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Conflict and Corporate Social Responsibility in Duopoly

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Abstract

Background: Recent scientific research explains corporate social responsibility as an economic activity. This paper interprets social responsibility as a means of power to increase firms' market share in a duopoly. **Objectives:** This paper analyses the duopoly model in which firms decide on optimal social investments and production in two phases. The basic research question is how the significance of the conflict affects social investments, market shares, production quantities, profits, and social welfare. **Methods / Approach:** Conflict technology is described by contest success functions determining market shares. Game theory, optimization, and comparative statics are used in the analysis. **Results:** The conditions of equilibrium existence and its characteristics are described. Conflict adversely affects the profit of the inefficient firm while it favourably affects social welfare. Conflict's impact on an efficient firm's profit depends on the marginal cost difference. **Conclusions:** If there is no significant cost difference, it is more favourable for firms not to invest in socially responsible activities by agreement, which hurts social welfare. When marginal cost difference is significant, corporate social responsibility increases an efficient firm's profit, positively impacting social welfare.

Introduction

Corporate social responsibility has social, environmental, and economic effects. Previously, it was thought that social responsibility resulted from altruism or social pressure, and modern scientific research views corporate social responsibility as an economic activity. Thus, in addition to consumer goods, companies also offer social goods for which there is a demand (Kaul et al., 2018). Social responsibility can be modelled so that firms maximize the sum of profit and part of consumer surplus (Fanti et al., 2017a, 2017b, 2018). This approach to corporate social responsibility modelling is dominant in the recent scientific literature and is followed by Planer-Friedrich et al. (2020, 2021).

In this paper, the problem of corporate social responsibility is approached from a different perspective. The company invests significant resources in socially responsible activities to encourage consumers to buy its products. Such activities include environmental action, donations of material resources, and the promotion of nature conservation awareness. In this way, companies strengthen their market position. This paper's basic idea is that companies' socially responsible activities are modelled as costs that companies make to increase their market share in conflict with other companies. The costs of socially responsible activities are measurable and visible in the company's financial reports. Hirshleifer (1989, 1991) describes the economic foundations of conflict theory. This paper analyses equilibrium in a duopoly when corporate social responsibility affects the firms' market shares. Production technology is described by the firm's costs, while conflict technology is summarised in the contest success functions. The analysis uses game theory, optimization, and comparative static methods.

The basic research question is how the importance of conflict and economic efficiency of the firm affects the firm's profits, investments in socially responsible activities, market shares, production quantities, and social welfare. Firms make decisions in two phases. In the first phase, they simultaneously decide on socially responsible investments, and conflict technology determines market shares. In the second phase, each firm decides on the production quantity that depends on the marginal costs and market share. The firm aims to maximize profit, and the model is solved by backward induction. Special research questions are under what conditions equilibrium exists in the duopoly of socially responsible firms and its characteristics. Equilibrium features include answers to questions about how increasing the importance of conflict for market sharing affects investments in socially responsible activities, market shares, production, firm profits, and social welfare.

The purpose of this paper is to analyze the duopoly model in which socially responsible firms compete for market shares. This paper explains in a new way the economic motives of socially responsible behaviour of firms that act selfishly and maximize their profits. This model is not known in the literature and combines the theory of corporate social responsibility and conflict theory. In this way, a theoretical framework is proposed to analyze corporate social responsibility as a means of power to increase the firm's market share.

After the introduction, the paper provides an overview of the literature that includes recent models of corporate social responsibility and the most important research on conflict theory; in the following chapter, the model of the duopoly in which firms make decisions on optimal investments in socially responsible activities and the optimal amount of production in two phases is presented. The model is solved by the backward induction method. The analysis of the results examines how the change in the significance of the conflict affects investments in socially responsible activities, market shares, production quantities, and the firm's profits. The special focus is on

analyzing the impact of conflict and the efficiency of technology on social welfare. Then follows a discussion and conclusion that answers the research questions, describes the model's limitations, and makes suggestions for future research.

