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ABSTRACT

This paper demonstrates that in a duopoly model with firms being concerned about profit as well as corporate social responsibility (CSR), the outcome of game may coincide with the Stackelberg outcome. We argue that owner of the firm may use CSR orientation as a strategy to become Stackelberg leader in the quantity competition game.

Keywords: Stackelberg outcome; Corporate social responsibility; Cournot game; Duopoly; Non-profit orientation

JEL Classification: D21, D43, L10, L20

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1. Introduction

In this paper, we show that Stackelberg leadership can emerge as equilibrium in a duopoly quantity setting game, where firms use corporate social responsibility (CSR) orientation along with profit maximization as a strategy to achieve higher profit and market share. The objective of this paper is to suggest an alternative explanation for emergence of Stackelberg leadership in a mixed duopoly.

We explore this aspect in the spirit of Basu (1995), who demonstrated that Stackelberg equilibrium can emerge as an outcome in a managerial incentive duopoly game. He established that, in a managerial incentive duopoly game (as in Fershtman and Judd, 1987), if one of the owner delegates a contract with linear combination of sales and profit maximization to the manager, the corresponding subgame perfect equilibrium can coincide with Stackelberg outcome, where delegated firm emerges as the leader.

Our model in this paper differs from Basu (1995) in the following ways. First, instead of considering managerial incentive contracts, our focus remains on the strategic role of CSR activities of the firms. In the recent time, there is emergence of extensive literature on the non-profit aspects of the firms and their impact on the market outcomes. There are various terms used for such non-profit orientation of firm such as non-profit commercial firms (Goering, 2008), consumer cooperatives (Kopel and Marini, 2014) and CSR oriented firms (Bian, Li and Guo, 2016). We model CSR orientation of the firm using the weighted linear combination of profit and consumer welfare in the market (Goering, 2008).

Second, we consider that though the firms are profit oriented, they strategically use CSR activities to show that they care about the consumers. We can also say that there is a distinction between owner and manager of the firm. While owner of the firm is concerned about profit, it delegates the product market decision making to manager for whom the objective function is a weighted linear sum of own profit and consumer welfare. The owner in first stage decides the weights (importance) being given to the component such that profit is maximized. This structure may seem counterintuitive in a way that if the owner is concerned about profit maximization, why does he delegate a semi-profit objective to the manager? But this type of behavior is not unheard off. Sometime it is optimal for the firm to not maximize the desired objective but a different objective which indirectly maximizes the desired outcome[2]. We discuss these aspects of the game later.

[2] One such example is, Pal and Sharma (2013), where regional governments competing for mobile capital, always have a unilateral incentive to maximize tax revenue irrespective of whether they are concerned about social welfare or pure tax revenue.

2. The Model

In a quantity setting duopoly, two firms (1 and 2) face the following inverse demand function:

$$p = a - q_1 - q_2 \qquad (1)$$

where $a > 0$ and q_1, q_2 are quantity sold by the firms. The cost of production for a firm is cq_i for $i = 1,2$. The profit function of firm $i(= 1,2)$ is as follows:

$$\pi_i = (p - c)q_i \qquad (2)$$

The corresponding consumer surplus is, $\mathrm{CS} = \frac{1}{2}(q_1 + q_2)^2$. Further, the CSR oriented objective function of the firm $i(= 1,2)$ can we written as:

$$F_i = \pi_i + \beta_i \mathrm{CS} - Z_i \qquad (3)$$

Here $\beta_i \in [0, \infty)$[3] is the relative weight assigned to profit and CSR orientation. Z_i denotes the fixed cost of CSR activities done by the firm, indicating that firms will have to incur some cost to convince the consumers and competitors that they are CSR oriented.

The stages of the game are: 1) In the first stage, owner of the firm decides whether to engage in CSR or not, with the objective of profit maximization; 2) In the second stage, manager/owner decides level of output to be sold in product market.

Before moving on to the solution, we need to understand a few points. In our game, use of CSR is of pure strategic nature without focusing on the welfare implications. Moreover, firms would consider engaging in CSR activities only if it leads to increase in their profit, otherwise they would not do this.

Coming to solution of the game, we use backward induction method. Given that firms are symmetric in nature, we would analyze it from the perspective of one firm and same follows for the other.

