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Abstract. There is a lot of anecdotal evidence that entry of new firms reduces not only prices but also costs. However, it is far from clear how this cost-reduction works. In this paper I investigate three models of how entry may cause cost reduction: managerial incentives, survival of the fittest, and imitation. The models have somewhat different implications for social welfare.

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Entry and Cost Reduction

Hal R. Varian

In standard models of oligopoly an increase in the number of firms tends to reduce prices.[1] However, the standard model takes the cost function of the firms in the industry as exogenous. Many observers have argued that this ignores a major reason for price reductions: entry makes an industry more competitive and forces firms to "tighten" up their production by reducing costs. The reduction in costs is in turn passed along to the consumers in the form of lower prices.

The idea that entry—often in the form of foreign competition—forces firms to reduce costs has been mentioned in passing in the international trade literature by several authors, including Balassa (1975), Bergsman (1974), Corden (1970), and Johnson (1970). More recently, Horn, Lang, and Lundgren (1990, 1991, 1992) have produced a series of papers on this topic.

Porter (1990a, 1990b) has argued persuasively that an effective way to enhance a nation's competitiveness is to encourage a highly-competitive domestic industry.

> "To compete globally, a company needs capable domestic rivals and vigorous domestic rivalry... Vigorous domestic rivalry creates sustainable competitive advantage." (p. 92)

Porter argues that domestic competition improves competitiveness in several ways:

> "Domestic rivalry, like any rivalry, creates pressures on companies to innovate and improve. Local rivals push each other to lower costs, improve quality and service, and create new products and processes." (p. 82)

However, despite the widespread interest in the idea that competition reduces costs, there is remarkably little economic analysis of how this cost-reduction occurs. However, it is important to understand the mechanism by which competition reduces costs if we are to design appropriate public policy to enhance national competitiveness. For example, Porter argues that a strong

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[1] See, e.g., Novshek (1980) for an explicit model of entry in a Cournot industry.

domestic antitrust policy is "fundamental to innovation." However, other observers have argued that a relaxed antitrust policy enhances competitiveness due to economies of scale.

Ultimately our understanding of the causal connection between cost-reduction and competition must rest on empirical evidence. However, some theoretical analysis may be useful since it allows us to examine *possible* influences on logical grounds. In this paper I examine some simple models of competition, entry, and cost-reduction. There are clearly many effects at work so these investigations must be viewed as highly tentative—my intention is simply to lay out a few possible mechanisms and examine their logical structure in the hopes that some insight may be gained.

1. Preliminaries

I will investigate these issues in the context of the standard Cournot model of industry competition. This is undoubtedly more static than one would like, but it seems appropriate to start with a model whose properties are well-understood.

Suppose that firm i produces output y_i for $i = 1, \ldots, n$, and let $Y = \sum_{i=1}^{n} y_i$ be the aggregate industry output. Let $p(Y)$ be the inverse demand function facing the industry. Each firm i has a cost function given by $c_i(y_i) = cy_i + F$. Since the cost functions are identical across firms, total industry costs are $cY + nF$. The fixed costs are a simple way of capturing increasing returns to scale.

Social welfare is given by $W(Y) = U(Y) - cY - nF$. In this model the first-best allocation is to have one firm in the industry that is compelled to set price equal to marginal cost. However, we assume that this form of regulation is undesirable and that the industry acts as a Cournot industry with free entry.

In this case the equilibrium output and number of firms will be determined by the two first-order conditions

$$p(Y) + p'(Y)y = c$$

$$p(Y)y - cy - F = 0,$$

where $Y = ny$. The first equation is simply marginal revenue equals marginal cost; the second is the zero profit condition due to free entry. The second-order condition for individual firm profit-maximization is

$$2p(Y) + p''(Y)y \leq 0.$$

We first consider the question of whether there are too many or two few firms in equilibrium. Of course there are always too many firms from the viewpoint of the first-best optimum, but our focus is on the second-best. If we increase the number of firms, the Cournot equilibrium price will decrease due to increased competition; this will tend to increase consumer welfare. However, increasing the number of firms will also increase the fixed costs. Which of these two effects dominates? From a policy perspective we are asking whether it is better to encourage entry—say by an entry subsidy—or to discourage entry.

