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NASH BARGAINING AND PERVERSE DEMAND SHIFT EFFECTS IN COURNOT OLIGOPOLY

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Abstract: Demand shift effects in Cournot oligopoly are examined when firms reach their decisions via Nash bargaining. As compared with profit maximization, perverse demand effects are less likely and perverse price effects more likely to occur. Perverse profit effects can occur even with perfect collusion.

1. INTRODUCTION

The hypothesis of profit-maximization has yielded fruitful insights not only in competitive situations, but also where strategic interactions between rival firms must be taken into account. However, the firm is a complex institution for the organization of productive activities and decisions within the firm are often the result of bargaining between the constituent elements. The adoption of the Nash bargaining solution for characterizing decision-making by firms readily generalizes the profit-maximizing hypothesis and provides a convenient framework for studying properties of market equilibrium. This approach can capture the joint interest of agents to maximize the size of quasirents accruing to the firm as well as the conflicts arising from the attempt of each set of agents to obtain a larger share of the rents for itself.

Quirmbach (1988) uses a conjectural variations model to analyze the effects of demand shifts in Cournot equilibrium with n profit-maximizing firms. He derives the conditions for perverse demand and price effects to occur and shows that perverse profit effects cannot occur under perfect collusion. The present note uses a Nash bargaining framework to reexamine his results.

Section 2 summarizes Quirmbach's results. Section 3 sets out the Nash bargaining framework and reworks Quirmbach's results. Section 4 concludes.

2. PERVERSE EFFECTS UNDER PROFIT-MAXIMIZATION

This section summarizes the relevant segment of Quirmbach's paper. The industry consists of n firms competing to supply a homogeneous good. The inverse market demand function for this commodity is given by $P=P(X)$, where P is the price and $X=\sum x_i$ is the industry output, x_i being the output of the i-th firm. All firms have the identical cost function $C(x_i)$. It is assumed that $P'(X)<0$, $P''(X)<0$ and $C_x(x_i)>0$, $C_{xx}(x_i)>0$ for all i, i.e. each firm faces positive and increasing marginal costs.

Let us define $\beta=(x_i/X)(\delta X/\delta x_i)$ as the common conjecture about the elasticity of industry supply with respect to x_i, $i=1, 2, \cdots, n$. $\beta=0$ corresponds to price-taking behavior, $\beta=1$ to perfect collusion and $\beta=1/n$ to symmetric Cournot solution. It is assumed that β is invariant to changes in output.

Let $MR(X)\equiv P(X)+XP'(X)$ be the industry marginal revenue curve. Then in symmetric equilibrium,

$$(1-\beta)P(X)+\beta MR(X)=MC(X/n) \tag{1}$$

i.e. marginal cost is equated to a weighted average of price and industry marginal revenue.

Next, a demand shift parameter Θ is introduced: $P=P(X, \Theta)$, $P_\Theta>0$. Let us denote equilibrium values by $*$ superscripts. It can then be shown that

$$\mathrm{d}X^*/\mathrm{d}\Theta=-CMR_\Theta/\Omega\,, \tag{2}$$

where

$$CMR=(1-\beta)P(X, \Theta)+\beta MR(X, \Theta)$$

and

$$\Omega=(1-\beta)P'(X)+\beta MR_x(X)-C_{xx}/n\,.$$

The second order conditions are fulfilled if $P'(X)$ and MR_x are both negative at equilibrium. It is easy to see that

$$\mathrm{d}X^*/\mathrm{d}\Theta<0 \quad \text{iff} \quad MR_\Theta<-[(1-\beta)/\beta]P_\Theta\,. \tag{3}$$

This is the condition for a perverse effect: since an increase in Θ shifts out the demand curve, we expect aggregate output to rise, not fall.

The effect on price is given by

$$\mathrm{d}P^*/\mathrm{d}\Theta=[\beta(P_\Theta MR_x-P_xMR_\Theta)-P_\Theta MC_x/n]/\Omega \tag{4}$$

and a sufficient condition for $\mathrm{d}P^*/\mathrm{d}\Theta$ to have a normal (positive) sign is that the quantity change be perverse (negative in sign). We can also write $\mathrm{d}P^*/\mathrm{d}\Theta=P_\Theta+P_x(\mathrm{d}X^*/\mathrm{d}\Theta)$. Therefore, conversely, for $\mathrm{d}P^*/\mathrm{d}\Theta<0$, it is necessary that $\mathrm{d}X^*/\mathrm{d}\Theta>0$.

Finally, the effect on firm profits is

$$\mathrm{d}\pi^*/\mathrm{d}\Theta=(X^*/n)[\beta P_\Theta+(1-\beta)(\mathrm{d}P^*/\mathrm{d}\Theta)] \tag{5}$$

Hence perverse profit effects cannot arise under perfect collusion: $\mathrm{d}\pi^*/\mathrm{d}\Theta=(X^*/n)P_\Theta>0$ if $\beta=1$.

3. NASH BARGAINING AND PERVERSE EFFECTS

Many of the conclusions of standard economic theory are based, among other things, upon the hypotheses that consumers maximize their utilities and firms maximize their profits. But the separation of ownership from control in modern, large enterprises casts serious doubt on the profit-maximizing hypothesis. There are different interest groups within the firm pursuing their respective agendas and the decisions arrived at ultimately are likely to be the result of bargaining between the different "stakeholders". Aoki (1980) and Svejnar (1982) have modeled the firm as a cooperative game between the different sets of agents working within the firm.

