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Environmental corporate social responsibility : A note on the first-mover advantage under price competition

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Abstract

We consider a model in which two firms choose whether to adopt environmental corporate social responsibility policies and then face Stackelberg competition under price competition. We show that the first-mover has the advantage, which is in contrast to the second-mover advantage typically seen in standard price competition models.

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1 Introduction

The industrial organization literature has extensively debated whether the first or second mover earns larger profits. As Gal-Or (1985) and Dowrick (1986) showed in symmetric duopolies, for strategic substitutes (complements), the first mover (second mover) has the advantage under the stability condition. Under standard condition, the strategies are strategic complements under price competition (Vives, 1999). Thus, under price competition, the second mover naturally enjoys an advantage. In this study, we incorporate environmental corporate social responsibility (ECSR) into the standard price competition model and show that this property does not holds.

ECSR has received increasing attention from broad research in social sciences. In particular, economic researchers have discussed this issue intensively (Liu *et al.*, 2015) because many listed firms are highly concerned about ECSR (KPMG, 2013). CDP (2013), for example, reported that some major companies such as ExxonMobil, Walt Disney, Walmart, and Microsoft use an internal (implicit) carbon price as an incentive and strategic planning tool, although their internal carbon prices differ significantly, ranging from 6 to 60 dollars per ton.[1]

In this study, we investigate Stackelberg competition after firms choose whether to adopt ESCR. We show that only the follower adopts ECSR. This follower's behavior increases the firms' profits, and further increases the leaders' profits. As a result, this price competition model shows a first-mover advantage. This result is in sharp contrast to the standard result showing a second-mover advantage under price competition.

This study contains another implication. It explains why profit-maximizing firms adopt ECSR and may explain why the degree of ECSR is different among firms. There are two well-known reasons why profit-maximizing firms adopt ECSR. One is that ECSR is connected with the advertisement or reputation of firms; thus, it eventually increases the demand, thereby earning the firms more profits (see Liu *et al.* (2015) and the works cited therein). The other is that voluntary agreement may serve as a countermeasure for the regulatory threat by the government, which allows firms to avoid more severe regulation (Maxwell *et al.*, 2000; Antweiler, 2003). Without those assumptions, we show that firms strategically choose ECSR because it serves as a commitment device.

This study is closely related to the literature using a delegation game with strategic reward contracts, which are a popular topic in the management science and industrial organization literature. Fershtman (1985), Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987) made groundbreaking theoretical contributions in this regard. They considered the separation of owners and managers and examined the following two-stage game. In the first stage, the owners write managers' reward contracts and announce them publicly. In the second stage, having read the contracts, the managers maximize payoffs. In these studies, the managers' rewards are proportional either to a linear combination of profits and outputs or to profits and firm revenues. Later, researchers investigated different types of strategic contracts based on relative performance or market share. In fact, management rewards often positively relate to firm revenues, market share, and/or relative performance,

[1] We should say from 0 to 60 dollars because some firms not reported in CDP do not introduce explicit internal carbon prices.

as well as their own profits. Because the model formulation in these studies provides an approximation of reality and explains much of the actual firm behaviors, it has become one of the most popular models in industrial organization and management science.

The incentive of such delegation has been analyzed in oligopoly theory, which is mainly focused on models of quantity competition (strategic substitute cases). Clearly, if we consider a model of price competition in this framework, the owners must attribute a negative weight to outputs, revenues, market share, or relative profits. It is, however, much less sustained from the empirical perspectives.[2] In our study, we discuss the commitment through adopting an ECSR policy. We believe that our formulation is more natural to address such firm's commitment for many industries than the standard delegation setting.[3]

2 The Model

We assume a standard differentiated duopoly with linear demand (Dixit, 1979). The quasi-linear utility function of the representative consumer is $U(q_1, q_2) = \alpha(q_1+q_2)-\beta(q_1^2+2\delta q_1 q_2+q_2^2)/2+y$, where y is the consumption of an outside good provided competitively with a unit price. Parameters α and β are positive constants, and $\delta \in (0, 1)$ represents the degree of product differentiation, where a smaller δ indicates a larger degree of product differentiation.

Firms 1 and 2 produce differentiated commodities for which the inverse demand function is given by $p_i = \alpha - \beta q_i - \beta\delta q_j$ $(i = 1, 2,\ i \neq j)$, where p_i and q_i are firm i's price and quantity, respectively. The common marginal production cost is constant and normalized to zero. Firm i's emission level producing a negative externality is ηq_i.[4]

The owners of firm i's payoff is π_i, and management's payoff is $V_i = \pi_i - \theta_i \eta q_i$, where $\theta_i (\geq 0)$ is an internal (implicit) emission price, representing the degree of ECSR and determined by the profit-maximizing owner of firm i.[5]

The game runs as follows. In the first stage, the owner of firm i independently chooses θ_i. In the second stage, firms choose their prices sequentially (Stackelberg competition).