von Weisacker (1980), Perry (1984), Mankiw and Whinston (1986) and Suzumura and Kiyono (1987), Okuno-Fujiwara and Suzumura (1993), Konishi, Okuno-Fujiwara, and Suzumura (1990) have shown in varying degrees of generality that the general tendency in Cournot oligopoly is for *excessive* entry: under plausible conditions social welfare will *increase* if the number of firms is reduced below the zero-profit equilibrium number. Mankiw and Whinston (1986) and Suzumura and Kiyono (1987) provide a very general treatment but our framework is so simple that we can analyze this question directly.

Let $Y(n)$ be industry output as a function of n and let $W(n) = U(Y(n)) - cY(n) - nF$ be social welfare. Differentiating welfare with respect to n we have

$$W'(n) = [p - c]Y'(n) - F.$$

Evaluating this at the free-entry equilibrium, we can use the zero-profit condition that $[p - c] = nF/Y$, and find

$$W'(n) = \left[\frac{nY'(n)}{Y} - 1\right] F.$$

This calculation establishes

Entry and welfare. *Welfare increases (decreases) as the number of firms increases above the zero-profit number if the elasticity of industry output with respect to n is greater (less) than 1.*

Output per firm. *Elasticity of industry output with respect to n is greater (less) than 1 if output per firm increases with n.*

Proof. Output per firm is $Y(n)/n$. Differentiating this with respect to n yields

$$\frac{nY'(n) - Y(n)}{n^2},$$

which establishes the result. ∎

In order to investigate how output responds to changes in n we totally differentiate the (aggregated) FOC, we find

$$Y'(n) = -\frac{p-c}{(n+1)p' + p''Y}$$

Using the zero-profit condition we have

$$Y'(n) = \frac{p'Y/n}{(n+1)p' + p''Y},$$

which we can also write as

$$Y'(n) = \frac{Y/n}{n+1+p''Y/p'}.$$

Rearranging this we find

$$\frac{nY'(n)}{Y} = \frac{1}{1+n+p''Y/p'}$$

Substituting this back into the expression for $W'(n)$ we have

$$W'(n) = -\left[\frac{n+p''Y/p'}{1+n+p''Y/p'}\right]F.$$

Let us attempt to sign this effect. First we observe that if $p'' < 0$ we are done: $W'(n) < 0$.

Suppose that $p'' > 0$. Note that the numerator is one less than the denominator. If the denominator is negative, then the numerator is also negative, and we are done: $W'(n) < 0$. (The second-order condition implies that the denominator will be negative for small n.) Similarly, if the denominator is a large positive number, then subtracting 1 won't change the sign of the numerator, so $W'(n) < 0$. The only troublesome case is when the denominator is positive number less than 1, so that the numerator is a negative number. In all other cases, $W'(n) < 0$.[2]

One useful case to examine is that of a constant elasticity demand curve. Using ϵ_{Yp} to denote the elasticity of demand, the expression becomes

$$W'(n) = -\left[\frac{n - 1/\epsilon_{Yp} - 1}{n - \epsilon_{Yp}}\right]F.$$

This will have the right sign as long as $n > 1 + 1/\epsilon_{Yp}$, a condition that is quite likely to hold in practice.

Excessive entry. *It is likely that welfare will rise if the number of firms decreases below the number that would result from free entry.*

[2] The papers cited above offer various conditions on the demand function for which it is possible to sign the welfare effect.

2. Managerial incentives

Let us now extend the simple model described in the last section to allow a route for costs to be affected by industry structure. Horn et al. (1992) examine a detailed model of how managerial incentives could be designed so as to encourage cost reduction. Since our concern has to do more with industry structure than incentive systems we will simply assume a reduced form for the manager's objective function. In particular we assume that firm i's manager has an objective function of the form

$$u(c) + \lambda[P(Y)y_i - cy_i - F],$$

where $u(c)$ is an increasing function of c and $\lambda > 0$ is a parameter that measures the weight that the manager attaches to corporate profits.

