THE P-MC RELATIONSHIP: CAN IT BE NON-MONOTONE?

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1. Introduction

In the traditional analysis of firm theory in microeconomics, price and marginal cost (MC) generally move in the same direction, that is, a lower marginal cost of production is associated with a lower product price. The important implication of this result is that when firms come up with a better method of production, consumers in general always benefit from the lower product price. This is the case, for example, both under competitive and monopoly markets as well as under symmethc oligopoly models.

Such a result presupposes that all firms have an equal access to the superior production technologies or lower marginal costs. In practice, however, asymmetry may be created when a firm (or a subset of firms) in the industry acquires superior methods of production either through imports or technological collaboration with the foreign multinationals or through own research and development efforts. These innovations are protected by patent laws, which prevent other firms from imitating these technologies. Even when patent protection is imperfect, imitation might not take place immediately. As a result asymmetry prevails at least for some time.

Then the question is: Can we necessarily get a similar monotone (direct) relation between price and MC when it is the case that only a subset of firms has access to low MC technologies? The present paper focuses our attention to the fact that under some circumstance there can be discontinuity in the price-MC relationship, and an application of lower MCs might lead to a sudden jump in the price. As a consequence, a lower MC might result in a higher price. The policy implication of this result is that any innovation that reduces marginal costs of production might not be doing any good for the users of such products. Hence policy makers might have to be more careful and selective in respect of its policies regarding technology transfer, technology imports, business alliance, R&D, and intellectual property rights, etcetera.

An application of low marginal cost has an efficiency effect in production, which tends to increase outputs and reduce prices. At the same time a low MC has an anti-competitive monopolizing effect. In the extreme, the market structure can be changed from symmetric oligopoly to monopoly of a firm. When the concentration effect dominates the efficiency effect, price tends to go up.[1] A theoretical model underlying this idea has been worked out in Kabiraj and Marjit (1992).

In the standard microeconomic models, of course, we can get situations when price remains unchanged for an interval of MC. For example, in Sweezy (1939) model when firms compete with differentiated goods, there is a kink on the demand curve at the prevailing price implying that a firm cannot increase its market share substantially by reducing its price, whereas it loses its market very rapidly if it increases price. Such a demand function corresponds to a (vertically) discontinuous MR (marginal revenue) curve. As long as the MC curve passes through the discontinuous stretch of the MR curve, price remains unchanged at the current level. Similar results can be reworked in a price leadership structure with a competitive fringe, where a firm acts as a price setter and all other firms take this price as given and adjust their quantities. Hence the MC curves will represent the supply curves of the fringe firms. Then the leader firm will face a residual demand curve kinked at a price at which the fringe ceases to operate. However, these models do not explain the possibility of a non-monotone relation between price and MC. We introduce a fixed cost of production in the oligopoly models. Then there are situations when a firm comes up with a superior technology, and the market structure is altered to monopoly of the low cost firm. In particular, monopoly

occurs not just because of a lower MC but because of the existence of fixed costs of production. When a market structure undergoes to such a change, the price-MC relationship becomes non-monotone.

The paper is organized as follows. The second section provides as a benchmark case the traditional monotone relation under monopoly, symmetric Cournot duopoly and Stackelberg structure. Then in the third section we discuss the possibility of the non-monotone relation when only one firm has access to a low MC technology. As an implication it follows that there are situations where an application of lower MC in fact increases commodity price resulting in a loss of consumer welfare.

2. Standard Monotone relation

In this section we consider the standard monotone relation between price and MC under the assumption that all firms have equal access to present and future technologies. Consider two symmetric firms, 1 and 2, with any MC = c, positive and constant. Under Cournot conjectures we can draw their reaction functions, R_1 and R_2, which are downward sloping and have absolute slopes less than one, that is, $\left|\frac{\delta q_i}{\delta q_j}\right| < 1$, $i \neq j$. This condition comes from the stability requirement and is very important for the subsequent analysis.[2] Figure 1 portrays equilibrium under each of monopoly, Cournot duopoly and Stackelberg structures.