Literature review

Recent economic literature explains corporate social responsibility in a variety of ways. A comprehensive review of the theoretical and empirical literature on corporate social responsibility is provided by Schmitz et al. (2015). Lundgren (2011) complements the microeconomic analysis of corporate social responsibility with a comparative static analysis and dynamics of the parameterized model and connects the derived results with empirical findings. Xu (2014) analyses the duopoly of hospitals competing for price and quality. The model is an extension of Hotelling's model of duopoly (Hotelling, 1929). In the first phase, hospitals determine the level of quality, and in the second phase, they determine prices simultaneously. Scenarios with and without social responsibility are compared. It is shown that the duopoly of a public and private hospital can be more efficient than the duopoly of two private hospitals. Xie et al. (2015) analyze corporate social responsibility by applying evolutionary game theory. Kaul et al. (2018) model the social and consumer goods market. In the social goods market, a company competes with a non-profit organization and shows how corporate social responsibility affects shareholders and social welfare. Fanti et al. (2017b) analyze the problem of corporate social responsibility in a duopoly with differentiated products and show that the equilibrium depends on the level of product differentiation and the degree of corporate social responsibility. The degree of corporate social responsibility describes the share of consumer surplus, and the socially responsible firm maximizes the profit and part of consumer surplus. The backward induction method can show how business owners determine the degree of social responsibility in an unionized duopoly with a homogeneous product and how the union determines wages (Fanti et al., 2019). The same authors using game theory show how socially responsible businesses can be a barrier to entering the industry (Fanti et al., 2017a). Planer-Friedrich et al. (2020) analyze the oligopoly in a similar theoretical framework and show how corporate social responsibility can increase market concentration. By this approach, they show that in the asymmetric Cournot duopoly model, a more efficient company chooses a higher degree of social responsibility, produces more, and makes a higher profit. When the cost difference is significant, the less efficient firm leaves the industry (Planer-Friedrich et al., 2021).

The approach to corporate social responsibility, which is based on the inclusion of part of the consumer surplus in the goal function of the firm, does not explain the firm's significant investments in socially responsible activities. Since investments in socially responsible activities of firms seek to attract customers and strengthen their market position, in this paper, the market shares of individual firms are described by conflict technology. Relative success in conflict is described by contest success functions (Hirshleifer, 1989, 1991), which represent the probability of success or a proportional share of the prize for which the subjects compete. Since the relative success depends on the funds invested in the conflict, the models based on quotient and difference differ. The mass effect parameter describes the significance of the conflict. Hirshleifer (1989) shows how the significance of conflict affects the shape of the contest success function in different models. It is usually assumed in the economic literature that economic activities are consumption, production, and exchange of goods. It is unjustifiably neglected that economic entities invest significant funds to strengthen their position concerning others. Hirshleifer (1991) describes the equilibrium of two rivals when the resources at their disposal can be invested in joint production or conflict

activity. This model explains the paradox of power according to which conflict is relatively more attractive to the poorer side. Experiments testing the theoretical results of an analytical model of power are explained by Durham et al. (1998).

Model

The market demand curve is assumed to be linear, $p = a - by$, where p is the price of the product, $y \in \left[0, \frac{a}{b}\right]$ refers to the demanded quantity, and a and b are positive real numbers. There are two firms in the market, p_i and y_i are price and quantity determined by the firm i and $c_i \in [0, a)$ are constant marginal costs of the firms, $i = 1,2$. The demanded quantity can be expressed depending on the price $y = \frac{a-p}{b}$. Firm's market shares ϑ_i are determined by contest success functions

$$\vartheta_i = \frac{s_i^m}{s_1^m + s_2^m}, i = 1,2, \tag{1}$$

where $s_i \geq 0$ are investments in socially responsible activities of the firm i, and $m > 0$ is the mass effect parameter. If firms do not invest in socially responsible activities, it is assumed that it is $\vartheta_1 = \vartheta_2 = \frac{1}{2}$. Therefore, firm i faces a demand curve

$$y_i = \vartheta_i \frac{a-p_i}{b} \text{ or } p_i = a - \frac{b}{\vartheta_i} y_i.$$

The profit of firm i is given by:

$$\pi_i = (p_i - c_i)y_i - s_i = \left(a - \frac{b}{\vartheta_i} y_i - c_i\right) y_i - s_i, i = 1,2. \tag{2}$$

