Lifetime employment and reaction functions of socially concerned firms under quantity competition

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Abstract

This paper considers a Cournot oligopoly model with a concave demand function where socially concerned firms compete. Each socially concerned firm maximises its profit plus a share of consumer surplus. The timing of the game is as follows. In stage one, each socially concerned firm simultaneously and non-cooperatively chooses whether to offer lifetime employment as a strategic commitment device. In stage two, 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. The results of the paper can be summarised as follows. (i) If firms are less willing to undertake socially responsible actions, their reaction functions are downward-sloping. (ii) If firms have more social responsibility, their reaction functions are upward-sloping. (iii) The slope of the reaction functions is gentler when socially concerned firms offer lifetime employment compared to when they do not.

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I. Introduction

This paper considers an oligopoly model in which socially concerned firms compete with each other. Each socially concerned firm aims to maximise its own profit plus a share of consumer surplus. Profit-maximising and socially concerned firms coexist across industries in developing, developed and former communist countries (Francoeur *et al.*, 2017; Kitzmueller and Shimshack, 2012; KPMG, 2015). Theoretical economic models that incorporate socially concerned firms are often investigated by economic researchers (see Chang *et al.*, 2014; Cracau, 2015; Fanti and Buccella, 2018; García, Leal and Lee, 2019; Goering, 2007, 2008; Han, 2019; Kopel, 2015; Kopel and Brand, 2012; Kopel, Lamantia and Szidarovszky, 2014; Lambertini and Tampieri, 2012; Leal, Garcia and Lee, 2019; Lien, 2002; Nakamura, 2013; Ouattara, 2017; Planer-Friedrich and Sahm, 2018; Wang and Wang, 2009; Wang, Wang and Zhao, 2012; Xu, 2014). For example, Kopel and Brand (2012) consider the managerial incentive contract when a socially concerned firm and a profit-maximising firm compete in output levels, and show that there is a subgame perfect Nash 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-maximising firms, and demonstrate that socially concerned firms can have larger market shares and profits than their profit-maximising rivals. 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-maximising firm, and shows that price competition might lead to lower social welfare than quantity competition. García, Leal and Lee (2019) examine a quantity-setting duopoly model in which a profit-maximising firm competes against a socially concerned firm by incorporating environmental externality and clean technology, and show that if the socially concerned firm is significantly concerned with consumer surplus, then it may earn a high profit. In addition, Fanti and Buccella (2018) examine a Cournot duopoly model in which firms compete in a non-cooperative way on the level of corporate social responsibility in network industries, and reveal that for sufficiently intense network externalities, the equilibrium in which both firms have social concerns is more profitable than in the profit-maximising duopoly equilibrium. However, these studies are restricted to the case of linear demand functions.

Several studies consider oligopoly models with nonlinear demand functions. For instance, Flores and García (2016) examine the output and welfare impacts of a socially

concerned firm in a mixed duopoly with a profit-maximising firm. It is assumed that each demand and cost function is twice differentiable. They demonstrate that if the profit-maximising firm is technically more efficient than the socially concerned firm, then a slight increase in the degree of social concern of the socially concerned firm may reduce social welfare. Ohnishi (2022) investigates a Cournot mixed duopoly model with a concave demand function, in which a profit-maximising firm competes against a socially concerned firm, and discusses the subgame perfect equilibrium outcomes of the mixed duopoly model. Furthermore, Ohnishi (2023) examines a two-stage Cournot duopoly model with a concave demand function in which each socially concerned firm decides simultaneously and independently whether to offer lifetime employment as a strategic commitment device, and presents the subgame perfect equilibrium outcomes of the model.

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 (for details, see Ohnishi, 2001, 2002, 2006). In the second stage, each firm non-cooperatively determines an actual output level. Delbono and Scarpa (1995) analyse a Cournot duopoly model with a concave demand function, in which a welfare-maximising public firm competes against a profit-maximising private firm, and demonstrate that if the public firm places a lower weight on the private firm's profit than on its own, its reaction function may be upward-sloping. Likewise, Flores and García (2016) explore a mixed duopoly model in which a socially concerned firm competes with a profit-maximising firm and show that, under quantity competition, the reaction function of the socially concerned firm may be upward-sloping. We present the reaction functions of socially concerned firms in the Cournot oligopoly model with lifetime employment as a strategic commitment device.

The remainder of this paper is structured as follows. In Section II, we formulate the model considered in this work. Section III analyses the reaction functions of socially concerned firms in the model. Finally, Section IV concludes the paper.

II. 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

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

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 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

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

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

III. Reaction functions

We consider the maximisation 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

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

where $q_{-i} = (q_1, q_{2,\ldots,} q_{i-1}, q_{i+1}, \ldots, q_n)$. On the other hand, if firm i wishes to produce $q_i > q_i^*$, then its reaction function is defined by

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

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

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

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

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

and the second-order condition is

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

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

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

and the second-order condition is

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

Therefore, we have

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

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. Conversely, 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).

Based on this analysis, we arrive at 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 gentler than that of $R_i(q_{-i})$.

In the case of (ii), we find that firm i treats its output as a strategic complement. The notion of strategic complementarity was introduced by Bulow, Geanakoplos and Klemperer (1985). It is clear that if $\theta_i = 0$, then both $R_i'(q_{-i})$ and $\overline{R}_i'(q_{-i})$ are negative, while if $\theta_i = 1$, then both $R_i'(q_{-i})$ and $\overline{R}_i'(q_{-i})$ are positive. Ohnishi (2023) provides a concrete example of 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 $\theta_k > (2q_1 + q_2)/2(q_1 + q_2)$ $(k = 1,2)$.

IV. Conclusion

We have examined a Cournot oligopoly model in which socially responsible firms can offer lifetime employment as a strategic commitment device, and we have analysed their reaction functions. In this paper, we have considered a two-stage game. In the near future, we will explore various long-run game models involving of socially responsible firms.

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