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Optimal choice of relative performance indicator and product market competition

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Abstract

In this note, we explore what performance indicator is optimal in a product market competition, when firm's owner compensates managers based on the relative performance evaluation (RPE). Comparing the firm's own profit with competitor's profit, prior studies examine RPE with product market competition. However, in practices, other performance indicator is sometimes adopted as an indicator, in addition to profits. Based on this motivation, we demonstrate that owners adopt sales as a relative performance indicator to evaluate CEOs' performance in specific economic conditions. This result implies following contributions to RPE studies. First, our result will conduct the future research avenue about the choice of relative performance indicators. Second, our study has an important implication to empirical RPE research.

Keywords: Relative performance evaluation; performance indicator; quantity competition; managerial delegation; game theory
JEL Classification Codes: L13, L25, M41, D43

1. Introduction

Managerial performance evaluation in managerial compensation contracts is a significant issue in practices because managerial performance can improve firm-wide performance to enhance firm value. In practices, several examples provide an importance of the relative performance evaluation (RPE) as an incentive system. For example, JPMorgan Chase & Co. states that "In determining companies to include in the relative ROTCE scale, the CMDC selected competitors with business activities that overlap with at least 30% of the firm's revenue mix.

These are unchanged from earlier years. They include Bank of America, Barclays, Capital One Financial, Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, Morgan Stanley, UBS, and Wells Fargo".[1]

According to Bannister and Newman (2003) and Gong et al. (2011), in the U.S., firms adopt several indicators to evaluate the CEO based on RPEs in managerial compensation. For example, profits are not only compared with peer group, CEOs are evaluated by sales, firm value, or cash flow. One can infer that this practice proposes the following question: What indicator does enhance the profits for the case each firm faces? Focusing on profits and sales which are typical performance indicators in practice and economic research, we explore the above question based on an analytical model.

Previous studies conduct the analysis of managerial performance evaluation systems which include RPEs. Aggarwal and Samwick (1999) and Fumas (1992) demonstrate the optimal weight under RPEs, depending on the competition modes in a product market. Following their model, several studies investigate the impact of RPE on the strategies and profits (e.g., Hamamura 2021, 2022, Hamamura and Ramani 2023; Matsumura et al. 2013; Miller and Pazgal 2001). Jansen et al. (2009) is one of the important works to examine the optimal choice of performance indicators. According to Jansen et al. (2009), RPE improves firm profits, comparing with the quantity and market share as a performance indicator. Therefore, Jansen et al. (2009) supports the importance of shedding light on the RPE theoretically. Additionally, Manasakis et al. (2010) consider the choice of performance indicators from the relative profit, market share, and sales (revenue), and demonstrate that, in a specific economic condition, the RPE enhances the firms' profit. Lastly, while Fanti et al. (2017) also investigates the choice of performance indicators from the firm's own profit, relative profit, and sales, they assume the negotiation among the owner and CEO to decide the managerial compensation contract.

While several studies examine the optimal choice of evaluation *systems* with performance indicators, our study explore the optimal choice of the performance evaluation *indicator* under the RPE. In other words, previous studies assume that, depending on the performance evaluation system, the performance indicator is decided in the managerial compensation contract. However, in practice, the performance indicator does not always depend on the performance evaluation system, and one can wonder whether its difference leads to the optimal decision-making for the firm's profit. Therefore, we consider the choice of the performance indicator under the RPE in this note.

2. Model

Let us set the model. There are two firms, firm 1 and firm 2, in an industry that engages in quantity competition. Each firm produces goods by marginal cost c and sells it in a final product market. Both firms have an owner and CEO who is delegated decision rights by owners.

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[1] We obtained this information from JPMorgan Chase & Co. the Annual Meeting of Shareholders Proxy Statement 2021, p.48. URL: https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/investor-relations/documents/proxy-statement2021.pdf (Last accessed, May 2, 2022)

Firm i's owner maximizes following own firm's profit

$$\pi_i = (p_i - c)q_i, \quad i = 1, 2, \tag{1}$$

where p_i is market price, and q_i represents quantity of firm i. Firm i's owner chooses performance indicators to maximize Eq. (1). While we analyze the model which assumes RPEs to the CEO, which is established by Fuams (1992) and Aggarwal and Samwich (1999), we consider the choice of relative performance indicators by owners. Owners can choose relative performance indicators by the profit (Eq. (1)) or sales ($p_i q_i$) to maximize Eq. (1).