In the first step, firms decide on optimal investments in socially responsible activities. They decide on the optimal quantity to maximize profits in the second step. The model is solved by the backward induction method. From

$$\frac{\partial \pi_i}{\partial y_i} = a - c_i - \frac{2b}{\vartheta_i} y_i = 0$$

follows

$$y_i = \frac{\vartheta_i(a-c_i)}{2b}. \tag{3}$$

It implies

$$p_i = \frac{a+c_i}{2} \text{ and } p_i - c_i = \frac{a-c_i}{2}. \tag{4}$$

Therefore, the profit of firm i is

$$\pi_i = \frac{a-c_i}{2} \frac{\vartheta_i(a-c_i)}{2b} - s_i = \frac{(a-c_i)^2}{4b} \vartheta_i - s_i. \tag{5}$$

$R_1(s_1) = \frac{(a-c_1)^2}{4b} \vartheta_1$ can be interpreted as income from socially responsible investments, and firm 1 chooses the optimal s_1 which for given s_2 maximizes profit. From the necessary condition for an interior solution $\frac{\partial \pi_1}{\partial s_1} = 0$ equality between marginal revenue and unit marginal cost of socially responsible investments is obtained

$$\frac{\partial R_1}{\partial s_1} = \frac{(a-c_1)^2}{4b} \frac{\partial \vartheta_1}{\partial s_1} = \frac{(a-c_1)^2}{4b} \frac{ms_1^{m-1}s_2^m}{(s_1^m + s_2^m)^2} = 1.$$

It is analogous to firm 2, and a system of equations describes Nash Equilibrium

$$4b(s_1^m + s_2^m)^2 = m(a - c_1)^2 s_1^{m-1} s_2^m,$$

$$4b(s_1^m + s_2^m)^2 = m(a - c_2)^2 s_1^m s_2^{m-1} \quad (6)$$

and non-negative conditions of profits $\pi_1 \geq 0$ i $\pi_2 \geq 0$. By dividing, it is obtained:

$$\left(\frac{a-c_1}{a-c_2}\right)^2 \frac{s_2}{s_1} = 1$$

and system (6) is solved by the substitution method. The following results are obtained

$$s_1 = \frac{m(a-c_1)^2}{4b} \frac{(a-c_1)^{2m}(a-c_2)^{2m}}{[(a-c_1)^{2m}+(a-c_2)^{2m}]^2} \qquad (7)$$

$$\vartheta_1 = \frac{(a-c_1)^{2m}}{(a-c_1)^{2m}+(a-c_2)^{2m}} \qquad (8)$$

$$\frac{(a-c_1)^{2m+1}}{2b[(a-c_1)^{2m}+(a-c_2)^{2m}]} \qquad (9)$$

$$\pi_1 = \frac{(a-c_1)^{2m+2}[(a-c_1)^{2m}+(1-m)(a-c_2)^{2m}]}{4b[(a-c_1)^{2m}+(a-c_2)^{2m}]^2} \qquad (10)$$

Analogous results are obtained for firm 2. Suppose $m \leq 1$ the conditions of non-negative profits are met. For $m > 1$, it is:

$$\pi_1 \geq 0 \Leftrightarrow (a - c_1)^{2m} \geq (m - 1)(a - c_2)^{2m} \Leftrightarrow \frac{a - c_1}{a - c_2} \geq (m - 1)^{\frac{1}{2m}}$$

and

$$\pi_2 \geq 0 \Leftrightarrow \frac{a-c_2}{a-c_1} \geq (m - 1)^{\frac{1}{2m}} \Leftrightarrow \frac{a-c_1}{a-c_2} \leq (m - 1)^{-\frac{1}{2m}}.$$

Therefore for $m > 1$, the profits of both companies are non-negative if and only if

$$(m - 1)^{\frac{1}{2m}} \leq \frac{a-c_1}{a-c_2} \leq (m - 1)^{-\frac{1}{2m}}. \qquad (11)$$

It follows from inequality (11) that necessarily $m \leq 2$. If mass effect parameter $m > 2$, then Nash equilibrium does not exist.

