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Abstract

This paper considers a Cournot oligopoly game model with a concave demand function where socially concerned firms compete with each other. Each socially concerned firm maximizes its own profit plus a share of consumer surplus. The timing of the game is as follows. In the first stage, each socially concerned firm simultaneously and non-cooperatively chooses whether to offer lifetime employment as a strategic commitment device. If a firm offers lifetime employment, then it chooses an output level, employs the necessary number of employees to produce the output level chosen, and enters into a lifetime employment contract with all of the employees. In the second stage, each socially concerned firm simultaneously and non-cooperatively chooses its actual output. The paper presents the reaction functions of socially concerned firms in the Cournot oligopoly model. As a result of this analysis, the paper shows that the Cournot reaction functions of socially concerned firms may be upward-sloping.

Keywords: Cournot model; Corporate social responsibility; Lifetime employment; Oligopoly; Reaction function; Socially concerned firm

JEL classification: C72; D21; L20

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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; Kopel and Brand, 2012; Lambertini and Tampieri, 2012; Kopel, Lamantia and Szidarovszky, 2014; Xu, 2014; Cracau, 2015; Kopel, 2015; Flores and García, 2016; Fanti and Buccella, 2018; Planer-Friedrich and Sahm, 2018; García, Leal and Lee, 2019; Han, 2019; Ohnishi, 2022a, 2022b; Wang and Wang, 2022). 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 addition, 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.

In this present paper, we examine 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.[2] As a result of this analysis, we show that under quantity competition, the reaction functions of socially concerned firms may be upward-sloping.

The remainder of this paper is structured 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.

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[1] For details, please see Ohnishi (2001, 2002, 2006).

[2] Delbono and Scarpa (1995) consider a Cournot duopoly model with a concave demand function where a public firm competes with a private firm, and show that if the public firm attaches to the private firm's profit a smaller weight than to its own profit, its reaction function may be upward-sloping. This paper considers a Cournot oligopoly model in which socially concerned firms compete with each other.

2. The model

We consider an oligopoly market composed of $n\ (\geq 2)$ 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. 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 $i\ (i = 1, \ldots, n)$ 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

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

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 of production 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

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

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 $q_{-i} = \left(q_1, q_{2,\ldots,} q_{i-1}, q_{i+1}, \ldots, q_n\right)$. 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 chooses 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

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

If $\theta_i = 0$, 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 $\theta_i = 1$, the numerators of (11) and (12) are $-p''q_{-i}$, and $-p''q_{-i}$ 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 $R_i(q_{-i})$.

In the case of (ii), we find that firm i treats its output as a strategic complement.[3] It is clear that if $\theta_i = 0$, $R_i'(q_{-i})$ and $\overline{R}_i'(q_{-i})$ both are positive, while if $\theta_i = 0$, $R_i'(q_{-i})$ and $\overline{R}_i'(q_{-i})$ both are negative. Ohnishi (2022a) provides a concrete example with a concave inverse demand function: $p = a - (q_1 + q_2)^2$, where a is a positive constant parameter. In this example, each firm's reaction function is upward-sloping if and only if $\theta_k > (2q_1 + q_2)/2(q_1 + q_2)$ $(k = 1,2)$.

4. Concluding remarks

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. As a result, we have shown that the Cournot reaction functions of socially concerned firms may be upward-sloping. 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.

[3] The notion of strategic complementarity was officially introduced by Bulow, Geanakoplos and Klemperer (1985).

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