output unchanged if firms expect proportionate price adjustment. It will change the real output in the same proportion and leave the price level unchanged if firms expect no change in prices. It then becomes rational to expect whatever that is expected to be expected! (See Ng 1982.)

Money may still be neutral under non-perfect competition though it may no longer be necessarily neutral even assuming no time lags, money illusion and other frictions. Ignoring the possibility of the existence of multiple equilibria and focussing on the fact that a real equilibrium can remain so after a nominal change, most analysts of imperfect competition (e.g. Benassy 1987, Blanchard and Kiyotaki 1987, Dixon 1987, 1990, Hart 1982) appear to conclude that money remains neutral in an imperfectly competitive economy. In the words of Hart (1982, p. 134), "there is no reason to think that a change in the nominal supply of money will lead to a change" in real variables. In fact, the relevant analysis only shows that, for any given real equilibrium E^1 with a given money supply M^1, E^1 is still a possible equilibrium at another money supply M^2. But money may no longer be neutral as the change in M may trigger a movement from E^1 to another real equilibrium E^2. Our analysis is more general in allowing for the neutrality result of Figure 5 and the non-neutrality result of Figures 2 and 4.

As nominal aggregate demand falls, if firms reduce prices, they may maintain real output and real profits unchanged as illustrated in Figure 5 (but reversing d with d', MR with MR'). On the other hand, if they keep their prices unchanged, their real output and real profit levels will fall as illustrated in Figure 2 (also reversing d with d', MR with MR'). Moreover, in a situation where all or most firms are reducing output levels instead of prices, the attempt by an isolated firm to maintain output and reduce price will not work. Thus, a kind of coordination problem may be present due to the existence of interfirm macroeconomic externality. Under a situation where a coordinated increase (relative to the low level output in Figure 2) in output is possible, an increase in output (through price reduction) by a representative firm has a positive external effect on the real profit level of another representative firm. A coordinated increase in output helps to reduce loss (or increase profit) by an amount *CDpB* in Figure 2. As shown in Appendix B, the effect of an increase in the output of a representative firm *j* on the profit-maximizing real profit of another representative firm *i* is

$$\frac{\partial R_i^*}{\partial q_j} = \frac{1}{N}\left\{\frac{1}{\eta}\left(\frac{1-\eta^{\alpha P}}{\eta}+1-\eta^{CP}-\eta^{\alpha Y}\right)-\eta^{CY}\right\} \tag{1}$$

where q = output level of a representative firm, p = the price charged by a representative firm, R^* = profit-maximizing nominal profit level divided by the price level, N = number of firms in the economy, $\eta \equiv (\partial q/\partial p)p/q$ = price elasticity of demand for the product of a representative firm, $\eta^{xy} \equiv (\partial x/\partial y)y/x$, α = nominal aggregate demand, P = general price level, C = total cost of production of a representative firm, Y = aggregate output (= income at equilibrium) of the economy.

Since η is necessarily negative, $\eta^{\alpha Y} \geq 0$ (non-negative effects of income on expenditure), $\eta^{\alpha P} < 1$ (otherwise the system is explosive; a requirement comparable to that of $C + I$ crossing the 45° line at the "right" direction in the simple Keynesian income-expenditure model), for $\partial R_i^*/\partial q_j$ to be positive, it is sufficient (but not necessary) that η^{CP} = 1 and $\eta^{CY} \leq 0$. If cost curves do not shift up/down as aggregate output increases/decreases as the case discussed with reference to Figure 2, and respond fully to the price level (no money illusion, no lags), the conditions are satisfied.

Though $\partial R_i^*/\partial q_j$ is then positive, its absolute value is negligible since N is very large. But $\partial R_i^*/\partial q_j$ is the effect of an increase in output of ***one*** representative firm on the profit of ***one*** other representative firm. Even for just the effect of one firm on all other firms, we have to multiply (1) by N. When all firms expand together, we have to multiply by ***another*** N.

Thus, for the economy as a whole, the interfirm externality is certainly not negligible unless the big bracketed term in (1) is extremely small, since it has to be small even after multiplied by N^2 and N is a large number.