Results

Previously calculated results can be presented in a simpler form after normalization $a = b = 1, c_1 = 0$ i $c_2 = c$, where without loss of the generality, it is assumed that firm 1 may potentially have lower costs. Then the description of Nash equilibrium for firm 1 is:

$$s_1 = \frac{m}{4} \frac{(1-c)^{2m}}{[1+(1-c)^{2m}]^2} \qquad (12)$$

$$\vartheta_1 = \frac{1}{1+(1-c)^{2m}} \qquad (13)$$

$$y_1 = \frac{1}{2[1+(1-c)^{2m}]} \tag{14}$$

$$\pi_1 = \frac{1+(1-m)(1-c)^{2m}}{4[1+(1-c)^{2m}]^2} \tag{15}$$

For firm 2 is:

$$s_2 = \frac{m(1-c)^2}{4} \frac{(1-c)^{2m}}{[1+(1-c)^{2m}]^2} \tag{16}$$

$$\vartheta_2 = \frac{(1-c)^{2m}}{1+(1-c)^{2m}} \tag{17}$$

$$y_2 = \frac{(1-c)^{2m+1}}{2[1+(1-c)^{2m}]} \tag{18}$$

$$\pi_2 = \frac{(1-c)^{2m+2}[(1-c)^{2m}+1-m]}{4[1+(1-c)^{2m}]^2} \tag{19}$$

It is important to note that the original results can be reconstructed from the normalized results if it is taken into account that it is $c = \frac{c_2-c_1}{a-c_1}$ whereby normalized y_i is multiplied by $\frac{a-c_1}{b}$, and normalized s_i and π_i are multiplied by $\frac{(a-c_1)^2}{b}$, $i = 1,2$. Given that it is for $m \in (1,2]$ satisfied $(m-1)^{\frac{1}{2m}} \leq 1 \leq \frac{1}{1-c}$ the condition of non-negativity of profits transforms to $\frac{1}{1-c} \leq (m-1)^{-\frac{1}{2m}}$. This condition can be written in equivalent ways

$$c \leq 1 - (m-1)^{\frac{1}{2m}} \tag{20}$$

and

$$m \leq 1 + (1-c)^{2m}. \tag{21}$$

The condition of non-negative profits (21) includes the case $m \leq 1$. The more significant the conflict for market sharing, the expression on the right in (20) is smaller, and the Nash equilibrium exists when the difference in firm costs is small enough.
From (15) and (19), it follows

$$\pi_1 - \pi_2 = \frac{1-(1-c)^{4m+2}+(1-m)(1-c)^{2m}[1-(1-c)^2]}{4[1+(1-c)^{2m}]^2}. \tag{22}$$

When there is a cost difference, and $m \leq 1$, the term (22) is positive. For $m > 1$ from the condition of non-negative profits (21), it follows $1 - m \geq -(1-c)^{2m}$. Then it is

$$1 - (1-c)^{4m+2} + (1-m)(1-c)^{2m}[1-(1-c)^2]$$
$$\geq 1 - (1-c)^{4m+2} - (1-c)^{4m}[1-(1-c)^2] = 1 - (1-c)^{4m} > 0$$

and again, expression (22) is positive. A more efficient firm invests more in socially responsible activities, has a higher market share, produces more, and makes a higher profit.

When firms do not invest in socially responsible activities, $s_i = 0$ i $\vartheta_i = \frac{1}{2}$ from (3) and (5) follows $\overline{y_i} = \frac{a-c_i}{4b}$ i $\overline{\pi_i} = \frac{(a-c_i)^2}{8b}$, that is, after normalization

$$\overline{y_1} = \frac{1}{4}, \overline{y_2} = \frac{1-c}{4}, \overline{\pi_1} = \frac{1}{8} \, i \, \overline{\pi_2} = \frac{(1-c)^2}{8}.$$

This relationship of firms in the market can be interpreted as a collusive equilibrium. Putting in (15) and (19) $m = 0$ implies

$$\pi_1(m = 0) = \frac{1}{8} = \overline{\pi_1} \text{ and } \pi_2(m = 0) = \frac{(1-c)^2}{8} = \overline{\pi_2}.$$

Therefore, collusive equilibrium can be interpreted as a marginal conflict equilibrium when the mass effect parameter m converges to zero.

