2011

RSMG Working Paper Series

TITLE: Intensity of Competition and the Number of Competitors

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Working Paper: R11_3

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Intensity of competition and the number of competitors*

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June 4, 2011

Abstract

We setup a model of competitive interaction among symmetric firms producing a homogeneous good that includes both Bertrand and Cournot competition as special cases. In our model the intensity of competition is captured by a single parameter – the perceived slope of competitors' supply functions. We show when the number of firms is fixed, total welfare increases monotonically with the degree of competition. We then examine how the intensity of competition affects the gains from changing the number of competitors. For very intense competition, most of the gains from extra competition are captured with the entry of a small number of firms and subsequent gains from entry are small. Conversely, when the intensity of competition is small, a reduction in the number of firms can have a large impact on welfare. We also examine the case when the intensity of competition is a function of the number of firms in the market and provide a sufficient condition for mergers to be profitable.

Key-words: Competition intensity; number of competitors; mergers.

JEL Classification: L11, L13, L41.

1 Introduction

Mergers are common in oligopolistic industries, and would be more common if it were not for anti-trust policies that prohibit anti-competitive mergers. Yet, ever since the analysis of losses from horizontal merger put forward by Salant, Switzer and Reynolds (1983), it has been known that a merger between two firms in a Cournot-Nash oligopoly with constant returns to scale will reduce the profitability of both firms. Only under stringent conditions (four out of five firms merging) will such mergers be profitable.

On this basis, Salant, Switzer and Reynolds conclude that when mergers are endogenous, socially injurious mergers (those that do not give rise to scale

*Menezes acknowledges the financial assistance from the Australian Research Council (ARC Grant 0663768).

economies sufficient to offset the reduction in competition) will not take place and therefore 'need not be guarded against'. Indeed, since some socially beneficial mergers will not take place, the policy problem is one of too few mergers rather than too many.

Noting the counterintuitive nature of their results, Salant Switzer and Reynolds consider and reject the idea that the solution is to replace the Cournot-Nash solution concept. They observe their result is robust to various modifications of the simple Nash equilibrium.

Instead, Salant Switzer and Reynolds argue for a two-stage approach in which firms first negotiate on possible partitions of the set of unmerged firms into coalitions, and then play the resulting Cournot game.

Salant Switzer and Reynolds briefly consider the possibility that firms sophisticated enough to merge will not subsequently be naive enough to play Cournot even if they behaved that way prior to the merger. They argue that this approach would knowledge of the historical circumstances under which each firm in an industry arose from earlier mergers.

This discussion also leaves unanswered the question raised by Salant, Switzer and Reynolds, 'on what foundation, if not the Nash-Cournot solution, is a theory of mergers to be based'

Ever since the 19th century, the main alternative to the Cournot solution has been that proposed by Bertrand. The existence of the Bertrand solution provides one possible explanation for horizontal mergers, which in some sense turns the discussion on its head. If firms that initially engaged in (zero-profit) Bertrand competition correctly predicted that a merger would change the industry structure in such a way as to produce the (positive profit) Cournot equilibrium outcome, then a merger would obviously be profitable.

In most situations of interest, however, the assumption of a sudden shift from Bertrand to Cournot seems implausible. However, it raises the more general idea that a reduction in the number of competitors might lead to less competitive behavior on the part of the remaining firms in the market and thereby to an increase in profits for all, including the merging firms.

A natural way to model this is to use the notion of competition in supply schedules. (See, for example, Grossman(1981), Robson(1981), Turnbull(1983), Klemperer and Meyer(1989), and Grant and Quiggin (1996)). By considering families of more or less elastic supply schedules, it is possible to generate spaces of oligopoly games of which Bertrand and Cournot are polar cases. If the game structure is itself endogenously determined by the number of firms, then it seems reasonable to propose that smaller numbers of firms will be associated with less competitive (or, alternatively, more collusive) behavior.

In this paper, we address this issue, by considering the class of games in which the strategy space consists of linear supply schedule of the form $q = \alpha + \beta p$. Within a given game, the slope of the supply curve, β, is taken to be fixed exogenously, representing the degree of competition in the market. The strategic variable for each firm is $\alpha \leq 0$, the constant term in the supply schedule, which also determines the firm's entry price $-\frac{\alpha}{\beta}$. We then examine the interaction between the competitiveness parameter β and the number of firms n, which jointly determine equilibrium prices, quantities and profits. Next, we consider the case when β is determined endogenously by the actual number of firms in the market and provide a sufficient condition for mergers to be profitable that generalise the work of Salant, Switzer and Reynolds. This complements the analysis of Akgün (2004) who shows that in setting where the industry's capital stock is fixed, production costs are quadratic and decreasing in capital, and firms compete in supply schedules in a homogenous market, mergers are always profitable.