[2]For empirical evidence, see Murphy (1985) and Coughlan and Schmidt (1985). These empirical studies suggest that negative weight on these variables is not realistic. Matsumura and Matsushima (2012) showed that firms put positive weight on a location-then-price model because it has a positive effect on location choice, and this effect dominates the negative effect on price choice.

[3]For example, most listed firms in Japan, as well as many Japanese economic associations, such as the Japan Association of Corporate Executives, the Japan Business Federation, the Japan Iron and Steel Federation, and the Federation of Electric Power Companies of Japan emphasize ECSR in their reports and websites.

[4]If we introduce an emission abatement activity that is independent of its production level, we obtain the same qualitative results.

[5]Our analysis is equivalent to the following scenario discussed in Graff Zivin and Small (2005) and Baron (2007). Firm i commits to donating a monetary amount to $\theta_i \eta y_i$ for environmental improvements, the management of firm i maximizes its net profit (the profit after subtracting the cost of donation), and the owner considers the corporate donation and private giving as perfect substitutes.

3 Results

First, we discuss the second-stage price competition. Firm 1 chooses its price and then firm 2 chooses its price. The first-order condition for firm 2 is

$$\frac{\partial V_2}{\partial p_2} = \frac{\alpha(1-\delta) + \eta\theta_2 - 2p_2 + \delta p_1}{\beta(1-\delta^2)} = 0.$$

The reaction function for firm 2 is

$$R_2(p_1) = \frac{\alpha(1-\delta) + \eta\theta_2 + \delta p_1}{2}.$$

Firm 1 maximizes $\pi_1(p_1, R_2(p_1)) - \theta_1\eta q_1(p_1, R_2(p_1))$ with respect to p_1. The first-order condition is

$$\frac{\alpha(-2+\delta+\delta^2) + \eta((\delta^2-2)\theta_1 - \delta\theta_2) + (4-2\delta^2)p_1}{2\beta(-1+\delta^2)} = 0.$$

The Stackelberg equilibrium is

$$\begin{aligned}
p_1 &= \frac{\alpha(-2+\delta+\delta^2) + \eta((-2+\delta^2)\theta_1 - \delta\theta_2)}{2(-2+\delta^2)} \\
p_2 &= \frac{\alpha(4-2\delta-3\delta^2+\delta^3) - \eta(\delta(-2+\delta^2)\theta_1 + (-4+\delta^2)\theta_2)}{4(2-\delta^2)} \\
\pi_1 &= \frac{(\alpha(-2+\delta+\delta^2) + \eta((-2+\delta^2)\theta_1 - \delta\theta_2))(\alpha(-2+\delta+\delta^2) - \eta((-2+\delta^2)\theta_1 + \delta\theta_2)))}{8\beta(-2+\delta^2)(-1+\delta^2)}, \\
\pi_2 &= \frac{H}{16\beta(-2+\delta^2)^2(1-\delta^2)},
\end{aligned}$$

where $H := (\alpha(4-2\delta-3\delta^2+\delta^3) + \eta(\delta(2-\delta^2)\theta_1 + (3\delta^2-4)\theta_2))(\alpha(4-2\delta-3\delta^2+\delta^3) - \eta(\delta(-2+\delta^2)\theta_1 + (\delta^2-4)\theta_2)$.

We now discuss the first-stage actions.[6] The owner of firm i chooses θ_i. The first-order conditions are

$$\begin{aligned}
\frac{\partial \pi_1}{\partial \theta_1} &= \frac{\eta^2(2-\delta^2)\theta_1}{4\beta(-1+\delta^2)} = 0, \\
\frac{\partial \pi_2}{\partial \theta_2} &= \frac{\eta(\delta^2(\alpha(4-2\delta-3\delta^2+\delta^3) - \eta\delta(-2+\delta^2)\theta_1) - \eta(16-16\delta^2+3\delta^4)\theta_2)}{8\beta(-2+\delta^2)^2(1-\delta^2)} = 0.
\end{aligned}$$

The equilibrium θ_i is

$$\theta_1 = 0, \;\; \theta_2 = \frac{\alpha(-1+\delta)\delta^2(\delta^2-2\delta-4)}{\eta(16-16\delta^2+3\delta^4)} := \theta^F > 0. \tag{1}$$

[6] In this study, we assume that firms choose θ simultaneously. Our results hold true if firms choose θ sequentially.