In a perfectly competitive economy, the first term in this big bracketed term is in fact zero since $\eta = -\infty$ under perfect competition. Thus, under perfect competition, the R.H.S. of (1) simplifies into $-\eta^{CY}/N$. The value of η^{CY} may differ from zero for two reasons. First, there may exist technological external economies or diseconomies which are recognized in the traditional analysis to affect efficiency. Secondly, a change in aggregate output may affect costs of firms through its effect on factor prices. This is a pecuniary externality which does not affect efficiency since it just represents a transfer (with gains offsetting losses) and is adequately taken account of by the working of a price mechanism, at least as far as efficiency is concerned. If we abstract from technological externalities, no market failure arises with perfect competition.[2]

With non-perfect competition, $\eta > -\infty$. Even abstracting from both technological and pecuniary externalities, making $\eta^{CY} = 0$, and assuming no money illusion, no lags, etc., making $\eta^{CP} = 1$, we still have $\partial R_i^* / \partial q_j > 0$ from (1) as $1 - \eta^{\alpha P} > 0$ and $\eta^{\alpha Y} > 0$. The term $(1 - \eta^{\alpha P})$ accounts for the increase in real aggregate demand when the nominal aggregate demand α increases relative to the average price P; the term $\eta^{\alpha Y}$ (income multiplier effect) accounts for the further increase in aggregate demand as real output (= real income) increases. Since both of these work through the increase in aggregate demand in shifting the demand curve of the representative firm with no effect on its production function, it is certainly not a technological externality and is more akin to the traditional pecuniary externality. But unlike the latter, it is not just a pure transfer. The increase in real profits is not gained at the expense of any other economic actor. Thus the failure to realize the possible gain associated with the interfirm macroeconomic externality imposes a real loss on the economy. In fact, had we not abstracted away the likely gain to the newly employed workers, the expansion would involve this additional gain as well.

That the interfirm macroeconomic externality works through $\eta^{\alpha Y}$ is obvious and is analogous to the Keynesian income multiplier effect. That it also works through $1 - \eta^{\alpha P}$ may need some explanation. As a firm wants to increase its output (or to keep its output from falling in the face of decreasing aggregate demand), it lowers its price (except in perfect competition, hence the appearance of η in Equation 1). A reduction in P reduces nominal aggregate demand α but by less than proportionately (i.e. $\eta^{\alpha P} < 1$). Hence, real aggregate demand increases, benefiting other firms.

4 Some Reinforcing Real World Factors

In this concluding section, a few real-world factors that increase the probability that a continuum of equilibria and the associated non-neutrality of money may exist are briefly outlined.

Revenue Maximization and AC-Pricing

Due to the separation of ownership from management, some modern firms behave closer to the maximization of revenue subject to a minimum profit constraint than to profit maximization (Baumol 1958). It can be seen that such behaviour increases the likelihood of our non-traditional result. First, following Baumol, we note that the profit constraint will always be effective as excess profit could be used for sales promotion to increase revenue. If we then include the minimum profit into the definition of average costs, a profit-constrained revenue-maximizer produce and price at the point where its AC curve cuts its demand curve from below, such as at the point E in Figure 6. An increase in nominal aggregate demand may then cause a real expansion even if cost curves shift up as aggregate output expands, making the non-traditional result more likely to prevail. This is so because it is more likely for an AC curve to be downward sloping than for an MC curve to be downward sloping over the relevant range. This is especially so in the short run where there is an important fixed costs component. In fact, the AC curve is made even more likely to be downward sloping because the minimum constrained profit has been included into the definition of average costs.