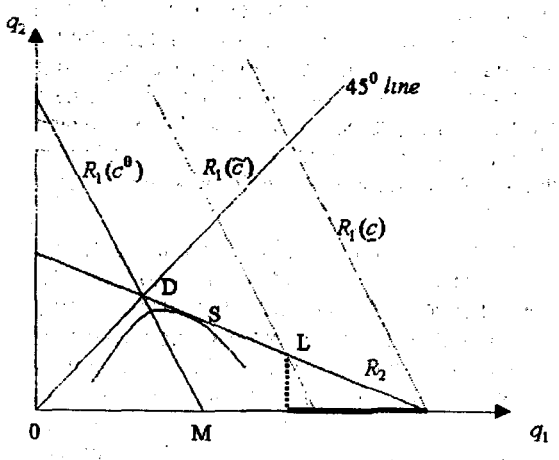

Figure 1: Equilibrium under different market structures

If the market is monopoly of firm 1, the equilibrium is attained at a point M at which R_1 intersects the corresponding quantity axis. In this structure Cournot equilibrium is shown at a point D at which R_1 and R_2 intersect each other. Because of symmetry of firms such a point must be on the 45^0 line through the origin. The Stackelberg equilibrium is a point S on R_2 line at which firm 1's one iso-profit curve is tangential with R_2. Given the restriction on the slopes of the reaction functions, it is easy to see that the industry output under Stackelberg equilibrium is larger than that under Cournot-Nash equilibrium, which is again larger than the monopoly output, that is, $Q^s(c) > Q^d(c) > Q^m(c)$. Then the following result is obvious.

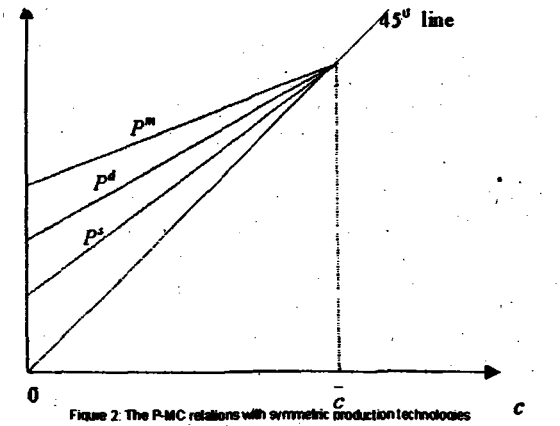

Figure 2: The P-MC relations with symmetric production technologies

Proposition 1: Given any c, we have $P^m(c) > P^d(c) > P^s(c)$.

Now, if MC falls, say to c', both reaction functions shift to the right and we shall

similarly get points like M', D' and S' as representing respectively monopoly, duopoly and Stackelberg equilibrium. From the properties of the slopes of the reaction functions it is easy to show that $\frac{dQ^r(c)}{dc} < 0$ for r = m, d, s, that is, given the market structure, industry output goes up as marginal costs fall. Hence we have the following result.

Proposition 2: When all firms have access to the same technology, we must have $\frac{dP^r(c)}{dc} > 0$ *for r = m, d, s.*

Figure 2 portrays the results of Propositions 1 and 2. Note that the market for a product becomes non-existent if $c \geq \phi^{-}(0) \equiv \bar{c}$ where $\phi(P)$ is the market demand function. To illustrate the above results, consider a market demand function linear of the form

$$\phi(P) = a - P,\ a > c.$$

Then,

$$P^m(c) = \frac{a+c}{2},\ P^d(c) = \frac{a+2c}{3},\ P^s(c) = \frac{a+3c}{4}.$$

3. The Non-Monotone Relation

In this section we assume that, given an initial MC = c^0 (say) for each firm, only one firm, say firm 1, has access to a lower MC, $c < c^0$. Quite obviously, the P-MC relation under monopoly will remain unchanged. Now consider Cournot equilibrium. As firm 1's MC goes down, its reaction function shifts to the right, and the new equilibrium is attained at a point on firm 2's reaction function. This implies that the industry output must increase. Hence again, we have the monotone relation between price and MC. Only difference compared to the case of symmetric technology is that under asymmetric technology price will be higher so long the market remains duopoly. Therefore, there is a low marginal cost, $\underline{c}$, such that for all $c \leq \underline{c}$, the inefficient firm ceases to operate and the market becomes monopoly of firm 1. Hence, given an initial MC = c^0 for each firm, under asymmetric technology case the price-MC relationship is described as follows.

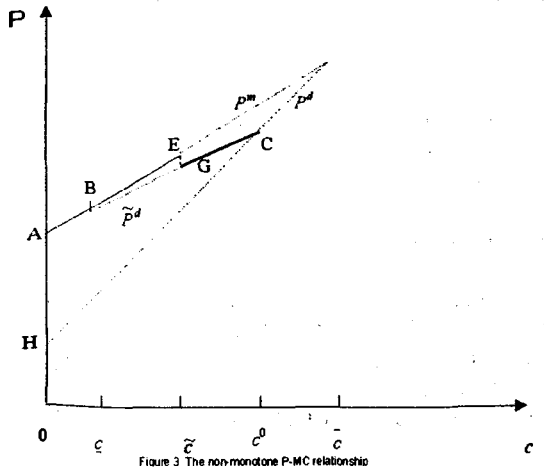

Figure 3 The non-monotone P-MC relationship

$$P(c) = \begin{cases} \tilde{P}^d(c) > P^d(c)\ \forall c \in (\underline{c}, c^0) \\ P^m(c)\ \forall c \leq \underline{c} \end{cases}$$

In this case again we have a monotone relation although there is a kink at $c = \underline{c}$. Such a relation is given by the kinked line ABC in figure 3.