The resulting profits are

$$\pi_1 = \frac{\alpha^2(-1+\delta)(-2+\delta^2)(-8-4\delta+4\delta^2+\delta^3)^2}{2\beta(1+\delta)(4-3\delta^2)(-4+3\delta^2)} := \pi^L$$

$$\pi_2 = \frac{\alpha^2(-1+\delta)(-4-2\delta+\delta^2)^2}{4\beta(1+\delta)(4-\delta^2)(-4+3\delta^3)} := \pi^F.$$

We obtain the following result.

Proposition 1 *Only the follower adopts ECSR, and this increases both firms' profits. The leader earns the larger profit (i.e., first-mover advantage appears).*
Proof First, we show that $\pi^L > \pi^F$.

$$\pi^L - \pi^F = \frac{\alpha^2(\delta-1)\delta^5\left(5\delta^3+4\delta^2-16\delta-16\right)}{4\beta(\delta+1)\left(4-3\delta^2\right)^2\left(\delta^2-4\right)^2} > 0.$$

Let us now check that ECSR increases both firms' profits. Firm 2 chooses $\theta_2 = \theta^F$ in equilibrium, and thus, firm 2's profit must be larger than that when $\theta_1 = \theta_2 = 0$. Firm 1's profit is less than firms 2's if $\theta_1 = \theta_2 = 0$ (i.e., the second mover has the advantage under standard price competition setting). Because $\pi^L > \pi^F$ and ECSR increases firm 2's profit, it increases firm 1's profit as well. ■

Each firm has an incentive to commit to a higher price in order to induce the rival's higher price. The price leader chooses its price, and then the follower chooses its price. Thus, the leader can directly commit to a higher price without using ECSR. Therefore, choosing a positive θ has no strategic value for the leader. In contrast, for the follower, ECSR has strategic value because the follower can commit to setting a higher price by choosing a positive θ as it increases the marginal cost. Observing a positive θ, the leader expects the higher price of the follower and also sets a price higher than that without the follower's ECSR, because the leader's pricing strategy is strategic complement. Firm 2's strategic behavior (less aggressive pricing rather than profit-maximizing pricing) benefits firm 1 and yields the first-mover advantage.

This result is in sharp contrast to the standard result under price competition. Gal-Or (1985) showed that when two symmetric firms move sequentially under price competition, the follower enjoys the second-mover advantage. Although we assume that the firms are identical, there is a difference between the leader and the follower in terms of adopting ECSR. This generates heterogeneity between the two firms and changes the profit ranking between the first and second movers.

Gal-Or (1987) and Shinkai (2000) also suggested that the standard result shown in Gal-Or (1985) may not hold under an incomplete information game. They assumed that the first mover has informational advantage, and the action of the first mover reveals its information. They showed that this signaling effect may change the profit ranking among the first and second movers. The mechanism of our study is completely different from theirs because we discuss the complete information game.

Ono (1978) considered a duopoly in a homogeneous product market with cost asymmetry. He showed that the firm with lower (higher) cost prefers the role of the leader (follower) if the cost difference is sufficiently large. Van Damme and Hurkens (2004) and Amir and Stepanova (2006) showed that this holds true in a differentiated product market. In contrast, Hirata and Matsumura (2011) presented another duopoly model in a homogeneous product market in which the firm with higher (lower) cost prefers the role of the leader (follower) if the cost difference is sufficiently large. In other words, they have already shown that in some price competition models, there is no clear profit ranking (neither unanimous first-mover nor second-mover advantage exits) under large cost difference. There are two important differences between our model and theirs. One is that we do not assume exogenous cost difference between the two firms. The other is that in our model, both firms prefer the role of the leader.

We now discuss the welfare implications of ECSR. The total social surplus (firm profits plus consumer surplus minus the loss from the externality) is given by

$$SW = p_1q_1 + p_2q_2 + \left[\alpha(q_1+q_2) - \frac{\beta(q_1^2 + 2\delta q_1q_2 + q_2^2)}{2} - (p_1q_1 + p_2q_2)\right] - \eta(q_1+q_2).$$

Without ECSR, the total social surplus is

$$SW^N = \frac{\alpha\left(\alpha\left(5\delta^5 + 23\delta^4 - 28\delta^3 - 96\delta^2 + 32\delta + 96\right) - 8\eta\left(\delta^5 + 3\delta^4 - 6\delta^3 - 14\delta^2 + 8\delta + 16\right)\right)}{32\beta(\delta+1)\left(\delta^2-2\right)^2}$$