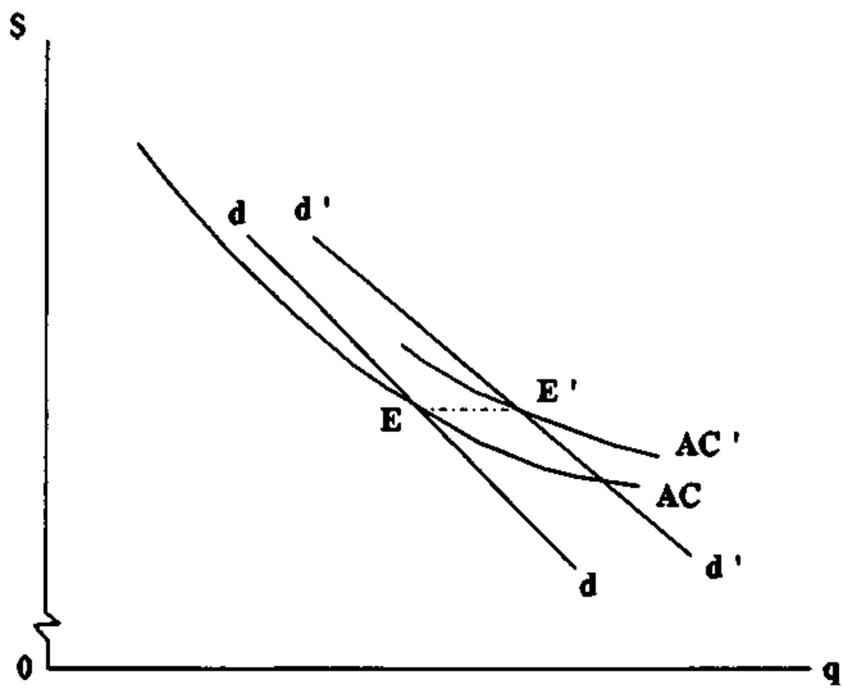

Figure 6

There are enterprises in the economy other than revenue-maximizing firms which effectively adopt AC-pricing. These include government or quasi-government enterprises that are constrained to make no losses or subject to some positive or negative profit constraints. Again, by defining the fixed profit constraint into the average costs, such enterprises effectively adopts AC-pricing. Then our conclusions in the previous paragraph also applies to these AC-pricing enterprises.

Time Lags, Menu Costs, and Other Frictions

With non-perfect competition, we have seen that the economy may have a continuum of equilibria. In such a situation, a change in money supply or any other factor that cause a change in aggregate demand may trigger a movement from one equilibrium to another, making money possibly non-neutral. This result has been obtained without introducing any time lags, menu costs, etc. If we allow for such frictions, then even if the other factors (i.e. the responses of costs and demand elasticity as discussed above) are such that the economy does not have a continuum of equilibria, money may yet be non-neutral. (This is discussed in Ng 1994).

The Role of Tax Reductions

For cases where the economy does not have a continuum of equilibria, a change in nominal aggregate demand will just change the price level without affecting the real output if we ignore factors such as time lags and frictions. However, if the economy possess characteristics close to having a continuum of equilibria, a change in government tax rates may again make money non-neutral. For example, if tax rates are decreased to offset the higher costs as aggregate output expands with an increase in nominal aggregate demand, equilibria at higher output levels with no increase in prices may yet be feasible. Moreover, the tax reduction may be self-financing in the sense that revenue lost through a lower tax rate is offset by the revenue gain through a higher output. This is illustrated in Figure 7 for the case of a reduction in indirect taxes. Respectively d_{0r} and d_0 are the initial pre-indirect tax and post-indirect tax demand curves of the representative firm, and MR_0 and MC_0 the (post-tax) marginal revenue and cost curves. The initial equilibrium is accordingly at p_0, q_0 (point A). Suppose that aggregate demand is now increased (by 50%, for the sake of exaggerated geometrical illustration) but that the firm expects this to bring no increase in the price level. The demand curves move horizontally to d_{1r} and d_1, and the marginal revenue curve to MR_1. (We are taking the case where the demand elasticity remains unchanged at any given price instead of the more favourable case where the absolute demand elasticity increases.)

