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Abstract

This paper considers a Cournot oligopoly model with a concave demand function where socially concerned firms can offer lifetime employment as a strategic commitment device. Each socially concerned firm maximizes its own profit plus a share of consumer surplus. The paper presents the reaction functions of socially concerned firms in the Cournot oligopoly model.

Keywords: Cournot oligopoly model; Lifetime employment; Reaction functions; Socially concerned firms
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1. Introduction

This paper considers an oligopoly model in which socially concerned firms compete with each other. Each socially concerned firm aims to maximize its own profit plus a share of consumer surplus. Theoretical economic models that incorporate socially concerned firms are sometimes investigated by researchers (see Goering, 2007; Lambertini and Tampieri, 2012; Xu, 2014; Cracau, 2015; Flores and García, 2016; Fanti and Buccella, 2018; García, Leal and Lee, 2019; Han, 2019). For example, Kopel and Brand (2012) consider the managerial incentive contract when a socially concerned firm and a profit maximizing firm compete in output levels, and show that there is a subgame perfect equilibrium in which both firms hire managers. Kopel, Lamantia and Szidarovszky (2014) examine a mixed Cournot oligopoly model consisting of socially concerned firms and profit maximizing firms, and demonstrate that socially concerned firms can have larger market shares and profits than their profit maximizing rivals. In adition, Kopel (2015) examines the endogenous choice of a price or quantity contract in a mixed duopoly consisting of a socially concerned firm and a profit maximizing firm, and shows that price competition might lead to lower social welfare than quantity competition.

We consider a two-stage oligopoly model in which socially concerned firms compete in quantities. In the first stage, each firm non-cooperatively chooses whether to offer lifetime employment as a strategic commitment device.[1] In the second stage, each firm non-cooperatively chooses an actual output level. We present the reaction functions of socially concerned firms in the Cournot oligopoly model.

The remainder of the paper is organized as follows. In Section 2, we formulate the model. Section 3 analyzes the reaction functions of socially concerned firms in the model. Finally, Section 4 concludes the paper.

2. Model

We consider an oligopoly market composed of n (≥ 2) socially concerned firms. There is no possibility of entry or exit. The market price is determined by the inverse demand function $p(Q)$, where $Q = \sum_{i=1}^{n} q_i$ denotes total output produced by all firms.

[1] For details see Ohnishi (2001, 2002).

We assume that the inverse demand function is strictly concave; that is, $p'<0$ and $p''<0$.

The two stages of the game are as follows. In the first stage, each firm simultaneously and independently decides whether to offer lifetime employment as a strategic commitment device. If firm i $(i=1,...,n)$ offers lifetime employment, then it chooses an output level $q_i^* \in (0,\infty)$, employs the necessary number of employees to produce q_i^*, and enters into a lifetime employment contract with all of the employees. In the second stage, each firm i simultaneously and independently chooses and sells an actual output $q_i \in [0,\infty)$.

Therefore, the profit of firm i is given by

$$\pi_i = \begin{cases} p(Q)q_i - c(q_i) - l(q_i) & \text{if } q_i > q_i^*, \\ p(Q)q_i - c(q_i) - l(q_i^*) & \text{if } q_i \le q_i^*, \end{cases} \tag{1}$$

where $c(q_i)$ denotes firm *i*'s capital input function and $l(q_i)$ is firm *i*'s labor input function. We assume that the marginal cost is increasing; that is, $c'>0$, $c''>0$, $l'>0$ and $l''>0$.