If there is no difference in the efficiency of these firms, then their marginal costs are equal, $c = 0$. It follows from the description of equilibrium that firms divide the market into equal parts. Investments in socially responsible activities are equal, $s_i = \frac{m}{16}$, and each company supplies a quarter of the entire market. The profits of both companies are equal. The more significant the conflict is for market sharing, the greater the mass effect parameter m, and the more firms invest in socially responsible activities to maintain their market shares. Therefore, the conflict reduces the profits of both firms,

$$\pi_i = \frac{2-m}{16} = \frac{1}{8}\left(1 - \frac{m}{2}\right) = \overline{\pi_i}\left(1 - \frac{m}{2}\right).$$

When $c \in (0,1)$ from the equilibrium description, the market share and production of a more efficient firm increase when the mass effect parameter grows, while the market share and production of a less efficient company decrease. From (15) and (19) by derivation follows

$$\frac{\partial \pi_1}{\partial m} = \frac{(1-c)^{2m}V}{4[1+(1-c)^{2m}]^3}$$

where is $V = -2[\ln(1 - c)] * [1 + m + (1 - m)(1 - c)^{2m}] - [1 + (1 - c)^{2m}]$ (23)

and $\frac{\partial \pi_2}{\partial m} = \frac{(1-c)^{2m+2}Z}{4[1+(1-c)^{2m}]^3}$,

where is $Z = 2[\ln(1 - c)] * \{1 + (1 - c)^{2m} - m[1 - (1 - c)^{2m}]\} - [1 + (1 - c)^{2m}]$ (24)

As $m[1 - (1 - c)^{2m}] < m \le 1 + (1 - c)^{2m}$ due to the non-negative condition of profit (21), the expression in curly braces in (24) is positive and $Z < 0$. Therefore $\frac{\partial \pi_2}{\partial m} < 0$, and the conflict is economically unfavourable for the less efficient firm 2. The profit of firm 2 is smaller the more significant the conflict is. Term (23) can take on both signs, and for a more efficient company 1 conflict can be economically unfavourable

$$\pi_1\left(m = 1, c = \frac{1}{4}\right) = \frac{64}{625} < \frac{1}{8} = \pi_1\left(m = 0, c = \frac{1}{4}\right),$$

$$\pi_2\left(m = 1, c = \frac{1}{4}\right) = \frac{729}{40000} < \frac{9}{128} = \pi_2\left(m = 0, c = \frac{1}{4}\right),$$

or economically favourable

$$\pi_1\left(m = 1, c = \frac{1}{2}\right) = \frac{4}{25} > \frac{1}{8} = \pi_1\left(m = 0, c = \frac{1}{2}\right),$$
$$\pi_2\left(m = 1, c = \frac{1}{2}\right) = \frac{1}{400} < \frac{1}{32} = \pi_2\left(m = 0, c = \frac{1}{2}\right).$$

Conflict affects a more efficient company depending on the cost difference and the mass effect parameter. This numerical example shows that conflict attracts a more efficient company only when the cost difference is large enough. It is confirmed that the conflict is economically unfavourable for a less efficient company 2, regardless of the cost difference.

The social welfare function is the sum of companies' profits, investments in socially responsible activities, and consumer surplus. The consumer surplus from buying the product from the firm i is

$$CS_i = \int_0^{y_i} \left(a - \frac{b}{\vartheta_i} y_i\right) dy_i - p_i y_i = \frac{1}{4}(a - c_i)y_i = \frac{(a-c_i)^{2m+2}}{8b[(a-c_1)^{2m}+(a-c_2)^{2m}]}.$$