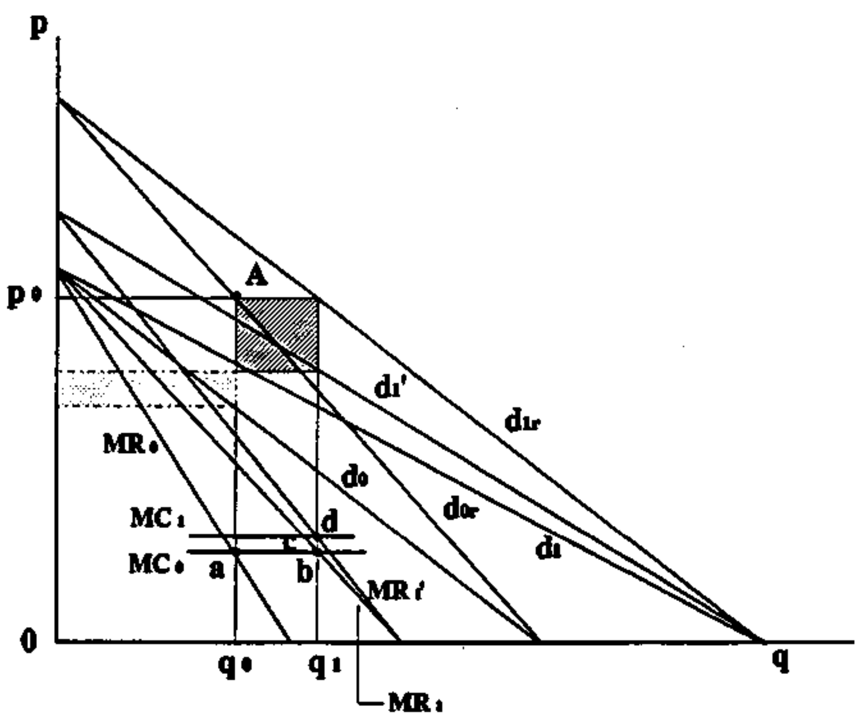

Figure 7

If the MC curve is horizontal (as shown in MC_0) and does not shift as output adjusts, then the new equilibrium point b involves an increase in output to q_1 with no change in P, thus confirming the firm's expectations. The result will be the same if the MC curve has a non-zero slope, the effect of which is balanced by a compensating shift of the curve as output changes. In both cases, the prevailing conditions in the labour and goods markets facilitate a response to the demand shift which validates entrepreneurial expectations.

But for our present purpose, let us assume that MC either is positively sloped, with no compensating downward shift, or alternatively is horizontal but (as illustrated) shifts upwards to MC_1 due to an increase in the wage rate as employment increases. The apparent new equilibrium at *c* then implies a higher price. Because this outcome invalidates the original expectation of a zero price change, it cannot be sustained. The demand curve will shift to a steeper locus, leading to a further price increase. The process will continue until finally an expectation-consistent equilibrium is achieved; this can occur only where P is 50% above its initial level, with no change in output.

However, if we introduce a reduction in direct taxes to shift the MC curve back to MC_0 (by reducing the pre-tax wage rate), or in indirect taxes to shift the demand curve from d_1 to d_1' , the new equilibrium point (*b* or *d*) will entail an increase in output from q_0 to q_1 with no change in price. If that increase in output is sufficiently large to offset the effect of the reduced tax rate, then tax revenue need not fall. In the case of indirect taxation, this will be so if the shaded area is no smaller than the dotted area.

Appendix A

In this appendix, we provide the mathematical analysis of results illustrated graphically in the text.

For the general case of either perfect or non-perfect competition, we may regard the product of each firm as a distinct good, then, from the maximization of a general utility function

$$\text{(A1)} \qquad U = U\left(x_1^1 x^2, \ldots, x^N\right)$$

where U = utility, x^i = amount of the ith good consumed, subject to a budget constraint

$$\text{(A2)} \qquad \sum p^i x^i = \alpha$$

where p^i = price of the ith good, α = budget constraint = nominal aggregate demand, as we are dealing with the whole economy, we have the demand function

$$\text{(A3)} \qquad q^i = f^i\left(p^1, p^2, \ldots, p^N, \alpha\right), \quad i = 1, \ldots, N$$

Now, to avoid a fully general equilibrium analysis, I adopted a crucial simplification to arrive at the mesoeconomic analysis. This is to concentrate on the representative firm and replace the price vector of all other firms by the average price. Without loss of generality, call this representative firm "Firm 1". From (A3), we then have

$$\text{(A4)} \qquad q^1 = f^1\left(p^1, P, \alpha\right)$$

where $p^2, \ldots, p^N$ has been replaced by P, the average price of $p^2, \ldots, p^N$. Due both to the fact that Firm 1 is representative, and the fact that it is assumed small relative to the whole economy, this average price P is also the general price level of the economy. In Ng (1986, Appendix 3I), a fully general equilibrium analysis is used to show that (1) for any (exogenous) change (in cost or demand) there exists (in a hypothetical sense) a representative firm whose response to the change ***accurately*** (no approximation needed) represents the response of the whole economy in aggregate output and average price, and (2) a representative firm defined by a simple method (that of a weighted average) can be used as a good approximation of the response of the whole economy to any economy-wide change in demand and/or costs that does not result in drastic inter-firm changes.