Solving the second stage of the game, we assume CSR orientation (β) given and the CSR *reaction function* of firm $i\ (= 1, 2;\ i \neq j)$ is:

$$q_i = \frac{(a-c)-(1-\beta_i)q_j}{2-\beta_i} \qquad (4)$$

In (4), $\beta_i = 0$ is the obvious case of Cournot reaction function. Further it is obvious that quantities are strategic substitutes and $\beta_i > 0$ leads to outward shift in reaction function, making firm more aggressive in the product market competition. Getting the value of $q_1(\beta_1, \beta_2)$ and $q_2(\beta_1, \beta_2)$, we move on to first stage of the game.

[3] We ignore the negative values for β for the obvious reasons. A negative value does not have a direct interpretation and explanation for the firm in the market.

In the first stage, there can be four different scenarios/cases where owners of the firms choose to CSR or not to CSR. We denote them by these pairs: {N, N}, {N, Y}, {Y, N} and {Y, Y}. Here "N" denotes that firms choose not to do CSR activities and they are pure profit maximizers; whereas "Y" denotes that firms choose to do CSR oriented activities and in product market competition they would optimize equation (3) mentioned above.

Solving the first stage, first case {N, N}, is the obvious one i.e. Cournot competition and corresponding outcomes are: $\mathrm{p_{NN}} = \frac{1}{3}(\mathrm{a} + 2\mathrm{c})$; $q_{1NN} = q_{2NN} = \frac{1}{3}(\mathrm{a} - \mathrm{c})$; $\beta_{1NN} = \beta_{2NN} = 0$; $\pi_{1NN} = \pi_{2NN} = \frac{1}{9}(a - c)^2$. Given that this is not our main focus, we would not discuss this in much detail.

The second {N, Y} and third {Y, N} cases are of symmetric nature, so we discuss just one of them. Considering that firm 1 chooses for CSR activities and firm 2 does not, outcomes in subgame perfect equilibrium of this game are as follow [4] : $\mathrm{p_{YN}} = \frac{1}{4}(\mathrm{a} + 3\mathrm{c})$; $q_{1YN} = \frac{1}{2}(\mathrm{a} - \mathrm{c})$, $q_{2YN} = \frac{1}{4}(\mathrm{a} - \mathrm{c})$; $\beta_{1YN} = \frac{1}{3}, \beta_{2YN} = 0$; $\pi_{1YN} = \frac{1}{8}(a - c)^2 - Z_1$, $\pi_{2YN} = \frac{1}{16}(a - c)^2$. This case is very interesting is a sense that the firm which engages in CSR activities get higher share of the market share than its competition along with relatively higher profit[5]. Moreover, though the firm is committing to CSR activities i.e. giving positive weight to consumer surplus in their objective function, they are able to generate higher profit. One plausible explanation for the same is this. Due to CSR orientation, firm becomes more aggressive in the product market competition and produces more than Cournot level of output. Given that quantity choice is strategic substitute in nature, the other firm reduces its output. Interestingly, we observe that firm 1 (CSR firm) has output and profit level equivalent to Stackelberg leader whereas firm 2 has outcomes of Stackelberg follower in the product market competition.

Proposition 1: *Every firm has incentive to commit for CSR as a strategy. This leads to Stackelberg leader and follower outcome for the CSR and no CSR firms respectively.*

Given that every firm gains by committing for CSR, the last case {Y, Y} is analyzed next. Coming to the solution, we observe that,$\mathrm{p_{YY}} = \frac{(-3+\sqrt{17})(a+4c)}{1+\sqrt{17}}$; $q_{1YY} = q_{2YY} = \frac{2(a-c)}{1+\sqrt{17}}$; $\beta_{1YY} = \beta_{2YY} = \frac{1}{4}(5 - \sqrt{17})$; $\pi_{1YY} = \frac{(-3+\sqrt{17})(a-c)^2}{9+\sqrt{17}} - Z_1$, $\pi_{2YY} = \frac{(-3+\sqrt{17})(a-c)^2}{9+\sqrt{17}} - Z_2$. Here we

[4] In these cases, the second order and stability conditions are satisfied if $\beta_i < 2 \; for \; i = 1,2$.

[5] Here we make the assumption that cost of CSR activity, $Z_1 < \frac{1}{16}(a - c)^2$, that is difference in the profit between firm 1 (CSR) and firm 2 (No CSR). We will analyze the threshold conditions of cost of provision of CSR activities in the coming section.

observe that when both the firms commit for CSR, both the firms produce more than Cournot case and generate lower profit. So if both the firms commit for CSR, this leads to worse outcomes for both. This creates a Prisoner's Dilemma situation because there is unilateral private incentive of committing for CSR, but the final outcome is worse than non-commitment. We discuss this outcome in detail in next section.