2 Intensity of competition and fixed number of firms

We begin by examining a standard oligopoly problem with linear demand, and N firms, producing output at zero cost. We write the inverse demand function as:

$$p = 1 - [q_1 + ... + q_N], \tag{1}$$

The strategy space for each firm consists of all linear supply schedules with a given slope β. More precisely, we specify the strategic choice for firm i as a choice of supply schedules, parametrized by the strategic variable α_i as follows:

$$q_i = \alpha_i + \beta p \tag{2}$$

where the strategic variable α_i is a scalar variable representing upward or downward shifts in supply and $\beta \geq 0$ is an exogenous parameter reflecting the intensity of competition. The slope of the residual demand curve facing any given firm is determined by the slopes of the demand schedule and of the supply schedules of other firms. The parameter β may, therefore, be interpreted as representing the aggressiveness of competition in the market.

The assumption of linear demand and supply schedules simplifies the analysis without any substantive loss of generality. The crucial assumption is that the strategy space for each firm consists of a family of smooth non-intersecting concave supply schedules, including all potentially optimal price-quantity pairs. Given this assumption, non-linear demand and supply curves can always be replaced with the linear approximation applicable at the unique equilibrium.

It is crucial to observe that the importance of β is not as a description of the way each firm regards its own supply decisions, but of how it perceives the strategic choices of others. For any given firm i, the vector α_{-i} representing the strategic choices of the other firms determines a residual demand curve. Given any perceived strategy space rich enough to allow the selection of any point on the residual demand curve, the firm's best response will yield the same equilibrium price and quantity. This point was first made by Klemperer and Meyer (1989) considering the duopoly problem when the possible strategic variables are prices and quantities:

> The equilibria are supported by each firm's choosing the strategic variable that its rival expects; although each firm sees its own choice between price and quantity as irrelevant,its choice is not irrelevant to its rival because the choice determines the residual demand that its rival faces

This point may be generalized to say that each firm's perception of the slope of its own supply curve is irrelevant, but is not irrelevant to other firms in the market.

Replacing (2) into (1) yields:

$$p = \frac{1 - \sum_{i=1}^{N} \alpha_i}{1 + N\beta} \tag{3}$$

Firm 1's profits are:

$$\begin{aligned} \Pi_1 &= pq_1 = p(1 - p - \sum_{j=2}^{N} q_j) \\ &= p\left[1 - p - \sum_{j=2}^{N} \alpha_j - (N-1)\beta p\right] \end{aligned}$$

Maximising:

$$\frac{\partial \Pi_1}{\partial \alpha_1} = \frac{\partial \Pi_1}{\partial p}\frac{\partial p}{\partial \alpha_1} = \left[1 - 2p - \sum_{j=2}^{N} \alpha_j - 2(N-1)\beta p\right]\frac{\partial p}{\partial \alpha_1}$$

So for $\frac{\partial \Pi}{\partial \alpha_1} = 0$:

$$\sum_{j=2}^{N} \alpha_j = 1 - p[2 + 2(N-1)\beta] \tag{4}$$

Using symmetry $\alpha_1 = \alpha_2 = ... = \alpha_N = \alpha^*$ and replacing (3) into (4) yields

$$\alpha^* = \frac{1 + (N-2)\beta}{[(N+1) + N(N-1)\beta]} \tag{5}$$

Replacing (5) into (3) yields:

$$p^* = \frac{1}{[(N+1) + N(N-1)\beta]} \tag{6}$$

Now replacing (6) into (2) yields:

$$q_1 = ... = q_N = q^* = \frac{1 + (N-1)\beta}{[(N+1) + N(N-1)\beta]} \tag{7}$$

So that

$$Q^* = Nq^* = \frac{N(1+(N-1)\beta)}{[(N+1)+N(N-1)\beta]} \tag{8}$$

and

$$\Pi = \frac{(1+(N-1)\beta)}{[(N+1)+N(N-1)\beta]^2}$$

Remark 1 $\beta = 0$ *represents Cournot competition*

$$p^* = q^* = \frac{1}{N+1}; Q^* = \frac{N}{N+1}; \Pi = \frac{1}{(N+1)^2}$$

and $\beta \to \infty$ *represents Bertrand Competition*

$$p^* \to 0, q^* \to \frac{1}{N}; \Pi \to 0; Q^* \to 1$$

3 Profitable mergers when β is a function of the number of competitors

We now assume that there is a potential total number of firms that is equal to N as before, but that there is a unmodeled first stage where firms decide to merge. We assume that $M \geq 2$ firms merge so that the actual total number of firms in the market is equal to $N - M + 1$. We assume that $\beta(\cdot)$ is an increasing function of the number of actual firms in the market. Therefore,