Since demand functions are homogeneous of degree zero in all prices and the budget, we may divide all elements in the functional form in (A4) by P to obtain, dropping superscript,

$$q = f(p/P,\ \alpha/P) \tag{A5}$$

where the effect of P/P, being a constant, is defined into the functional form of f.

The representative firm is assumed to take the aggregate variables as given and maximize its profit with respect to its own output or price. Its profit function is

$$pf(p/P,\ \alpha/P) - C(q, Y, P, \epsilon^c) \tag{A6}$$

where C = total cost, Y = aggregate output of the economy, ε^c exogenous factors affect costs. The possible effects of Y on C may work through the input market. It may be noted that the cost function is rather general. The first-order condition for the maximization of (A6) gives

(A7)
$$\mu \equiv p\left\{1+\frac{1}{\eta\left(\frac{p}{P},\frac{\alpha}{P}\right)}\right\} = c(q, Y, P, \epsilon^c)$$

where $\eta \equiv (\partial q/\partial P)p/q$, $c \equiv \partial C/\partial q$ are respectively the price elasticity of demand and marginal cost and μ is marginal revenue.

From the representativeness of the firm and the requirement of equilibrium, we have

(A8)
$$P = p$$

(A9)
$$\alpha / P \equiv A = Y = qN$$

where A = real aggregate demand, N = number of firms. (The latter is taken as given in the short-run exercise. Otherwise, an additional equation of free entry/exit may be added; see Ng 1986, Ch. 4. The possible feedback of changes in profit is allowed through the effect of real income on aggregate demand in Eq. 10 below, abstracting from distributional effects.)

The nominal aggregate demand of the economy is taken to be a function of P, Y (real income which equals real output at equilibrium) and some exogenous factors ε^α which should include the money supply.

(A10)
$$\alpha = \alpha(P, Y, \epsilon^\alpha);\ 1 > \eta^{\alpha P} > 0,\ 1 > \eta^{\alpha Y} > 0$$

where the restriction $1 > \eta^{\alpha Y} > 0$ is similar to the case of the Keynesian cross diagram that the slope of $C + I$ is positive but less than one to avoid an explosive system. Similarly for $\eta^{\alpha P}$. (A10) is a very general function and include the simple Keynesian and Monetarist aggregate demand functions as special cases. This completes the specification of our very simple, general, but powerful model. We turn now to the comparative-statics analysis. The total differentiation of (A7), after substituting in the total differentiation of (A8) and (A9), division through by μ or c, gives

(A11)
$$(1-\eta^{cP})\frac{dP}{P} - (\eta^{cq} + \eta^{cY} - D)\frac{dY}{Y} = \frac{d\bar{c}}{c}$$

where $\eta^{xy} \equiv \frac{\partial x}{\partial y}\frac{y}{x}$, $D \equiv \frac{\partial \mu}{\partial A}\frac{A}{\mu}|p,P| = -\frac{p}{\eta}\frac{\partial \eta}{\partial A}\frac{A}{\eta}$ is the proportionate effect of real aggregate demand on marginal revenue at given prices through possible effects on the demand elasticity (in Ng 1982, D is assumed zero for simplicity), $d\bar{c} \equiv \left(\frac{\partial c}{\partial \epsilon^c}\right)d\epsilon^c$ is the exogenous change in marginal cost.

The total differentiation of (A10), after dividing through by α and substituting in $d\alpha/\alpha = dP/P + dY/Y$ from the total differentiation of (A9), gives

(A12)
$$(1-\eta^{\alpha P})dP/P + (1-\eta^{\alpha Y})\frac{dY}{Y} = \frac{d\bar{\alpha}}{\alpha}$$

where $d\bar{\alpha} \equiv \left(\frac{\partial \alpha}{\partial \epsilon^{\alpha}}\right) d\epsilon^{\alpha}$ is the exogenous change in nominal aggregate demand.