3. To CSR or not to CSR: Endogenous choice of CSR activities

In this section, we analyze what are the possible feasible outcomes of the game, of four possible scenarios considered above.

The structure of the game in stage 1 and corresponding pay-offs are depicted in Table 1.

Table 1: Whether to CSR or not: Pay-off Matrix

		Firm 2	
		No CSR (N)	CSR (Y)
Firm 1	No CSR (N)	$\pi_{1NN}, \quad \pi_{2NN}$	$\pi_{1NY}, \quad \pi_{2NY} - Z_2$
	CSR (Y)	$\pi_{1YN} - Z_1, \quad \pi_{2YN}$	$\pi_{1YY} - Z_1, \quad \pi_{2YY} - Z_2$

First we check whether there is a dominant strategy for a firm or not. For firm 1, we observe that if $\pi_{1YN} - Z_1 > \pi_{1NN}$ and $\pi_{1YY} - Z_1 > \pi_{1NY}$, then the dominant strategy is to "*CSR*". In this game, the subgame perfect equilibrium would be {CSR (Y), CSR (Y)}, if

$$0 < Z_1 < \frac{1}{72}(a-c)^2 \qquad (5)$$

$$0 < Z_2 < \frac{1}{72}(a-c)^2 \qquad (6)$$

Due to symmetric nature, we can say that if the cost of CSR for both the firms is below $\frac{1}{72}(a-c)^2$, then strategic choice of "To CSR" is the optimal condition.

Proposition 2 (Prisoner's Dilemma): *Given that cost of CSR activities is below a threshold,* $\frac{1}{72}(a-c)^2$*, the equilibrium of the game is "CSR, CSR" and the profit would be sub-optimal than "No CSR, No CSR".*

Proof: Using the proposition 1 and discussion above, both firms have "CSR" as their dominant strategy under symmetric costs. Therefore, the solution of the game is "CSR, CSR". Further, we find that $\pi_{1NN} > \pi_{1YY}$, irrespective of the level of cost of CSR. This indicates that equilibrium outcome is sub-optimal, leading to Prisoner's Dilemma situation. QED.

3.1 Endogenous Stackelberg Equilibrium

Next, we explore the possibility of Stackelberg equilibria in this game, in the spirit of Basu (1995). For that we need to satisfy two conditions for each firm: i) For Firm 1: $\pi_{1YN} - Z_1 > \pi 1NN$, ii) For Firm 2: $\pi 2YN > \pi 2YY - Z2$ (or vice versa). These conditions lead to:

$$i)\ \pi_{1YN} - Z_1 > \pi_{1NN} \implies Z_1 < \frac{1}{72}(a-c)^2$$

$$ii)\ \pi_{2YN} > \pi_{2YY} - Z_2 \Rightarrow Z_2 > \frac{-57a^2 + 15\sqrt{17}a^2 + 114ac - 30\sqrt{17}ac - 57c^2 + 15\sqrt{17}c^2}{144 + 16\sqrt{17}}$$

To satisfy these two conditions simultaneously, $Z_2 - Z_1 > \frac{1}{144}(-110 + 27\sqrt{17})(a-c)^2$. If Z_2 is sufficiently large than Z_1, we can observe Stackelberg outcome in subgame perfect equilibrium of the game[6].

Proposition 3 (Stackelberg Equilibria): *A firm emerges as endogenous leader if there is sufficient CSR cost advantage over the other firm.*

Comparing this result with Basu (1995), we bring forth two main arguments.

First, in Basu (1995), the firms were considered asymmetric in terms of their cost of production, whereas we consider cost of production to be same for both the firms. Basu (1995) argues that either cost of production asymmetry or cost of hiring a manager asymmetry is the key force that drives the Stackelberg outcome in the game. He demonstrates that if cost of production asymmetry exists then for positive but symmetric costs of hiring a manager, Stackelberg outcomes would be the subgame perfect equilibria of the game.

[6] One point to be noted here is that if cost of CSR activity is same for both the firms, then emergence of Stackelberg solution is not possible. We have to introduce some sort of asymmetry between the firms to get Stackelberg outcomes for the game.

Second, since we consider that the cost of production is same for both the firms, subgame perfect equilibria corresponding to Stackelberg outcomes emerge from substantial difference between costs of engaging in CSR activities. A justification for different cost of CSR activities for firms can be given in terms of matching of their real and pseudo goals. We can say that if the firm has an orientation for CSR activity and then uses it for strategic purpose, will have to incur lesser economic cost, as compared to another firm which has no orientation for it but still uses it for strategic advantage in the product market competition.

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