The objective function of firm i is defined by

$$V_i = \theta_i CS + \pi_i, \tag{2}$$

where *CS* represents consumer surplus and $\theta_i \in [0,1]$ is the percentage of the consumer surplus. Therefore, (1) can be rewritten as

$$V_i = \begin{cases} \theta_i \left[\int_0^Q p(X)dX - p(Q)Q \right] + p(Q)q_i - c(q_i) - l(q_i) & \text{if } q_i > q_i^*, \\ \theta_i \left[\int_0^Q p(X)dX - p(Q)Q \right] + p(Q)q_i - c(q_i) - l(q_i^*) & \text{if } q_i \le q_i^*. \end{cases} \tag{3}$$

We adopt subgame perfection as our solution concept. In the next section, we present the reaction functions of socially concerned firms in the model

3. Reaction functions

We consider the maximization problem for firm *i*. We derive firm *i*'s best reaction function from (3). If firm i produces output q_i within the limit of the output level it has chosen in the first stage, then its reaction function is defined by

$$\overline{R}_i(q_{-i}) = \arg\max_{q_i \geq 0} \left\{ \theta_i \left[\int_0^Q p(X)\,dX - p(Q)Q \right] + p(Q)q_i - c(q_i) - l\left(q_i^*\right) \right\}, \tag{4}$$

where $q_{-i} = (q_1, q_2, ..., q_{i-1}, q_{i+1}, ..., q_n)$. On the other hand, if firm i wishes to produce $q_i > q_i^*$, then its reaction function is defined by

$$R_i(q_{-i}) = \arg\max_{q_i \geq 0} \left\{ \theta_i \left[\int_0^Q p(X)\,dX - p(Q)Q \right] + p(Q)q_i - c(q_i) - l(q_i) \right\}. \tag{5}$$

Therefore, if firm i selects q_i^* and offers lifetime employment, then its best reply is shown as follows:

$$R_i^L(q_{-i}) = \begin{cases} R_i(q_{-i}) & \text{if } q_i > q_i^*, \\ q_i^* & \text{if } q_i = q_i^*, \\ \overline{R}_i(q_{-i}) & \text{if } q_i < q_i^*. \end{cases} \tag{6}$$

Firm i chooses q_i in order to maximize V_i, given q_{-i}. Therefore, the first-order condition for firm i when $q_i > q_i^*$ is

$$p - c_i' - l_i' + (1-\theta_i)p'q_i - \theta_i p' q_{-i} = 0, \tag{7}$$

and the second-order condition is

$$p' + (1-\theta_i)p' - c_i'' - l_i'' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i} < 0. \tag{8}$$

On the other hand, the first-order condition for firm i when $q_i < q_i^*$ is

$$p - c_i' + (1-\theta_i)p'q_i - \theta_i p' q_{-i} = 0, \tag{9}$$

and the second-order condition is

$$p' + (1-\theta_i)p' - c_i'' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i} < 0. \tag{10}$$

Therefore, we have

$$R_i'(q_{-i}) = -\frac{(1-\theta_i)p' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i}}{p' + (1-\theta_i)p' - c_i'' - l_i'' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i}} \tag{11}$$

and

$$\overline{R}_i'(q_{-i}) = -\frac{(1-\theta_i)p' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i}}{p' + (1-\theta_i)p' - c_i'' + (1-\theta_i)p''q_i - \theta_i p'' q_{-i}}. \tag{12}$$

If $\theta = 0$, the numerators of (11) and (12) are $p' + p''q_i$. Since $p' < 0$ and $p'' < 0$, $p' + p''q_i$ is negative. On the other hand, if $\theta = 1$, the numerators of (11) and (12) are $-p''q_{-i}$, and thus $-p''q_{-i}$ is positive. In addition, since $c'' > 0$ and $l'' > 0$, the denominator of (11) is smaller than that of (12).

We can now state the following proposition.

Proposition: (i) If θ_i is sufficiently close to 0, then $R_i(q_{-i})$ and $\overline{R}_i(q_{-i})$ both are downward-sloping.

(ii) If θ_i is sufficiently close to 1, then $R_i(q_{-i})$ and $\overline{R}_i(q_{-i})$ both are upward-sloping.

(iii) The slope of $\overline{R}_i(q_{-i})$ is more gentle than that of $R_i(q_{-i})$.

4. Conclusion

We have investigated a Cournot oligopoly model in which socially concerned firms are allowed to offer lifetime employment as a strategic commitment device, and have analyzed the reaction functions of socially concerned firms. In this paper, we have considered a two-stage game. In the near future, we will study various long-run game models consisting of socially concerned firms.

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