Basically, we assume that it is costly to the manager to reduce production costs: doing so requires effort and exertion. The shareholders of the firm care about profits and have set up an incentive system so that the manager balances the shareholders' objective of increasing profits with the manager's objective of remaining "comfortable."[3]

If the manager chooses output and costs to maximize this objective function, the choices will satisfy

$$u'(c) = \lambda y_i$$

$$P(Y)y_i + P'(Y)y_i - c = 0.$$

The first condition implies that the larger the firm the lower the production costs. This is due to the fact that a given reduction in marginal cost saves more money for larger firms; hence the manager is willing to put more effort into cost-reduction for large firms than for small ones.[4]

It turns out that adding managerial incentives of this format amplifies the effect described in the last section. Recall that the welfare function is

$$W(n) = u(Y) - cY - nF,$$

[3] This is the objective function that would arise from a simple linear incentive scheme. Linear incentive schemes arise naturally in a simple mean-variance model; see Holmstrom and Milgrom (1987) for details.

[4] Note that we are assuming that the managerial incentive scheme (here represented by λ) does not vary with the size of the firm. It would be interesting to allow this parameter to vary, but of course we would then need to have a model of how λ is determined.

and the derivative at the Cournot equilibrium now becomes

$$W'(n) = \left[\frac{nY'}{Y} - 1\right] F - c'(n)Y.$$

The first term is the effect we described earlier, with fixed c. The second effect is the new one. We have already seen that increasing the number of firms will (almost certainly) decrease the output per firm. Since the output per firm goes down the managers have less of an incentive to reduce costs. Hence both effects work in the same direction implying that it is socially desirable to *discourage* entry.

Managerial incentives. *If the managers maximize a weighted sum profits and their personal utility, it is still welfare-enhancing to discourage entry.*

This result should be taken with a grain (or perhaps a shaker) of salt. The model is extremely simple. However, the causal chain is fairly robust: entry reduces the size of the typical firm. But if the size of the firm goes down, the benefit to the managers of a given reduction in costs is less, discouraging them from putting much effort into reducing costs.

It should be possible to develop a model with the opposite result. If there are diseconomies of scale from organizational effects, as in McAfee and McMillan (1990), then entry that reduces the size of the representative firm may enhance operating efficiency. But in order to provide a *net* welfare gain, the increase in efficiency has to be sufficiently large to outweigh the inefficiency from free entry.

3. Evolution

Suppose that production costs, instead of being determined by managerial effort, instead are randomly drawn from some distribution. Potential entrants have some given operating costs; if these costs are lower than the costs of firms that are currently producing, the potential entrants may well find it profitable to enter the industry.

I think of this model in Darwinian terms. There is a current population of operating firms and a supply of "mutants" with different cost parameters. If a mutant has low enough costs, it will attempt to enter the industry.

There is some empirical support for this view. Liu (1991) investigated a large cross section of firms in Chile in order to see how industry structure changed as the result of tariff reform.

She found that inefficient firms (as measured by frontier estimation techniques) tended to exit the industry, but that new entrants to the industry were less efficient than the incumbents on average. The more efficient entrants tended to survive while the less efficient ones exited. This is very much a Darwinian story.

We model this in the following simple way. We suppose that the industry is in long-run symmetric equilibrium where all firms have constant marginal cost c_H. Originally the aggregate equilibrium output is Y_0. A potential entrant arises with marginal cost $c_L < c_H$. We suppose that the new firm enters the industry; in the new equilibrium, total industry output is Y_N. Of this Y_H is produced by the original high-cost incumbents and Y_L is produced by the new, low-cost entrant.

It is useful to consider the following aggregation result from Bergstrom and Varian (1985, 1986).