To give a possibility of non-monotone relation let us now introduce a fixed cost of production. Assume that production involves a fixed cost F>0, and at the initial MC = c^0, both firms operate at positive output levels. Then assume that only firm 1 comes up with a better method of production. Existence of a fixed cost means that under this situation firm

2's reaction function becomes discontinuous at some point, L, beyond which firm 2 will cease to operate (see Figure 1). Let $\tilde{c} \equiv c(F)$, $c < \tilde{c} < c^0$, be the MC for which firm 1's reaction function passes through L. This means, for all $c \in (\tilde{c}, c^0)$ price-MC relationship will follow the path of $\tilde{P}^d(c)$ (since duopoly structure is retained), but at $\tilde{c}$ market structure is altered to monopoly, and as a result there will be a discontinuous jump of price to $P^m(\tilde{c})$. Thereafter as c falls, the equilibrium price will follow the path $P^m(c)$. In figure 3, given initially c^0, the price path under symmetric duopoly is shown to be the line HC; the price path under asymmetric duopoly with zero fixed cost is the kinked line ABC. But when there is a positive fixed cost, the associated P-MC relationship will be the discontinuous line AEGC. From the figure it is also easy to understand that if F is relatively high, so that $\tilde{c}$ is close to c^0, then if the new marginal cost, c, is less than $\tilde{c}$ but close to it, product price becomes, in fact, higher than the initial price $P^d(c^0)$.

The above non-monotone relation between price and MC is discussed in Cournot setup. But the similar result can also be obtained under other non-cooperative structures such as Stackelberg leadership structure or price leadership-cum-fringe structure.[3] What is needed in all these cases is the existence of a fixed cost of production, and as one firm acquires better technologies, the market structure is altered to monopoly not because of the superior technologies but because of the fixed cost. Since existence of fixed costs is very common in practice, a non-monotone price-MC relation seems to be the more general case.

Proposition 3: The price-MC relation can be non-monotone if there is a fixed cost of production.

4. Conclusion

Superior technologies are acquired either through research and development activity, or through imports or by forming technological agreements with the technology owners. Because of patent protection and complexities of modern technologies, only a subset of firms in the industry has access to these technologies. So market concentration goes up and, in the extreme, market structure is altered. When production involves a fixed cost, even a small reduction in (marginal) cost might lead to a monopoly situation. Under such circumstance, an application of a lower marginal cost might result in an increase in the product price implying that the price-MC relationship can be non-monotone. Such a result is quite robust --- it does not depend on a particular market structure chosen, but it is a consequence of any imperfect market structure with having fixed costs of production.

The welfare implication of such a result is very important. An application of a superior method of production might be rewarding to the firms concerned, but in the aggregate it can be welfare reducing --- consumers might suffer from the price rise and domestic industrial profits might fall. For example, suppose that initially the market was duopoly of two local firms. Then an alliance is formed between a foreign firm and a local firm. The foreign firm supplies a superior production technology that involves a lower marginal cost of production. Suppose that the collaborating firm emerges as monopoly. Now if the local firm is not sufficiently strong in bargaining vis-à-vis the foreign partner, domestic industrial profits can, in fact, fall. When such an alteration of market structure increases price, consumers are also worse off. Hence our result has implication to government policies in respect of R&D, technology licensing or foreign collaboration, and patent protection. All innovations that reduce costs of production might not be good from the viewpoint of the society.[4] The size and quality of an innovation and its consequence to the industrial structure are important considerations while judging the value of an innovation.

NOTES

1. Bagchi (1987) notes that 'one of the characteristics of the frontier technologies is that they can and do lead to the break up of established industry structures and the birth of new industry structures' (p.12). Swaminathan (1988) provides a study showing market concentration due to imported technologies.
2. See Dixit (1986) and Bulow et al. (1985) for comparative statics in oligopoly.
3. See Kabiraj (1994a) for a detailed analysis of these cases.
4. Kabiraj (1994b) discusses the issues related to obsolete technology transfer to developing countries.

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