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Price-setting mixed duopoly, subsidization and the order of firms' moves: the relevance of privatization

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Abstract

This paper first examines a price-setting mixed duopoly game with production subsidies where a public firm acts as a leader against a private firm. Second, the paper examines a price-setting duopoly game with production subsidies where the public firm remains a leader after privatization. Third, the paper compares the equilibrium values for private leadership with those for public leadership and shows that the optimal subsidy and economic welfare are higher in the privatized Stackelberg market than in the mixed Stackelberg market. In consequence, we find that our result makes a sharp contrast with that of quantity-setting market games.

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1. Introduction

In recent years, the theoretical analysis of privatization of public firms has been extensively studied by many researchers. For instance, White (1996) shows three effects of production subsidies in a mixed Cournot oligopoly market regarding privatization and efficiency. First, if production subsidies are used before and after privatization, then privatization does not change outputs, profits, consumer surplus and economic welfare. Second, if production subsidies are used before privatization, then economic welfare is always reduced. Third, the production subsidy contributes to overall efficiency because of cost distribution effects in a mixed Cournot market. Poyago-Theotoky (2001) extends the work by White (1996) and shows that the optimal production subsidy is identical irrespective of whether (i) a public firm and n private firms simultaneously choose output, (ii) the public firm is a Stackelberg leader, or (iii) all firms are profit-maximizers.

The following represents an example of a state-owned company operating in a historically monopolistic sector privatized in a recent wave of free market fundamentalism. The UK's Royal Mail was a public monopoly for more than three hundred years, but the UK's postal service market was fully opened to competition from January 1, 2006. Nonetheless, Royal Mail acted as a leader in price setting and introduced a new pricing method called Pricing in Proportion for first and second class mail, where prices were calculated based on the weight as well as the size of posted items. Furthermore, in 2013, Royal Mail was privatized and was floated on the London Stock Exchange. However, Royal Mail retained leadership after privatization and maintained earnings at a stable level as a consequence of the increased freedom over stamp prices (KPMG and Bocconi University, 2018).

Fjell and Heywood (2004) examine privatization of a public firm in a quantity-setting mixed Stackelberg oligopoly and show that when the public firm remains a leader after privatization, economic welfare will be reduced after privatization. In the postal service market described in the real-world example above, it can be said that price rather than quantity is a strategic choice variable for inter-firm competition. Therefore, we study privatization of a public firm in a price-setting mixed Stackelberg oligopoly.

The remainder of this paper is organized as follows. In Section 2, we describe the basic setting. Section 3 examines the mixed Stackelberg market. Section 4 studies the privatized Stackelberg market. Section 5 compares the result of the mixed Stackelberg market with that of the privatized Stackelberg market. Finally, Section 6 concludes the paper.

2. Basic setting

There is an industry composed of a public firm and a private firm producing imperfectly substitutable goods. In the remainder of this paper, subscripts 0 and 1 denote the public firm and the private firm, respectively. In addition, when i and j are used to refer to firms in an expression, they should be understood to refer to 0 and 1 with $i \neq j$. There is no possibility of entry or exit. The basic setting is taken from Barcena-Ruiz and Garzón (2007). Each firm's demand function is given by

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

where $a > 0$, $0 < b < 1$, and p is each firm's price. For the sake of simplicity, we assume $b = 0.5$. Each firm's profit is given by

$$\pi_i = (p_i - c + s)q_i \tag{2}$$

where c represents the total cost for each unit of output and s is the subsidy for each unit of output. The private firm seeks to maximizes (2). We assume $0 < c < a$ to assure that the firms' production levels are positive. We also assume that prices are positive.

Consumer surplus is given by

$$CS = U(q_0, q_1) - p_0 q_0 - p_1 q_1 \tag{3}$$

where $U(q_0, q_1) = a(q_0 + q_1) - (q_0^2 + q_0 q_1 + q_1^2)/2$. Economic welfare is

$$W = CS + \pi_0 + \pi_1 - s(q_0 + q_1) \tag{4}$$

The public firm aims to maximizes (4). In this paper, we solve for the subgame perfect equilibrium through backward induction.

3. Mixed Stackelberg market

We consider the following three-stage game. In stage one, the government chooses the production subsidy to maximize economic welfare. In stage two, the public firm sets its price. In stage three, the private firm sets its price. Starting from stage three, we obtain

$$p_1 = \frac{a + 2c - 2s + p_0}{4} \tag{5}$$

In stage two, the public firm chooses its price for a given subsidy level anticipating how its choice affects the private firm's price decision. Therefore, we obtain the equilibrium prices in terms of the subsidy:

$$p_0^{\mathrm{M}} = \frac{a + 6c - 2s}{7} \tag{6}$$

$$p_1^{\mathrm{M}} = \frac{2a + 5c - 4s}{7} \tag{7}$$

where the superscript "M" denotes the value of the mixed Stackelberg duopoly game.