$$\beta(N) \geq \beta(N - M + 1).$$

In this section we are interested in the conditions under which such merger will be profitable for the merged entities. As it is standard, a merger will be profitable for the merged entity if the profits of the new entity are greater than or equal to the sum of the profits of the firms absent a merger. Thus, we assume either M firms merge or no firms merge (our counterfactual).Thus, a merger is profitable when:

$$\pi(\beta(N-M+1), N-M+1) \geq M\pi(\beta(N), N).$$

We can use (6) and (7) to compute profits under the factual and counterfactual and show that a merger of M firms will be profitable if:

$$\frac{1+[N-M]\beta(N-M+1)}{[[N-M+2]+[N-M+1][N-M]\beta(N-M+1)]^2} \geq \frac{M[1+[N-1]\beta(N)]}{[[N+1]+N[N-1]\beta(N)]^2}. \tag{9}$$

Remark 2 *For $\beta(\cdot) \equiv 0$ (i.e., Cournot under both the factual and counterfactual) , condition (9) becomes*

$$\frac{1}{(N-M+2)^2} \geq \frac{M}{(N+1)^2},$$

which is essentially Salant, Switzer and Reynolds result. For example, if $N = 5$, then the minimum number of firms that need to merge for the merger to be profitable is $M = 4$. That is , we need 80% of the firms to merger for the merger to be profitable.

The next example posits a simple linear relationship between β and N and shows how such relationship can shed light on the profitability of mergers in the absence of economies of scale and scope.

Example 3 *Suppose $\beta(N) = N - 2$, so that a merger to two firms produces Cournot behavior. Then*

$$\Pi(N) = \frac{1 + (N-1)(N-2))}{[(N+1) + N(N-1)(N-2)]^2}.$$

We can then compute

$$: \begin{array}{cc} N & \Pi \\ 2 & \frac{1}{9} \approx 0.11 \\ 3 & \frac{3}{100} = 0.03 \\ 4 & \frac{7}{31^2} \approx 0.007 \\ 5 & \frac{13}{66^2} \approx 0.002 \end{array}$$

We show next that merging all but one firm down to Cournot is always profitable, that is,

$$\Pi(N) \leq \frac{1}{N-1}\Pi(2) = \frac{1}{9(N-1)}.$$

We can check the inequality directly for cases $N = 3, 4$. So assume $N > 4$

$$\begin{aligned} \Pi(N) &\leq \frac{1 + (N-1)(N-2))}{[N(N-1)(N-2)]^2} \\ &\leq \frac{N(N-2)}{[N(N-1)(N-2)]^2} \\ &= \frac{1}{[N(N-1)(N-2)](N-1)} \\ &< \frac{1}{24(N-1)}. \end{aligned}$$

While this example shows that merger to two firms playing Cournot is always profitable, it is clearly not the case that a merger of any number of firms that result in Cournot behaviour is profitable. For example, for large N, we can approximate $\Pi(N) \approx \frac{1}{N^2}$ and in this case, it won't be profitable to merge two firms even when the post-merger behaviour is Cournot.

4 Conclusion

In this paper we explore the link between the intensity of competition and the number of firms. When both N and β are exogenous, there are some interesting trade-offs.

For example, for large N and when competition is already very intense, the gains from an increase in the degree of competition are small. Similarly, when the intensity of competition is very small, the impact of an increase in the intensity increases with the number of firms.

Moreover, for very intense competition, most of the gains from entry of additional competitors are captured with the entry of a small number of firms and subsequent gains from entry are small. Conversely, when the intensity of competition is small, a reduction in the number of firms can have a large impact on welfare.

When we posit a positive relationship between the intensity of competition and the number of competitors, we show that socially injurious mergers are more likely than suggested by Salant, Switzer and Reynolds (1983).

This paper suggests that a better understanding of the relationship between β and N might lead to new insights into existing industrial organization models.

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