When the follower adopts ECSR, the total social surplus is

$$\begin{aligned} SW^E \quad = \quad & \frac{\alpha^2\left(5\delta^9 + 71\delta^8 - 92\delta^7 - 696\delta^6 + 496\delta^5 + 2336\delta^4 - 896\delta^3 - 3200\delta^2 + 512\delta + 1536\right)}{8\beta(\delta+1)\left(4-3\delta^2\right)^2\left(\delta^2-4\right)^2} \\ & - \frac{\alpha\eta\left(\delta^5 + 7\delta^4 - 12\delta^3 - 32\delta^2 + 16\delta + 32\right)}{2\beta(\delta+1)\left(\delta^2-4\right)\left(3\delta^2-4\right)}. \end{aligned}$$

We obtain

$$SW^E - SW^N = \frac{\alpha\delta^2\left(\delta^3 - 3\delta^2 - 2\delta + 4\right)G}{32\beta(\delta+1)\left(4-3\delta^2\right)^2\left(\delta^2-4\right)^2\left(\delta^2-2\right)^2},$$

where $G := 8\eta(3\delta^8 - 6\delta^7 - 34\delta^6 + 44\delta^5 + 136\delta^4 - 96\delta^3 - 224\delta^2 + 64\delta + 128) - \alpha(25\delta^8 - 2\delta^7 - 240\delta^6 + 24\delta^5 + 800\delta^4 - 32\delta^3 - 1088\delta^2 + 512)$. This is positive if and only if

$$\eta > \overline{\eta} := \frac{\alpha\left(25\delta^8 - 2\delta^7 - 240\delta^6 + 24\delta^5 + 800\delta^4 - 32\delta^3 - 1088\delta^2 + 512\right)}{8\left(3\delta^8 - 6\delta^7 - 34\delta^6 + 44\delta^5 + 136\delta^4 - 96\delta^3 - 224\delta^2 + 64\delta + 128\right)} > 0.$$

These lead to the following proposition.

Proposition 2 *ECSR improves welfare if and only if* $\eta > \overline{\eta}$.

There is a tradeoff between the environment and the anti-competitive effect. On one hand, ECSR reduces emissions that yield negative externalities. On the other hand, it raises the prices and reduces consumer surplus. Thus, it does not always have a beneficial effect on welfare. Because the equilibrium level of $\theta^F\eta$, the additional marginal cost due to ECSR, is independent of η, the equilibrium prices (and outputs) are independent of η. From the viewpoint of social welfare, the optimal outputs are decreasing in η. Therefore, the equilibrium outcome is more likely excessive when η is larger. If the degree of negative externalities is significant, the emission-reducing effect dominates the price-raising effect, and thus ECSR benefits welfare.

In energy-intensive industries, such as electricity, steel, cement, and some other heavy industries, the negative externality is significant, and thus the welfare improving effect of ECSR may be prominent. However, in industries with less significant negative externality (industries with low emission per output), it is possible that the price-raising effect dominates the emission-reducing effect. In this context, estimating the degree of negative externalities in industries (e.g., emission per unit of outputs) is important.[7]

Finally, we discuss outcomes for endogenous timing in the second-stage competition (i.e., when the first mover identity is endogenous). Consider the following model. The first stage remains the same as in the basic model; however, in the second stage, firms experience Hamilton and Slutsky's (1990) observable delay game.[8] As Hamilton and Slutsky (1990) showed, if two firms have the same costs, two Stackelberg equilibria (either firm 1 or firms 2 is the leader) exist. As Amir and Stepanova (2006) demonstrated, if the two firms have different costs (in our model if $\theta_1 \neq \theta_2$), the firm with the lower cost becomes the leader.[9] Thus, given $\theta_1 = 0$, firm 2 becomes the follower unless it chooses $\theta_2 = 0$. If it chooses $\theta_2 = 0$ and may become the leader, the leader's profit when $\theta_1 = \theta_2 = 0$ is less than π^F (because of the second-mover advantage under the standard price competition). If firm 2 becomes the follower, choosing $\theta_2 = \theta^F$ is optimal. Therefore, firm 2's best reply is choosing $\theta_2 = \theta^F$, thus becoming the follower in the subsequent game. Under these conditions, Stackelberg competition appears in equilibrium if the firms' roles are endogenous. Therefore, Stackelberg competition is natural in this context.

[7] For the empirical works on this problem, see Holland *et al.* (2016).

[8] The observable delay game is the most popular model among endogenous timing games and has been adopted extensively in various contexts. See Pal (1998), Bárcena-Ruiz (2007), and Matsumura and Ogawa (2014).

[9] Strictly speaking, two Stackelberg equilibria can exist, but the equilibrium with the lower-cost firm's leadership is risk dominant. In the context of price leadership, Ono (1978) first pointed out that the firm with lower costs becomes the price leader.

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