Substituting dY/Y and dP/P from (A12) ***in turn*** into (A11), we obtain

(A13) $$\Delta \frac{dP}{P} = (\eta^{cq} + \eta^{cY} - D)\frac{d\bar{\alpha}}{\alpha} + (1 - \eta^{\alpha Y})\frac{d\bar{c}}{c}$$

(A14) $$\Delta \frac{dY}{Y} = (1 - \eta^{cP})\frac{d\bar{\alpha}}{\alpha} - (1 - \eta^{\alpha P})\frac{d\bar{c}}{c}$$

where $\Delta \equiv (1 - \eta^{\alpha Y})(1 - \eta^{cP}) + (1 - \eta^{\alpha P})(\eta^{cq} + \eta^{cY} - D)$. These two equations are the basic comparative-statics results which can be used to analyse the general equilibrium effects of economy-wide changes in demand and costs on the price level and aggregate output of the economy. For example, to analyse the effects of a change in nominal aggregate demand (including a change in money supply), we put $d\bar{c} = 0$ (i.e. no exogenous cost shifts; this is not a partial-equilibrium analysis since endogenous cost changes are allowed through η^{cP} , η^{cY} , and η^{cq} and endogenous demand changes are allowed through $\eta^{\alpha Y}$, $\eta^{\alpha P}$, and endogenous changes in demand elasticity through D), and obtain from (A13) and (A14) respectively, (A15) $$\Delta \frac{dP}{d\bar{\alpha}} \frac{\alpha}{P} = \eta^{cq} + \eta^{cY} - D$$

(A16) $$\Delta \frac{dY}{d\bar{\alpha}} \frac{\alpha}{Y} = 1 - \eta^{cP}$$

It is reasonable to take $\eta^{cY} \geq 0$ (i.e. an increase in aggregate output does not decrease costs). For the case of perfect competition, $\eta^{cq} > 0$, $D = 0$ (as demand elasticity always equals minus infinity). Then, if nominal costs respond fully to prices such that $\eta^{cP} = 1$, we always have $\frac{dY}{d\bar{\alpha}} = 0$ and $\frac{dP}{d\bar{\alpha}} \frac{\alpha}{P} = \frac{1}{(1 - \eta^{\alpha P})} > 1$. This greater than proportionate effect of $\bar{\alpha}$ on P may appear surprising but is explained by the further endogenous increase in α as P increases with $\bar{\alpha}$. This is the price-multiplier effect, similar to the income-multiplier effect. An increase in ε^{α} (say money supply) increases α by x% (this is the initial exogenous increase) at existing income and price levels. In the case of perfect competition, this leads to an x% increase in prices with no effect on output. As $\eta^{\alpha P} > 0$, this increases aggregate demand further even if ε^{α} does not change further. If $\eta^{\alpha P} = 1/3$, the final equilibrium will involve an increase in prices by $1.5x$%, the price-multiplier being $\frac{1}{(1 - \eta^{\alpha P})}$.

With non-perfect competition, it is still possible that $\eta^{cP} = 1$, $\eta^{cq} + \eta^{cY} - D \leq 0$. Then, we still have a unique equilibrium and the neutrality of money $\frac{dY}{d\bar{\alpha}} = 0$. However, it is then possible for $\eta^{cq} + \eta^{cY} - D \leq 0$, leading to the case of a continuum of equilibria and that of a cumulative effect of nominal demand on real output.

Appendix B

To examine the interfirm macroeconomic externality, we take the simplification that demand elasticity of the representative firm remains unchanged as real aggregate demand changes. This allows us to derive (Ng 1982) from the general demand function

(B1) $$q = F(p, P, \alpha)$$

the case of

(B2) $$q = \frac{\alpha}{P} h\left(\frac{p}{P}\right)$$

From (B2), the profit of the firm may be written as

(B3) $$\frac{p\alpha}{P} h\left(\frac{p}{P}\right) - C(q, P, Y)$$

where C is the total cost function and Y is the aggregate output. The maximization of (B3) with respect to only p (or q), taking aggregate variables Y, P, α as given, gives the first-order condition (the second-order condition is taken as satisfied),

(B4) $$p + P\frac{h(p/P)}{h'(p/P)} = c(q, P, Y)$$

where $c \equiv \partial C / \partial q$ is the marginal cost. The ***real*** profit R of a representative firm i, denoted

R_i, is obtained by dividing its nominal profit by the average price P.

(B5) $$R_i = \left\{ p_i q_i - C_i\left(q_i, P, Y\right) \right\} / P$$

where q_i is as given in (B2).

