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Abstract: The literature analysing social efficiency of entry argues that entry is *always socially excessive* in industries with asymmetric cost firms and no scale economies. We show that *exogenous cost asymmetr*y is responsible for this result. In a simple model with endogenous R&D investment by the more cost efficient firm, thus creating *endogenous cost asymmetry*, we show that entry is socially insufficient instead of excessive if slope of the marginal cost of R&D is not very high.

Key Words: Excessive entry; Insufficient entry; Cost asymmetry; R&D

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1. Introduction

The literature analysing social efficiency of entry in oligopolistic markets gets momentum with the work by Mankiw and Whinston (1986). While this literature mainly concentrates on industries with scale economies and symmetric cost firms,[1] Ghosh and Saha (2007) provide a new perspective to this literature by analysing social efficiency of entry under cost asymmetry and no scale economies. They show that entry is *always socially excessive*,[2] thus suggesting that anti-competitive entry regulation policies are *always* desirable in industries with asymmetric cost firms and no scale economies.[3]

We show that *exogenous cost asymmetry* is responsible for the result of Ghosh and Saha (2007). In a simple model with endogenous R&D investment by the more cost efficient firm, thus creating *endogenous cost asymmetry*, we show that entry is socially insufficient instead of excessive if slope of the marginal cost of R&D is not very high. Hence, if cost asymmetry is determined endogenously, the anti-competitive entry regulation policies may not be justifiable with no scale economies.

2. The model and the results

Assume that there is a firm (firm 0) which can produce a product with the marginal cost of production c and there is free entry of large number of firms (called entrants), each of which can produce the product at the marginal cost of production d, with $d \geq c$. An entrant enters the industry if its output is positive. We assume that firm 0 invests in R&D to reduce its

[1] See, Suzumura and Kiyono (1987), Okuno-Fujiwara and Suzumura (1993), Anderson et al. (1995), Fudenberg and Tirole (2000), Cabral (2004) and Ghosh and Morita (2007a and b) for some other works on social efficiency of entry under scale economies.

[2] Excessive (insufficient) entry implies that welfare maximizing number of firms is lower (higher) than the free entry equilibrium number of firms.

[3] Governments often take actions to foster or deter entry into particular industries. For example, in the post-war period, preventing excessive entry was a guiding principle in the Japanese industrial policy (Suzumura and Kiyono, 1987 and Suzumura, 1995).

marginal cost of production from c to $(c-x)>0$, where x is the R&D investment of firm 0. We assume that the cost of R&D is $e(x)=\frac{ex^2}{2}$.

The inverse market demand function is $P = a - q$, where P is price and q is the total output sold. We derive the condition for insufficient entry under a general demand function in the *Appendix*.

We consider the following game. At stage 1, the entrants decide whether to enter the industry. At stage 2, firm 0 determines its R&D investment. At stage 3, firm 0 and all the entrants which have entered the industry produce like Cournot oligopolists. We solve the game through backward induction.

If n entrants enter the industry and the R&D investment of firm 0 is x, firm 0 and the ith entrant maximize the following expressions respectively to determine their outputs:

$$\underset{q_0}{Max}(a-q-c+x)q_0 \tag{1}$$

$$\underset{q_i}{Max}(a-q-d)q_i, \qquad i=1,2,...,n. \tag{2}$$

The equilibrium outputs can be derived as

$$q_0^* = \frac{a-(n+1)(c-x)+nd}{n+2} \tag{3}$$

$$q_i^* = \frac{a-2d+c-x}{n+2}, \quad i=1,2,...,n. \tag{4}$$

The net profits of firm 0 and the ith entrant are respectively

$$\pi_0^* = \frac{[a-(n+1)(c-x)+nd]^2}{(n+2)^2} - \frac{ex^2}{2} \tag{5}$$

$$\pi_i^* = \frac{(a-2d+c-x)^2}{(n+2)^2}, \qquad i=1,2,...,n. \tag{6}$$

We do the analysis under assumptions **A1 – A4**:

A1: *(a – 2d + c) > 0*. This assumption ensures that the outputs of firm 0 and all the entrants are positive with no innovation by firm 0. This is similar to the assumption made in Ghosh and Saha (2007).

A2: $e > \frac{2(n+1)(a+dn)}{c(n+2)^2}$. This will ensure $(c - x^*) > 0$ for a given *n*, where x^* is the equilibrium R&D investment of firm 0. This will also satisfy the second order condition for equilibrium R&D investment.

A3: *a < 2d*. Given that $(c - x^*) > 0$, this is *necessary but not sufficient* for encouraging only a finite number of entrants to enter the industry. This assumption will also satisfy **A2** at the free entry equilibrium number of firms.

A4: $e > \frac{(a-d)}{(a-2d+c)}$. This will make entry of at least one entrant profitable.