Cournot aggregation. *Let there be H firms with constant marginal costs of c_H and L firms with constant marginal cost of c_L. Then an interior Cournot equilibrium in this market has the same output and price as if there were $H + L$ firms each having constant marginal cost of*

$$c_A = \frac{Hc_H + Lc_L}{H + L}$$

Proof. Let y_H be the output of a high-cost firm and y_L be the output of a low-cost firm. The interior FOCs are:

$$p(Y) + P'(Y)y_H = c_H$$

$$p(Y) + P'(Y)y_L = c_L.$$

Adding up, we have

$$(H + L)p(Y) + P'(Y)Y = Hc_H + Lc_L,$$

or

$$p(Y) + P'(Y)\frac{Y}{H + L} = \frac{Hc_H + Lc_L}{H + L}$$

which proves the result. ∎

In our context, $H = n$ and $L = 1$. Hence the effect of a new, low-cost entrant is just the same as the effect of adding a new firm with cost c_A and reducing the incumbent firms' marginal costs to c_A.

We can use the this result to simplify the analysis of adding a new, low-cost firm to an existing high-cost industry. According to Cournot aggregation, this is just like adding a new firm and then reducing *all* firms' costs to $(nc_H + c_L)/(n+1)$. The total derivative of welfare is

$$dW = \left[(p-c)\frac{dY}{dn} - F\right] dn + \left[(p-c)\frac{dY}{dc} - Y\right] dc. \qquad (1)$$

We've already seen that under plausible conditions the first effect is negative. Since dY/dc is almost certainly negative, the second effect is negative, too. But since we are talking about *decreasing* costs dc is negative so we end up with a positive contribution to welfare from the second bracketed expression.

The question is, is this positive effect large enough to outweigh the negative effect of the first term? The answer depends, in part, on the magnitude of dc. The change in the average industry cost from adding *one* low-cost firm is

$$\Delta c = \frac{c_L - c_H}{n+1}.$$

The effect of a cost reduction on the industry is $1/n^{th}$ the effect of the cost reduction on the individual firm. It seems likely that the addition of a single low-cost firm to a Cournot industry with a relatively large number of incumbents is unlikely to increase welfare unless the cost reduction is very dramatic.

We can manipulate equation (1) a bit more to put it in a form that is amenable to back-of-the-envelope calculations.

$$dW = [\epsilon_{Yn} - 1]\, F dn + \left[\frac{p-c}{c}\epsilon_{Yc} - 1\right] Y dc.$$

In this expression, ϵ_{Yn} is the output elasticity with respect to the number of firms, which we've seen is likely to be less than 1, and ϵ_{Yc} is the output elasticity with respect to costs, which is negative. The term $(p-c)/c$ is the Lerner index of monopoly power.

Further insight can be had by noting that

$$\frac{dp}{dc}\frac{c}{p}\frac{dY}{dp}\frac{p}{Y} = \frac{dY}{dc}\frac{c}{Y},$$

which we can write in elasticity terms as

$$\epsilon_{pc}\epsilon_{Yp} = \epsilon_{Yc}.$$

In the case of constant elasticity demands, price is proportional to marginal cost, so $\epsilon_{pc} = 1$. Hence the output elasticity with respect to costs is essentially the elasticity of demand.

Furthermore, in the case of constant elasticity demand

$$p(Y)\left[1 + \frac{1}{n\epsilon_{Yp}}\right] = c,$$

so

$$\frac{p-c}{c} = -\frac{p}{nc\epsilon_{Yp}}.$$

Using these expressions we have

$$\left[\frac{p-c}{c}\epsilon_{Yc} - 1\right] Y dc = -\left[1 + \frac{p}{nc}\right] Y dc.$$

The final expression has two terms. The first term, 1, is the direct effect of lower costs; the second term, p/nc, is the effect of the low cost firm having a larger market share. All that we need to estimate this magnitude is the initial price/cost margin and the magnitude of the total cost reduction.

It is worth observing that since dc is on order of $1/n$ the p/nc term will end up being of order $1/n^2$. For reasonably large n this can't be much of an effect. This observation reinforces the point made earlier: adding a single low-cost firm to an industry with several incumbents already present can't be expected to contribute much to welfare.

There are two important qualifications to this statement. The first is that it requires an interior solution: entry does not drive any of the firms out of the market. If a new entrant has a *dramatic* cost advantage, it may drive out incumbent firms which would result in a more dramatic effect on industry costs. Secondly, these results rest heavily on the model of Cournot competition. The story is quite different with Bertrand competition, for example. In this case a new entrant with low (and constant) marginal cost would completely replace incumbent firms, leading to a significant change in industry structure.