While there are a number of ways of modeling such behavior, I use a simple generalization of the profit-maximization hypothesis that has been suggested by Fershtman (1985). Let us consider a situation where the output decision in each firm is reached via bargaining between two "managers", with the two managers not necessarily possessing the same "bargaining power". (In Fershtman, the two managers have equal bargaining powers). One manager would like to maximize profit while the other would like to maximize sales (output).

Kalai's [Kalai (1977)] generalization of the Nash bargaining solution provides for unequal bargaining powers and hence a means of modeling a wide range of bargaining outcomes. The firm is therefore assumed to act as if wants to maximize

$$O_i=(\pi_i)^{\alpha}(x_i)^{1-\alpha}, \quad \alpha\varepsilon(0, 1] \tag{6}$$

where α (resp. $1-\alpha$) measures the "bargaining power" of the first (resp. second) manager and is exogenously determined. A value of 1 for α implies profit-maximizing behavior by the firm. To keep things simple, it is assumed that the second manager never has all the bargaining power. The threat points for all managers are assumed to be zeros.

The first order conditions

$$\delta O_i/\delta x_i=0\,, \qquad i=1, 2, \cdots, n \tag{7}$$

yield the symmetric Cournot equilibrium solution and can be written as

$$(1-\alpha\beta)P(X, \Theta)+\alpha\beta MR(X, \Theta)=\alpha MC(X/n)+(1-\alpha)AC(X/n) \tag{8}$$

where AC is the average cost of any firm at equilibrium.

Comparing this expression with (1), we see that the left hand side is the conjectural marginal revenue, with the weights on price and industry marginal revenue being $(1-\alpha\beta)$ and $\alpha\beta$ respectively, instead of $1-\beta$ and β. Thus, generally, the weight on price is greater and that on industry marginal revenue is smaller. On the other hand, the right hand side now is (symmetrically) a weighted average of marginal cost and average cost. Note that the conjectural variations terms β does not enter the right hand side of (8).

We continue to assume that $P'(X)$ and MR_x are both negative at equilibrium.

Let us also assume that $MC(X/n) > AC(X/n)$ so that $AC_x > 0$ at equilibrium. From (8) we obtain

$$dX^*/d\Theta = -CMR'_\Theta/\Omega', \tag{9}$$

where

$$CMR'_\Theta = (1-\alpha\beta)P_\Theta + \alpha\beta MR_\Theta,$$

and

$$\Omega' = (1-\alpha\beta)P'(X) + \alpha\beta MR_x - (\alpha/n)MC_x - \{(1-\alpha)/n\}AC_x < 0.$$

Hence a necessary and sufficient condition for a perverse output effect to occur now is that

$$MR_\Theta < -\{(1-\alpha\beta)/\alpha\beta\}P_\Theta = -\{\frac{1}{\alpha\beta} - 1\}P_\Theta. \tag{10}$$

Since $\alpha\varepsilon(0, 1]$, $1/\alpha\beta > 1/\alpha$. For any MR_Θ and P_Θ, it is less probable that a perverse effect will occur with bargaining than under profit-maximization.

Next, consider the effect on price:

$$dP^*/d\Theta = [\alpha\beta(MR_xP_\Theta - MR_\Theta P_x) - (1/n)P_\Theta\{\alpha MC_x + (1-\alpha)AC_x\}]/\Omega' \tag{11}$$

A sufficient condition for $dP^*/d\Theta$ to have a normal (positive) sign is that MR_Θ should be negative, which is true if $MR_\Theta < -\{(1-\alpha\beta)/\alpha\beta\}P_\Theta$. Hence $dX^*/d\Theta < 0$ is a sufficient condition for $dP^*/d\Theta > 0$. Conversely, for $dP^*/d\Theta < 0$, it is necessary that $dX^*/d\Theta > 0$. Since it is more probable that the effect on X will be in the normal direction, it is *more probable* that a perverse price effect will occur.

Finally, the effect of a change in Θ on firm profits is

$$d\pi^*/d\Theta = (X^*/n)[\alpha\beta P_\Theta + (1-\alpha\beta)(dP^*/d\Theta)] \tag{12}$$

using $MR - MC = (1-\alpha\beta)X^*P'(X)$ and $dP^*/d\Theta = P_\Theta + P_x(dX^*/d\Theta)$. When $\beta = 0$, the sign of $d\pi^*/d\Theta$ is determined by the sign of $dP^*/d\Theta$. This ambiguity in the sign of $d\pi^*/d\Theta$ remains even when $\beta = 1$, contrary to what Quirmbach obtains. Thus perverse profit effects can occur if $\beta = 1$, but $\alpha < 1$, i.e. under perfect collusion with Nash bargaining within firms.

4. CONCLUSION

The present note uses a generalized Nash bargaining framework to examine the possibility of perverse demand shift effects under oligopoly. It is shown that with Nash bargaining, perverse demand effects are less likely, but perverse price effects are more likely to occur. Moreover, perverse profit effects can occur even with perfect collusion.

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