We assume that the CEO is compensated based on the RPE by the owner. When the firm adopts firm's profit as a relative performance indicator, the CEO's performance is decided by the following objective function:

$$O_i^P = \pi_i - \alpha_i \pi_j, \tag{2}$$

where superscript P signifies that the firm adopts the firm's profit as a relative performance indicator, and $0 < \alpha_i < 1$ is the constant of the weight placed on the competitor's profit. On the other hand, when the firm adopts the firm's sales as a relative performance indicator, the CEO's performance is decided by the following objective function:

$$O_i^S = p_i q_i - \alpha_i p_j q_j, \tag{3}$$

where superscript S signifies that the firm adopts the firm's sales as a relative performance indicator, and $0 < \alpha_i < 1$ is the constant of the weight placed on the competitor's sales. In this study, without loss of generality, we assume $\alpha_1 \leq \alpha_2$ for simplifying our discussion. In prior studies, $O_i^S = \pi_i - \alpha_i p_j q_j$ is assumed, and therefore, our assumption of its own sales leads to the uniqueness of our model.

This paper considers the choice of performance indicators when firms engage quantity competition in a product market, because Aggarwal and Samwich (1999) shows $\alpha_i < 0$ under quantity competition. When firms engage quantity competition in a product market, CEOs decide the quantity to maximize their performance considering the objective function. In this study, following previous RPE studies (e.g., Aggarwal and Samwich 1999), we assume the following demand function of firm i's product:

$$p_i = a - q_i - q_j, \tag{4}$$

where a is positive constant greater than c. In this study, we assume the homogenous goods for simplicity. Hereafter, (i, j) represents $(1,2)$ or $(2,1)$, when two valuables simultaneously appear in one equation.

The timeline of events proceeds as follows. At Date 1, each owner chooses relative performance indicators from the profit or sales to evaluate CEO. At Date 2, CEOs decide the quantity in a product market. At Date 3, profits and sales are realized. Lastly, the owner rewards to CEOs based on their objective function.

3. Analysis

We derive the sub-game perfect Nash equilibrium (SPNE) by backward induction. In this analysis, first, we derive the optimal solutions in Date 2 (2nd stage). After that, we consider profits to specify the SPNE.

3.1. 2nd stage solutions

We identify the optimal quantities in the 2nd stage under three cases: (i) both firms use the profit (denote as (P, P)), (ii) both firms use the sales (denote as (S, S)), and (iii) firm i uses the profit, and firm j uses the sales as a performance indicator (denote as (P, S)). We obtain the following outcomes in this stage.

$$q_i^{(P,P)} = \frac{(a-c)(1+\alpha_i)}{3+\alpha_i+\alpha_j-\alpha_i\alpha_j}, \qquad q_i^{(S,S)} = \frac{a(1+\alpha_i)}{3+\alpha_i+\alpha_j-\alpha_i\alpha_j},$$

$$q_i^{(P,S)} = \frac{a(1+\alpha_i)-2c}{3+\alpha_i+\alpha_j-\alpha_i\alpha_j}, \qquad q_j^{(P,S)} = \frac{a(1+\alpha_j)+c(1-\alpha_j)}{3+\alpha_i+\alpha_j-\alpha_i\alpha_j}. \tag{5}$$

where superscript $(i, j) = (P, P), (P, S), (S, P), (S, S)$ denotes combinations of performance indicator which is chosen by owners. From this outcome, one can confirm that when the firm sets the profit as a performance indicator, the quantity decreases as the marginal cost increases. On the other hand, when only the competitor uses the profit as an indicator, the quantity of the firm which adopts the sales as an indicator increases as the marginal cost increases. This outcome represents the positive effect of the sales as a performance indicator.