I think that the Cournot model is the right "default" model to examine these phenomena, for two reasons. First, the analysis of Kreps and Scheinkman (1983) suggests that the right way to think about the Cournot model is one where firms first choose "capacity" and then choose prices. This seems like the right framework for the issues we are examining. Secondly, there is the simple empirical observation that industries seems to tolerate significant differences in production costs for extended periods, which would not be possible in a standard Bertrand model with a homogeneous good.

4. Imitation and innovation

We next consider an extension of the previous model. Suppose that the cost innovation by the potential entrant is something that is easy to imitate. To take an extreme example, suppose that once the entrant joins the industry, all the incumbent firms can adopt the new technology.

I am thinking here of cost-reduction techniques that are innovations in process: things like just-in-time inventory systems, switches to stop the assembly line, and so on. These innovations are not protected by any intellectual property laws. Anyone can adopt them *if* they know that they actually work. This is the role of the innovator/entrant: to provide the proof of concept. According to Porter (1990a):

> "Much innovation is mundane and incremental, depending more on cumulation of small insights and advances than on a single major technological breakthrough. It often involves ideas that are not even "new"—ideas that have been around, but never vigorously pursued." (74)

Mundane, incremental and "old" ideas are, by their nature, not patentable. They are ideas that can be relatively quickly diffused through an industry once they have been shown to be workable. This is the phenomenon we consider now: an entrant with an appropriable production technology reduces *everyone's* costs to c_L. This is much larger effect than reducing the costs to c_A. Hence there is a reasonable chance that social welfare will be enhanced by entry in when the cost-reducing innovation can be copied.

5. Incentives to enter

We have argued that the entry of a new firm with a low-cost non-appropriable technology into an industry in long-run zero profit equilibrium may well reduce welfare. However, if the technology is appropriable, so that entry likely reduces *all* firms' cost, social welfare is likely to increase.

Here we consider the potential entrant's incentives to enter the industry. Recall that our maintained hypothesis is that profits are zero for the incumbent *high-cost* firms. If a new low-cost entrant comes into the industry output will increase, and price will decrease, making the profits of the incumbent firms negative. This will either lead to exit or to revaluation of existing capital assets, depending on one's assumptions about what constitutes the fixed costs.

However, the potential entrant only cares about the effect on *its profits* of its entry. It can easily happen that it is socially detrimental for entry to occur, due to the effects we have already analyzed, but privately profitable. See Kato (1993) for examples that show this can easily happen.

Now consider the case with an appropriable technology. In this case a firm with lower costs may enter the industry, only to see its cost advantage quickly eroded by the incumbent firms. We have seen that it may well happen that entry is socially desirable, but *privately* unprofitable in this case. The benefits of new entry are partially captured by the existing firms: they can imitate an entrant's technology if it turns out to be successful. But the entrant cannot capture any of these social benefits and may therefore be discouraged from entering the industry.

6. Summary

We have examined three models that describe a causal link between competition, entry and cost reduction. The first model was a simple model of managerial incentive: managers maximize a weighted sum of their utility, which is positively related to costs, and firm profits, which is negatively related to costs. We saw that in the framework there was no reason to encourage entry.

We next examined a model where a potential entrant possessed a lower cost technology than incumbents. The issue here was whether the reduction in costs was sufficient to outweigh the tendency towards excessive entry. We showed that a single entrant whose costs were Δc lower than the incumbents was like reducing all incumbents costs by $\Delta c/n$; for large n this "order $1/n$" effect is small and probably outweighed by the excess entry result characterizing Cournot equilibrium.

Finally we looked at a model where incumbent firms could quickly imitate the technological advantage of a low-cost entrant. It is only this case that yields a clear argument for subsidizing entry. Indeed, it is this case where the divergence between the private and social interests in the largest: if cost-reducing technologies can be quickly copied, potential entrants may well be discouraged from entry, and a case for public policy to encourage entry may be warranted.

This scenario is not implausible. It could well be that cost-reducing innovations are often mundane and seldom appropriable. Furthermore there is some evidence that entry and exit decisions in industries are better described by evolutionary models than optimizing models.

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