Total consumer surplus is:

$$CS = CS_1 + CS_2 = \frac{(a-c_1)^{2m+2}+(a-c_2)^{2m+2}}{8b[(a-c_1)^{2m}+(a-c_2)^{2m}]}$$

and the social welfare function is given by:

$$W = \pi_1 + \pi_2 + s_1 + s_2 + CS,$$

$$W = \frac{3[(a-c_1)^{2m+2}+(a-c_2)^{2m+2}]}{8b[(a-c_1)^{2m}+ (a-c_2)^{2m}]}.$$

After normalization, it is obtained

$$W = \frac{3[1+(1-c)^{2m+2}]}{8[1+(1-c)^{2m}]}. \tag{25}$$

If the conflict does not affect market share, follows $W(m = 0) = \frac{3[1+(1-c)^2]}{16}$. The derivation of the social welfare function by the mass effect parameter is positive when there is a difference in the costs of the company,

$$\frac{\partial W}{\partial m} = \frac{3\{(1-c)^{2m}[\ln(1-c)][(1-c)^2-1]\}}{4[1+(1-c)^{2m}]^2} > 0.$$

Social welfare function, W, is increasing in m, and conflict favourably affects social welfare when there is a difference in company costs. When there is no difference in the efficiency of the firms, $W(c = 0) = \frac{3}{8}$ is obtained, and the conflict has no impact on social welfare. Then social welfare is maximal, and higher investments in socially responsible activities compensate for lower company profits. From (25) follows $W(m = 1) = \frac{3[1+(1-c)^4]}{8[1+(1-c)^2]}$, and

$$W(m = 1, c = 0) = 0.375 \geq W(m = 1, c = 0.4) = 0.311 \leq W(m = 1, c = 0.9) = 0.371.$$

This numerical example shows that increasing the marginal cost difference can affect social welfare differently. It is interesting to note that increasing the marginal cost of production of a technologically inefficient firm can benefit social welfare.

Discussion

Corporate social responsibility can be a tool for businesses to attract consumers. A firm's market share is described by conflict technology, where firms can have different production costs. The more significant the conflict is for market sharing, the Nash equilibrium exists for the smaller cost difference. Suppose the marginal cost of production is equal. In that case, firms invest equally in socially responsible activities, divide the market into equal parts, have equal profits, and each firm supplies a quarter of the entire market. The more significant the conflict for market sharing, the fewer profits firms make because they invest more in socially responsible activities to maintain their market shares.

When there is a difference in production technology, a firm with lower marginal costs invests more in socially responsible activities, has a larger market share, produces more, and makes a higher profit. As the significance of the market-sharing conflict increases, the market share and production of the more efficient company increase, while the market share, production, and profit of the less efficient company decrease. How a change in the significance of the conflict affects the profit of a more efficient firm depends on the difference in marginal costs. When this difference is large enough, the profit of a more efficient firm increases, and the conflict is economically attractive for the more efficient firm. When the difference in the marginal costs is small, the conflict has an economically unfavourable effect on both firms. In this case, companies should act collusively, divide the market into equal parts and not invest in socially responsible activities.

When there is no difference in the efficiency of the firms, the conflict has no impact on social welfare. Then social welfare is maximal, and higher investments in socially responsible activities compensate for lower company profits. When there is a difference in the efficiency of the firms, the conflict positively affects social welfare. The more significant the conflict for market sharing, the greater the social welfare. An increase in the marginal cost of production of a technologically inefficient firm can benefit social welfare. In this paper, the analysis is limited to a duopoly in which companies make decisions on investments in socially responsible activities simultaneously. In reality, more firms in the industry may make decisions on investments in socially responsible activities sequentially.

Conclusion

This paper's basic idea is to interpret socially responsible businesses as a means of power to increase market share. In this way, a new duopoly model is presented, in which firms decide on optimal investments in socially responsible activities and production in two phases. Contest success functions describe market shares. In contrast, the mass effect parameter describes the importance of conflict for market sharing, and the model is solved by the backward induction method. This approach combines socially responsible business and conflict theory. Suppose there is no significant difference in production technology. In that case, it is more favourable for firms not to invest in socially responsible activities by agreement, negatively affecting social welfare. When the marginal cost difference is significant, corporate social responsibility is a means of power to increase the profit of an efficient firm, which reduces the profit of an inefficient firm and positively affects social welfare.

This model assumes that two companies are operating in the market and that decisions on investments in socially responsible activities are made simultaneously. Future research includes an analysis of corporate social responsibility in the oligopoly and the possibility of sequential decision-making.

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