

Research Note

Managerial Incentives in Price-Setting Mixed Duopoly Model with Complementary Goods

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Abstract

This paper examines a price-setting mixed duopoly model in which a state-owned public firm and a private firm produce complementary goods. There is no possibility of entry or exit. Each firm has one owner and can hire one manager to make its production decisions. The paper first analyzes the following four possible cases: neither firm hires a manager, only the private firm hires a manager, only the state-owned public firm hires a manager and both firms hire managers. It is shown that economic welfare is identical in all the four cases. Next, this paper presents the equilibrium of the model. The paper shows that there exist two equilibrium outcomes: only the public firm hires a manager and neither firm hires a manager. As a result, it is found that the equilibrium of the paper is contrast with that obtained under price-setting mixed duopoly competition with substitute goods, where both the public firm and the private firm hire managers.

Keywords: Bertrand model, managerial delegation, mixed duopoly, private firm, public firm

Introduction

The analysis by (White, 2001) examines firms' decisions whether to hire managers when a state-owned public firm with economic welfare objectives competes on quantity against private firms with profit objectives, and demonstrates that in equilibrium only private firms hire managers. (Fernández-Ruiz, 2009) examines managerial incentives in a quantity-setting mixed duopoly model where a state-owned public firm competes

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against a foreign private firm and demonstrates that in equilibrium both firms hire managers. (Bárcena-Ruiz, 2009) examines a price-setting mixed duopoly model in which a public firm and a private firm produce substitute goods and shows that in equilibrium both firms hire managers. In addition, (Ohnishi, 2018) examines a mixed duopoly model in which a state-owned public firm competes on price against a foreign private firm and demonstrates that there is an equilibrium solution in which only the foreign private firm hire a manager.

In this paper, we analyze managerial incentive contracts in price-setting mixed duopoly competition where a public firm and a private firm produce complementary goods. Each firm decides whether or not to hire a manager. We present the equilibrium of the model and as a result find that our equilibrium is contrast with that obtained under price-setting mixed duopoly competition with substitute goods.

Model

There are two firms. Firm C is a private firm that maximizes its own profit and firm S is a public firm that maximizes economic welfare. The duopolists produce complementary goods. Each firm has one owner and can hire one manager to make its production decisions. There is no possibility of entry or exit. Throughout this paper, subscripts C and S represent firm C and firm S, respectively. In addition, when i and j are employed in an expression, they should be understood to represent C and S with $i \neq j$. Following (Bárcena-Ruiz, 2009) and (Ohnishi, 2020), each firm's demand as a function of prices p_i and p_j is given by

$$q_i = \frac{a(1-b) - p_i + bp_j}{1-b^2}. \quad (1)$$

where $a \in (0, \infty)$ represents a constant and $b \in (-1, 0)$ is a measure of the degree of complementarity among products. For simplicity, we assume that $b = -0.5$. Each firm's profit is given by

$$\pi_i = (p_i - m)q_i - M_i, \quad (2)$$

where $m \in (0, a)$ represents the constant marginal cost of production and $M_i \in (0, \infty)$ is firm i 's manager's payoff (if hired). The owner of firm C seeks to maximize (2). Furthermore, economic welfare is given by

$$\begin{aligned} W &= CS + \pi_C + M_C + \pi_S + M_S \\ &= CS + (p_C - m)q_C + (p_S - m)q_S, \end{aligned} \quad (3)$$

where $CS = [p_0^2 - 2bp_0p_1 + p_1^2 + 2a(1-b)(a - p_0 - p_1)]/2(1-b^2)$ is consumer surplus. The owner of firm S aims to maximize (3).

The owner of firm i can hire a manager to make its production decisions. The manager of firm i seeks to maximize a function of firm i 's profit π_i and revenue R_i :

$$\begin{aligned} O_i &= \beta_i \pi_i + (1 - \beta_i) R_i \\ &= (p_i - \beta_i m) q_i, \end{aligned} \quad (4)$$

where $\beta_i \in [0, 1]$ can be interpreted as a discount factor on costs.

In this model, we consider the following three-stage situation. In stage one, each owner decides whether or not to hire a manager. In stage two, the owners who hired managers select incentive parameters for them. In stage three, the managers or, in their absence, the owners simultaneously and independently choose the firms' prices. We adopt subgame perfection as an equilibrium concept and solve the game model by backward induction.

Results

In this section, we first examine the following four possible cases: neither firm hires a manager, only the private firm hires a manager, only the public firm hires a manager and both firms hire managers. At the end of the section, we present the equilibrium of the model.