Firm 0 maximizes (5) to determine the equilibrium R&D investment, which is

$$x^* = \frac{2(n+1)[a - c(n+1) + dn]}{e(n+2)^2 - 2(n+1)^2}. \tag{7}$$

Assumption **A2** satisfies $(c - x^*) > 0$ and the second order condition for the equilibrium R&D investment, i.e., $e > \frac{2(n+1)^2}{(n+2)^2}$.

We get from (4) and (7) that the net equilibrium output of an entrant is zero if

$$n[2(a-d) - e(a-2d+c)] + 2[(a-d) - e(a-2d+c)] > 0. \tag{8}$$

The following result follows immediately from (8).

Lemma 1: *Free entry equilibrium number of entrant is finite if* $e(a-2d+c)$ *is not greater than* $2(a-d)$.

Lemma 1 suggests that if slope of the marginal cost of R&D is sufficiently high, i.e., $e > \frac{2(a-d)}{(a-2d+c)}$, it reduces the effectiveness of R&D by firm 0. In this situation, R&D by firm 0 does not deter the entrants from entering the industry, and infinitely many entrants enter at the free entry equilibrium.

If $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$, i.e., slope of the marginal cost of R&D is not very high, the free entry equilibrium number of entrants is finite and is given by $n^* = \frac{2[e(a-2d+c)-(a-d)]}{2(a-d)-e(a-2d+c)}$.

If $e < \frac{(a-d)}{(a-2d+c)}$, i.e., slope of the marginal cost of R&D is low, we get $n^* = 0$, thus creating a corner solution in the sense that no entrant enters the industry. To prove our point in the simplest way, we ignore this situation.

The above discussion suggests that R&D by firm 0 reduces competitiveness of the entrants and may encourage only a finite number of entrants to enter the industry.

Now determine the welfare maximizing number of entrants. Welfare is the sum of "the profit of firm 0, the total profits of the entrants that have entered the industry and consumer surplus". Following the tradition of the literature, we assume that the social planner can control the number of entrants but it cannot affect the product market behaviour of the firms, i.e., the firms compete like Cournot oligopolists. It is intuitive that the social planner will not restrict entry of firm 0, since it is the more cost efficient firm. However, the social planner may have the incentive to restrict entry of more cost inefficient firms.

The social planner determines the welfare maximizing number of firms by maximizing the following expression:

$$\underset{n}{Max}\, W = \underset{n}{Max}\, \pi_0^* + \sum_{i=1}^{n} \pi_i^* + \frac{1}{2}(q_0^* + \sum_{i=1}^{n} q_i^*)^2 . \tag{9}$$

The welfare maximizing number of firms is given by

$$\frac{\partial W}{\partial n} = 0 . \tag{10}$$

Assuming $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$ and evaluating $\frac{\partial W}{\partial n}$ at the free entry equilibrium number of firms $n^* = \frac{2[e(a-2d+c)-(a-d)]}{2(a-d)-e(a-2d+c)}$, we get that

$$\left.\frac{\partial W}{\partial n}\right|_{n=n^*} = \frac{(a-d)[2(a-d)-e(a-2d+c)]^3}{2e[2(a-d)^2-e(a-2d+c)^2]} . \tag{11}$$

The second order condition for the equilibrium R&D investment at the free entry equilibrium implies that $e < \frac{2(a-d)^2}{(a-2d+c)^2}$. Because we are considering $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$, we get that $e < \frac{2(a-d)^2}{(a-2d+c)^2}$ for $c \le d$, since $\frac{2(a-d)}{(a-2d+c)} \le \frac{2(a-d)^2}{(a-2d+c)^2}$. Further, $(c-x^*) > 0$ is satisfied at $n^* = \frac{2[e(a-2d+c)-(a-d)]}{2(a-d)-e(a-2d+c)}$ if $(2d-a) > 0$. Hence, $\left.\frac{\partial W}{\partial n}\right|_{n=n^*} > 0$ for $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$.

The following proposition is immediate from the above discussion.

Proposition 1: *If* $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$, *i.e., slope of the marginal cost of R&D is not very high, the free entry equilibrium number of entrants is* $n^* = \frac{2[e(a-2d+c)-(a-d)]}{2(a-d)-e(a-2d+c)}$, *and entry is socially insufficient.*

Proposition 1 is in contrast to Ghosh and Saha (2007), and shows that if slope of the marginal cost of R&D of firm 0 is not very high, entry is socially insufficient under endogenous cost asymmetry and no scale economies.