We now wish to examine the effect on the profit-maximizing real profit R_i^* of a representative firm i of an increase in the output and a resulting reduction in the price of ***another*** representative firm j. For profit-maximization, the first-order condition (B4) must apply before and after the change. Thus, we may totally differentiate (B4), yielding after rearrangement and dividing through by (B4),

(B6) $$\left[\frac{p}{c} \left\{ 2 - \frac{hh''}{(h')^2} \right\} - \eta \eta^{cq} \right] \frac{dp}{p} = \eta^{cq} \frac{d\alpha}{\alpha} + \eta^{cY} \frac{dY}{Y} - \left\{ 1 - \eta^{cP} + \eta \eta^{cq} + \frac{p}{c} \frac{hh''}{(h')^2} \right\} \frac{dP}{P}$$

where $\eta^{xy} \equiv (\partial x/\partial y)y/x$ and $\eta \equiv (\partial q/\partial p)p/q$.

From (B6), we have,

(B7) $$\frac{q_j}{p} \frac{\partial p}{\partial q_j} = \frac{\eta^{cq} \dfrac{q_j}{\alpha} \dfrac{\partial \alpha}{\partial q_j} + \eta^{cY} \dfrac{q_j}{Y} \dfrac{\partial Y}{\partial q_j} - \left\{ 1 - \eta^{cP} + \eta \eta^{cq} + \dfrac{p}{c} \dfrac{hh''}{(h')^2} \right\} \dfrac{q_j}{P} \dfrac{\partial P}{\partial q_j}}{\dfrac{p}{c} \left\{ 2 - \dfrac{hh''}{(h')^2} \right\} - \eta \eta^{cq}}$$

where the subscript i associated with p, c, q, etc. has been dropped.

After substituting (B2) into (B5), differentiate (B5) with respect to q_j, obtaining, dropping the subscript i,

$$\text{(B8)} \qquad \frac{\partial R}{\partial q_j} = \frac{p-c}{P}\left(\frac{h}{P}\frac{\partial \alpha}{\partial q_j} - \frac{\alpha h}{P^2}\frac{\partial P}{\partial q_j} + \frac{\alpha h'}{P^2}\frac{\partial p}{\partial q_j} - \frac{p\alpha h'}{P^3}\frac{\partial P}{\partial q_j}\right) + \frac{q}{P}\frac{\partial p}{\partial q_j} - \frac{1}{P}\frac{\partial C}{\partial P}\frac{\partial P}{\partial q_j} - \frac{1}{P}\frac{\partial C}{\partial Y}\frac{\partial Y}{\partial q_j} - \frac{pq-C}{P^2}\frac{\partial P}{\partial q_j}$$

where all the subscript i in the R.H.S. associated with p, c, h, h', q and c have been dropped.

From (B2), $h = qP/\alpha$, $h' = (\partial q/\partial p)P^2/\alpha$, $h'' = (\partial^2 q/\partial p^2)P^3/\alpha$, and (B4) may be written as $p(1+1/\eta) = c$. Since Y is the aggregate output, $\partial Y/\partial q_j = 1$ and since P is the average price for all the N firms, $\partial P/\partial q_j = (\partial p_j/\partial q_j)/N$, as firm j is a representative firm. Also, since both firm i and firm j are representative, p_i (or p) $= p_j = P$, and q_i (or q) $= q_j = Y/N$. Substitute all these relations and $\partial p/\partial q_j$ from (B7) into (B8), we have, after simplification and rearrangement,

$$\text{(B9)} \qquad \frac{\partial R}{\partial q_j} = \frac{1}{N}\left[\frac{1}{\eta}\left\{\frac{\left(1-\eta^{\alpha P}\right)}{\eta} + \frac{C}{pq}\left(1-\eta^{CP}\right) - \eta^{\alpha Y}\right\} - \frac{C}{pq}\eta^{CY}\right]$$

If we start from a position of long-run equilibrium with zero profit, $pq = C$, and (B9) simplifies into (1) in the text. The use of (B9) instead of (1) does not affect the argument in the text.

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Notes

1. However, this paper is more concerned with the conditions for multiple equilibria than with the selection of a particle equilibrium from the multiple equilibria. On this latter issue of equilibrium selection, see Cooper (1994).

2. Our result thus differs from an apparently similar one of Shleifer and Vishny (1988). See also Bohn and Gorton (1993) on the role of nominal contracts and monetary policies to overcome the relevant coordination failure. Cooper and John (1988) provide a survey of related literature and a general framework in terms of Nash equilibria and strategic complementarity.

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