In stage one, the government anticipates how its choice of subsidy affects firms' price choices and maximizes (4). Therefore, the optimal subsidy is

$$\bar{s}^{\mathrm{M}} = \frac{a - c}{2} \tag{8}$$

where the upper bar denotes the equilibrium value. Since $0 < c < a$, $\bar{s}^{\mathrm{M}}$ is strictly positive.

From (6) – (8), we derive the following subgame perfect equilibrium outcomes:

$$\bar{p}_0^{\mathrm{M}} = \bar{p}_1^{\mathrm{M}} = c$$

$$\bar{q}_0^{\mathrm{M}} = \bar{q}_1^{\mathrm{M}} = \frac{2(a - c)}{3}$$

$$\bar{W}^{\mathrm{M}} = \frac{2(a - c)^2}{3}$$

Note that the public leader's price and output are respectively identical with the private follower's price and output. Also note that each firm's price equals c.

4. Privatized Stackelberg market

In this section, we assume that the public Stackelberg leader is privatized. The private leader decides its price to maximize its profit for a given subsidy level anticipating the follower's reaction as given in (5). This results in

$$p_0^{\mathrm{P}} = \frac{5a + 9c - 9s}{14} \tag{9}$$

where the superscript "P" denotes the value of the privatized Stackelberg duopoly game. Furthermore, we obtain

$$p_1^{\mathrm{P}} = \frac{19a + 37c - 37s}{56} \tag{10}$$

The government sets the following subsidy level in order to maximizes economic welfare:

$$\bar{s}^{\mathrm{P}} = \frac{711(a - c)}{1333} \tag{11}$$

From (9) – (11), we can derive the following equilibrium outcomes:

$$\bar{p}_0^{\mathrm{P}} = \frac{19a + 1314c}{1333}$$

$$\bar{p}_1^{\mathrm{P}} = \frac{2701c - 35a}{2666}$$

$$\bar{q}_0^{\mathrm{P}} = \frac{2555(a-c)}{3999}$$

$$\bar{q}_1^{\mathrm{P}} = \frac{2774(a-c)}{3999}$$

$$\bar{W}^{\mathrm{P}} = \frac{5329(a-c)^2}{7998}$$

Note that the optimal subsidy no longer leads to symmetric prices and quantities in equilibrium.

5. Comparisons

In this section, we compare the equilibrium values for private leadership with those for public leadership. These comparisons can be depicted as follows:

$$\bar{s}^{\mathrm{P}} - \bar{s}^{\mathrm{M}} = \frac{89(a-c)}{2666}$$

$$\bar{p}_0^{\mathrm{P}} - \bar{p}_0^{\mathrm{M}} = \frac{19(a-c)}{1333}$$

$$\bar{p}_1^{\mathrm{P}} - \bar{p}_1^{\mathrm{M}} = -\frac{35(a-c)}{2666}$$

$$\bar{q}_0^{\mathrm{P}} - \bar{q}_0^{\mathrm{M}} = -\frac{37(a-c)}{1333}$$

$$\bar{q}_1^{\mathrm{P}} - \bar{q}_1^{\mathrm{M}} = \frac{36(a-c)}{1333}$$

$$\bar{W}^{\mathrm{P}} - \bar{W}^{\mathrm{M}} = \frac{2663(a-c)^2}{7998}$$

The optimal subsidy is higher under privatization. The main result of this study can be summarized in the following proposition.

Proposition 1: If privatization results in a public leader becoming a private leader, then the optimal subsidy, the leader's price, the follower's output and economic welfare are higher after privatization while the follower's price and the leader's output are lower.

This proposition states that our result makes a sharp contrast with that of

quantity-setting market games obtained by Fjell and Heywood (2004).

6. Conclusion

We have first considered a price-setting mixed duopoly game when a public firm acts as a leader against a private firm and have shown that the public leader's price and output are respectively identical with the private follower's price and output. Second, we have examined a price-setting duopoly game when the public firm remains a leader after privatization. Third, we have compared the equilibrium values for private leadership with those for public leadership and have shown that the optimal subsidy and economic welfare are higher in the privatized Stackelberg market than in the mixed Stackelberg market. Therefore, we have found that our result makes a sharp contrast with that of quantity-setting market games. In consequence, we see that if large public firms that have leadership compete in price with private firms, then governments that wish to improve economic welfare should implement policies that promote privatization of public firms.

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