The reason for Proposition 1 will be clear once we look at the effect of *n* on the R&D investment of firm 0 at $n^* = \frac{2[e(a-2d+c)-(a-d)]}{2(a-d)-e(a-2d+c)}$. We get that

$$\left.\frac{\partial x^*}{\partial n}\right|_{n=n^*} = \frac{(a-d)[2(a-d)+e(a-2d+c)]^2}{e[2(a-d)^2 - e(a-2d+c)^2]} > 0\,, \qquad (12)$$

which implies that the R&D investment of firm 0 increases as the number of more cost inefficient firms increases from the free entry equilibrium number of firms.

Entry of more cost inefficient firms creates two effects in our analysis. First, like Ghosh and Saha (2007), for a given R&D investment of firm 0, entry of more cost inefficient firms tends to reduce welfare at the free entry equilibrium number of firms by shifting output from the more cost efficient firm to the more cost inefficient firms. Second, R&D investment of firm 0 increases at the free entry equilibrium number of firms, and this effect tends to increase welfare by making firm 0 more cost efficient. If $\frac{(a-d)}{(a-2d+c)} < e < \frac{2(a-d)}{(a-2d+c)}$, we show that the R&D effect outweighs the output switching effect and increases welfare at the free entry equilibrium number of firms.

It is worth mentioning that if slope of the marginal cost of R&D of firm 0 is sufficiently high so that $e > \frac{2(a-d)}{(a-2d+c)}$, infinitely many entrants enter the industry, and it approximates the case of exogenous cost asymmetry by reducing the effectiveness of R&D investment significantly. In this situation, the above-mentioned R&D effect is negligible and the output switching effect dominates the R&D effect to create socially excessive entry.

3. Conclusion

In contrast to the vast literature examining social efficiency of entry under scale economies and symmetric cost firms, Ghosh and Saha (2007) show that entry is *always* socially excessive under cost asymmetry and no scale economies. We show that *exogenous* cost asymmetry is responsible for their result. Considering endogenous cost asymmetry created by the R&D investment of the more cost efficient firm, we show that entry is socially insufficient instead of excessive if slope of the marginal cost of R&D is not very high. Hence, anti-competitive entry-regulation policies are not justifiable in this situation.

Appendix

The case of a general demand function: Assume that the inverse market demand function is *P(q)*, with $P' < 0$ and $P'' \leq 0$.

If n entrants enter the industry, firm 0 and the ith entrant maximize the following expressions respectively to determine their outputs:

$$\underset{q_0}{Max}(P - c + x)q_0 \tag{A1}$$

$$\underset{q_i}{Max}(P - d)q_i\,, \qquad i = 1, 2, ..., n\,. \tag{A2}$$

The respective equilibrium outputs are determined by

$$P - c + x + q_0^* P' = 0 \tag{A3}$$

$$P - d + q_i^* P' = 0\,, \qquad i = 1, 2, ..., n\,. \tag{A4}$$

Firm 0 maximizes the following expression subject to (A3) and (A4) to determine its R&D investment:

$$\underset{q_0}{Max}(P - c + x)q_0 - e(x)\,. \tag{A5}$$

Due to the symmetry of the entrants and using (A3), the equilibrium R&D investment is given by

$$q_0^*(1 + nP'\frac{\partial q_i}{\partial x}) - e' = 0\,. \tag{A6}$$

We assume that the cost of R&D is such that $(c - x^*) > 0$, where x^* is the equilibrium R&D investment.

Free entry equilibrium number of entrants is given by $P - d = 0$.

Now consider welfare maximizing number of entrants. Due to the symmetry of the entrants, the welfare maximizing number of entrants is determined by maximizing the following expression:

$$\underset{n}{Max}W = \underset{n}{Max}\int_0^{q^*} P(q)dq - (c - x^*)q_0^* - ndq_i^* - e(x^*)\,, \tag{A7}$$

where $q^* = q_0^* + nq_i^*$.

Differentiating (A7) with respect to n and evaluating it at the free entry equilibrium where $P = d$, and using (A3), (A4) and (A6), we get that

$$\frac{\partial W}{\partial n} = [P(q^*) - c + x^*]\frac{\partial q_0^*}{\partial n} + (q_0^* - e')\frac{\partial x^*}{\partial n}$$

$$= -q_0^* P'(\frac{\partial q_0^*}{\partial n} + n\frac{\partial q_i^*}{\partial x^*}\frac{\partial x^*}{\partial n}) . \qquad \text{(A8)}$$

Entry is insufficient if $\frac{\partial W}{\partial n} > 0$ or

$$\frac{\partial q_0^*}{\partial n} > -n\frac{\partial q_i^*}{\partial x^*}\frac{\partial x^*}{\partial n} , \qquad \text{(A9)}$$

implying that the *total* effect (which includes also the effect through the R&D investment) of n on the equilibrium output of firm 0 dominates the effect of n on the total outputs of the entrants due to the change in the R&D investment of firm 0. It can be checked that Proposition 1 satisfies (A9), thus creating insufficient entry.

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