3.2. Optimal choice of performance indicators

From Eq. (5), we obtain following profits under three cases:

$$\pi_i^{(P,P)} = \frac{(a-c)^2(1+\alpha_i)(1-\alpha_i\alpha_j)}{\left(3+\alpha_i+\alpha_j-\alpha_i\alpha_j\right)^2},$$

$$\pi_i^{(S,S)} = \frac{a(1+\alpha_i)\left(a(1-\alpha_i\alpha_j)-c(3+\alpha_i+\alpha_j-\alpha_i\alpha_j)\right)}{\left(3+\alpha_i+\alpha_j-\alpha_i\alpha_j\right)^2}, \tag{6}$$

$$\pi_i^{(P,S)} = \frac{(a(1+\alpha_i)-2c)\left(a(1-\alpha_i\alpha_j)-c(2+\alpha_i-\alpha_i\alpha_j)\right)}{\left(3+\alpha_i+\alpha_i-\alpha_i\alpha_j\right)^2},$$

$$\pi_j^{(P,S)} = \frac{\left(a(1+\alpha_j)+c(1-\alpha_j)\right)\left(a(1-\alpha_i\alpha_j)-c(2+\alpha_i-\alpha_i\alpha_j)\right)}{\left(3+\alpha_i+\alpha_j-\alpha_i\alpha_j\right)^2}.$$

Under $c < a(1 - \alpha_i \alpha_j)/(2 + \alpha_i - \alpha_i \alpha_j) \equiv \bar{c}$, all of outcomes are positive, and second order condition is satisfied. Additionally, from this outcome, we can obtain $\pi_i^{(P,S)} = \pi_j^{(S,P)}$ and $\pi_i^{(S,P)} = \pi_j^{(P,S)}$ from the asymmetric payoff without weights. We represent this outcome as the following lemma.

Lemma 1. When both firms' CEOs are evaluated using profits or sales, we obtain the following outcomes in this case.

$$\pi_i^{(P,P)} = \frac{(a - c)^2 (1 + \alpha_i)(1 - \alpha_i \alpha_j)}{\left(3 + \alpha_i + \alpha_j - \alpha_i \alpha_j\right)^2},$$

$$\pi_i^{(S,S)} = \frac{a(1 + \alpha_i)\left(a(1 - \alpha_i \alpha_j) - c(3 + \alpha_i + \alpha_j - \alpha_i \alpha_j)\right)}{\left(3 + \alpha_i + \alpha_j - \alpha_i \alpha_j\right)^2}.$$

On the other hand, when firm i's CEO is evaluated using profit and firm j's CEO is evaluated using sales, quantities and profits in equilibrium is as follows:

$$\pi_i^{(P,S)} = \frac{(a(1 + \alpha_i) - 2c)\left(a(1 - \alpha_i \alpha_j) - c(2 + \alpha_i - \alpha_i \alpha_j)\right)}{\left(3 + \alpha_i + \alpha_i - \alpha_i \alpha_j\right)^2},$$

$$\pi_j^{(P,S)} = \frac{\left(a(1 + \alpha_j) + c(1 - \alpha_j)\right)\left(a(1 - \alpha_i \alpha_j) - c(2 + \alpha_i - \alpha_i \alpha_j)\right)}{\left(3 + \alpha_i + \alpha_j - \alpha_i \alpha_j\right)^2}.$$

From Lemma 1, we consider the best response strategies of firms. First, when the competitor adopts profit as a relative performance indicator, we consider $\pi_i^{(S,P)} - \pi_i^{(P,P)}$ to identify the best response strategy.

$$\pi_i^{(S,P)} - \pi_i^{(P,P)} = \frac{c\left(a(1 - \alpha_i - \alpha_j + 3\alpha_i \alpha_j) - c\left(3 + \alpha_j - \alpha_i(1 + 3\alpha_j)\right)\right)}{\left(3 + \alpha_i + \alpha_j - \alpha_i \alpha_j\right)^2}. \tag{7}$$