Neither firm hires a manager

In stage three, the owner of firm C maximizes its profit given by (2), while the owner of firm S maximizes economic welfare given by (3). Solving these maximization problems simultaneously, we obtain the following prices:

$$p_C^n = \frac{6a + m}{7}, \quad p_S^n = \frac{10m - 3a}{7}, \quad (5)$$

where the superscript "n" represents that neither firm hires a manager. These price choices imply:

$$q_C^n = \frac{8(a - m)}{7},$$

$$q_S^n = 2(a - m),$$

$$\pi_C^n = \frac{48(a - m)^2}{49},$$

$$\pi_S^n = \frac{6(a - m)(m - a)}{7},$$

$$CS^n = \frac{74(a - m)^2}{49},$$

$$W^n = \frac{80(a - m)^2}{49}.$$

Only firm C hires a manager

In this case, at the third stage, the manager of firm C maximizes the objective function given by (4), while the owner of firm S maximizes (3). These maximization problems lead to the following prices:

$$p_C^c = \frac{6a - 3m + 4m\beta_C}{7}, \quad p_S^c = \frac{12m - 3a - 2m\beta_C}{7}, \quad (6)$$

where the superscript “c” represents that only firm C hires a manager.

In stage two, the owner of firm C chooses the incentive parameter β_C to maximize (2). Therefore, the following is obtained:

$$\beta_C^c = 1. \quad (7)$$

Notice that the manager of firm C maximizes the profit of the firm. Therefore, the following is obtained:

$$\pi_C^c = \frac{48(a - m)^2}{49} - M_C,$$

$$\pi_S^c = \frac{6(a - m)(m - a)}{7},$$

$$W^c = \frac{80(a - m)^2}{49}.$$

In this case, the owner of firm C is required to pay M_C to its manager.

Only firm S hires a manager

In this case, at stage three, the manager of firm S maximizes the objective function given by (4), while the owner of firm C maximizes (2). These lead to the following prices:

$$p_C^s = \frac{9a + 8m - 2m\beta_S}{15}, \quad p_S^s = \frac{9a - 2m + 8m\beta_S}{15}, \quad (8)$$

where the superscript “s” indicates that only firm S hires a manager.

In stage two, the owner of firm S chooses the incentive parameter β_S to maximize economic welfare. Therefore, the following is obtained:

$$\beta_S^s = 1,$$

$$\pi_C^s = \frac{48(a - m)^2}{49},$$

$$\pi_S^s = \frac{6(a-m)(m-a)}{7} - M_S,$$

$$W^s = \frac{80(a-m)^2}{49}.$$

Both firms hire managers

If there is a manager at each firm, then the simultaneous maximization of these managers' objective functions can lead to the following price at stage three:

$$p_i^b = \frac{9a + 8m\beta_i - 2m\beta_j}{15}, \quad (9)$$

where the superscript "b" denotes that both firms hire managers.

In stage two, the owner of firm S choose β_S to maximize economic welfare, as given by (4), and the owner of firm C also chooses β_C to maximize (4). From simultaneous maximization of these objective functions, the following is obtained:

$$\beta_i^b = 1,$$

$$\pi_C^b = \frac{48(a-m)^2}{49} - M_C,$$

$$\pi_S^b = \frac{6(a-m)(m-a)}{7} - M_S,$$

$$W^b = \frac{80(a-m)^2}{49}.$$

In this case, each owner is required to pay M_i to its manager.

Finally, we present the equilibrium of the model. From the above analyses, we find that firm C never hires a manager. We also find that the managerial incentive contract is not profitable for the firms in the price-setting mixed duopoly model with complementary goods. The main result of this study can be described by the following proposition.

Proposition 1: In price-setting mixed duopoly competition comprising firm C and firm S, there exist two subgame perfect equilibrium solutions: neither firm hires a manager and only firm S hires a manager.

Conclusion

We have examined firms' decisions whether to hire managers when a public firm and a private firm produce complementary goods. We have shown that there exist two sub-

game perfect equilibrium outcomes. We have found that economic welfare is identical irrespective of whether a firm hires a manager, only the private firm hires a manager, only the public firm hires a manager or both firms hire managers.

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HOW TO CITE THIS ARTICLE

Ohnishi, K. (2021). Managerial Incentives in Price-Setting Mixed Duopoly Model with Complementary Goods. *International Journal of Management, Accounting and Economics*, 8(5), 362-367.

DOI: 10.5281/zenodo.5065856

URL: https://www.ijmae.com/article_132911.html