From this outcome, when

$$c < \frac{a(1 - \alpha_i - \alpha_j + 3\alpha_i \alpha_j)}{3 + \alpha_j - \alpha_i(1 + 3\alpha_j)} \equiv c_A, \tag{8}$$

is satisfied, $\pi_i^{(S,P)} > \pi_i^{(P,P)}$ is obtained. Because $c_A < \bar{c}$ is satisfied, $\pi_i^{(S,P)} > \pi_i^{(P,P)}$ is obtained under $0 < c < c_A$, and $\pi_i^{(S,P)} < \pi_i^{(P,P)}$ is obtained under $c_A < c < \bar{c}$. In other words, considering the best response strategy of firm i, when the rival sets the profit as a performance indicator, then the firm can enhance the profit by using the sales as a performance indicator under $0 < c < c_A$. We summarize this outcome as the following proposition.

Proposition 1. Firm i's best response strategy toward the rival's strategy P depends on the parameters. Formally, because we obtain $\pi_i^{(S,P)} > \pi_i^{(P,P)}$ under $0 < c < c_A$, firm i sets the sales as an indicator in this case. On the other hand, because we obtain $\pi_i^{(S,P)} < \pi_i^{(P,P)}$ under $c_A < c < \bar{c}$, firm i sets the profit as an indicator in this case.

The economic intuition behind this result is as follows. Comparing the profit, the firms can commit to supply the large quantity in the product market for the small marginal cost. This outcome implies that the sales become a commitment device for the credible threaten to reduce the rival's residual demand (positive effect). On the other hand, if the managers ignore the marginal cost, they supply quantities excessively (negative effect). While the firms can enhance the quantity in the product market using the sales as an indicator, when the firms face the large cost, the negative effect dominates the positive effect. However, under the small marginal cost, the positive effect dominates the negative effect.

Next, analyzing $\pi_i^{(S,S)} - \pi_i^{(P,S)}$, we consider the best response strategy of firms, when competitor adopts sales as a relative performance indicator.

$$\pi_i^{(S,S)} - \pi_i^{(P,S)} = \frac{c\left(a(1 - \alpha_i - \alpha_j - 3\alpha_i\alpha_j) - 2c(2 + \alpha_i - \alpha_i\alpha_j)\right)}{\left(3 - \alpha_i + \alpha_j + \alpha_i\alpha_j\right)^2}, \tag{9}$$

From this outcome, when

$$c < \frac{a(1 - \alpha_i - \alpha_j - 3\alpha_i\alpha_j)}{2(2 + \alpha_i - \alpha_i\alpha_j)} \equiv c_B, \tag{10}$$

is satisfied $\pi_i^{(S,S)} > \pi_i^{(P,S)}$ is obtained. Considering c_B and $\bar{c}$, because $c_B < \bar{c}$ is satisfied, $\pi_i^{(S,S)} > \pi_i^{(P,S)}$ is obtained under $0 < c < c_B$, and $\pi_i^{(S,S)} < \pi_i^{(P,S)}$ is obtained under $c_B < c < \bar{c}$. This outcome represents best response strategies of firms. From this analysis, we obtain the following proposition.

Proposition 2. Firm i's best response strategy toward the rival's strategy S depends on the parameters. Formally, because we obtain $\pi_i^{(S,S)} > \pi_i^{(P,S)}$ under $0 < c < c_B$, firm i sets the sales as an indicator in this case. On the other hand, we obtain $\pi_i^{(S,S)} < \pi_i^{(P,S)}$ under $c_B < c < \bar{c}$, firm i sets the profit as an indicator in this case.

Proposition 2 indicates that, under specific economic environment, owners adopt the sales as a best response.

Using Propositions 1 and 2, we specify the equilibrium. In particular, we specify the case in which S becomes a dominant strategy. In other words, we identify the SPNE where the firms set the sales as a performance indicator in equilibrium. We compare c_B with c_A, and when the common region is obtained, we can propose that the sales is adopted as a performance indicator in a unique equilibrium. We consider $c_A - c_B$ and get the following outcome.

$$c_A - c_B = \frac{\left(1 - \alpha_i - \alpha_j - 3\alpha_i\alpha_j\right)\left(1 - \alpha_j + \alpha_i(3 - 5\alpha_j)\right)}{2\left(2 + \alpha_i(1 - \alpha_j)\right)\left(3 + \alpha_j - \alpha_j(1 - 3\alpha_j)\right)}. \tag{11}$$

From this outcome and our assumption ($\alpha_1 < \alpha_2$), under $\alpha_2 > (1 + \sqrt{6})/5$, $c_A < c_B$ is obtained. Therefore, when $\alpha_1 < \alpha_2$ and $\alpha_2 > (1 + \sqrt{6})/5$ is satisfied, (S, S) arises as a unique equilibrium under $c_A < c < c_B$. We summarize this result as the following proposition.

Proposition 3. When $\alpha_1 < \alpha_2$ and $\alpha_2 > (1 + \sqrt{6})/5$ is satisfied, (S, S) arises as the unique equilibrium under $0 < c < c_A$. On the other hand, under $c_A < c < c_B$, (S, S) and (P, P) arise, and, under $c_B < c < \bar{c}$, (P, P) arises in equilibria.

The economic intuition behind this result is as follows. When c is extreme large, the impact of c is too small to choose the sales under the small α. However, when the firm sets the large weight placed on the rival's profit, firms commit to a very aggressive strategies in a product market. In this case, they cannot obtain the large market share because of the rival's commitment to an aggressive strategy. On the other hand, in this case, firms can use the sales as a new commitment device to supply the large quantity because when firms adopt the sales as a performance indicator, they can enhance the quantity from Eq. (5).

4. Discussion and conclusion

Under specific economic environments, we demonstrate that firms adopt the sales as a performance indicator under the RPE. In the U.S. practice, according to Gong et al. (2011),

about 25% of firms use RPE to determine the compensation of managers. Their survey demonstrates that firms evaluate the CEO by diverse indicators in RPE. Therefore, our analysis proposes one of the explanations of this practice, and therefore, our study suggests that it is important to consider the performance indicator under the RPE. Additionally, our analysis implies that the level of marginal cost has an important role to decide the performance indicator. This result indicates that, given the weights, when firms decide the performance indicator under the RPE, they should pay attention to the level of marginal cost as a managerial implication.

This study has following contributions. First, because this study is seminal work on the choice of relative performance indicators under product market competition, our result will conduct the future research avenue about the choice of relative performance indicators. While prior literature which considers product market competition assumes that owners evaluate CEOs using the profit as a relative performance indicator, our result suggests that other relative performance indicators may be adopted to evaluate CEOs in a specific economic environment. Therefore, we propose future research opportunities on the choice of relative performance indicators. Second, our study has an important implication to empirical research on RPE. Using an implicit approach, in empirical RPE, prior studies assume profit as a relative performance indicator (Joh 1999; Vrettos 2013). However, our outcomes demonstrate that the sales will be also adopted as a relative performance indicator in a specific economic environment, and empirical research may pay attention to the sales as one of the indicators.

From our work, one can consider the following future research. First, one can assume the price competition and endogenize the weight placed on the rival's profit. This paper considers only quantity competition, because we consider the negative weight put on competitor's profit in this research. In addition, we do not consider the endogenous choice of α in this research, because it is beyond our scope, and it is difficult to control the effect of weight and performance indicators. Second, in dynamic price competition, previous studies indicate that CEOs can engage in tacit collusion to obtain higher profits using the performance evaluation (Opp et al., 2014; Chen et al., 2024). On the other hand, other previous studies consider whether tacit collusion is effective, depending on the persistence of market leadership (Dou et al., 2021, 2022). Therefore, in future research, one can extend the model by adding a variable of the persistence of market leadership. Third, regardless of RPE, Bloomfield (2021) demonstrates the use of sales as a performance indicator under quantity competition. In other words, based on empirical results and theoretical analysis, our findings highlight the usefulness of empirical analysis of RPEs with sales as a performance indicator in the future. Lastly, one can assume the other performance indicator to evaluate the CEO by the relative performance. According to Bannister and Newman (2003) and Gong et al. (2011), there are a lot of performance indicators, and future research has an opportunity to examine other performance indicators.

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