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Lifetime Employment and Mixed Cournot Duopoly with State-Owned and Joint-Stock Firms

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Abstract

This paper examines a mixed duopoly model in which a state-owned firm competes with a joint-stock firm. The following two stages are considered. In the first stage, each firm can simultaneously and independently decide whether or not to offer lifetime employment as a strategic commitment. In the second stage, each firm simultaneously and independently chooses its actual output. The paper shows that there are two equilibrium solutions in the model.

Keywords: Joint-stock firm, lifetime employment, mixed duopoly, state-owned firm

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Introduction

The analysis of mixed market models that incorporate state-owned public firms has been widely performed by many researchers. For example, Mujumdar and Pal (1998) consider a mixed duopoly model in which a state-owned firm and a capitalist firm produce a homogeneous commodity, and show that an increase in tax (ad valorem or specific) does not change total output, but increases the output of the state-owned firm and the tax revenue. Poyago-Theotoky (1998) examines a mixed duopoly model in which firms compete to introduce a new product under uncertainty and easy imitation, and finds that the state-owned firm invests more in R&D than the capitalist firm. There are also lots of studies (for example, see Nett, 1993; Willner, 1994; Fjell and Pal, 1996; White, 1996; Pal, 1998; Chang, 2005; Beladi and Chao, 2006; Chao and Yu, 2006; Ohnishi, 2008; Saha and Sensarma, 2008; Lu and Poddar, 2009; Wang and Wang, 2009; Heywood and Ye, 2010; Wang and Lee, 2010; Zhang and Li, 2013; Pal and Saha, 2014).

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On the other hand, there are only a few theoretical studies on joint-stock firms. For example, Meade (1972) shows the differences in incentives, monopolistic behavior, short-run adjustment, macro-economic effects, and the importance of free entry among labor-managed, joint-stock and capitalist firms. Hey (1981) restricts attention to the case of a perfectly competitive firm producing a single output with two inputs, capital and labor, and examines the behavior of labor-managed, joint-stock and capitalist firms. Ohnishi (2010) examines a Cournot model in which a joint-stock firm and a capitalist firm can offer lifetime employment as a strategic commitment, and shows that there are two asymmetric equilibria in which only one firm offers lifetime employment. Furthermore, Ohnishi (2016) analyzes a three-stage game model in which a joint-stock firm and a state-owned firm sequentially offers lifetime employment before competing in quantities, and shows that there is an equilibrium in which only the joint-stock firm offers lifetime employment.

We study a Cournot game model of duopoly between a state-owned firm and a joint-stock firm. We consider the following situation. At stage 1, each firm can simultaneously and independently choose whether to offers lifetime employment or not, If firm i offers lifetime employment, then it chooses an output level and enters into a lifetime employment contract with the number of employees necessary to achieve the output level. At stage 2, each firm simultaneously and independently chooses its actual output level. We discuss the equilibrium of the model.

The purpose of this study is to show the effect of lifetime employment as a strategic commitment in a mixed duopoly model where a state-owned firm compete with a joint-stock firm.

The Model

Let us consider an economy composed of one state-owned firm (firm S) and one joint-stock firm (firm J). Throughout this paper, subscripts S and J denote firm S and firm J, respectively. There is no possibility of entry or exit. They produce perfectly substitutable products. The inverse demand function is given by $P(Q)$, where $Q = q_S + q_J$. We assume that $P' + P''q_i < 0$ (i = S, J) and $P'' \geq 0$. The timing of the game is as follows. In stage one, each firm can simultaneously and noncooperatively choose whether to offer lifetime employment or not. If firm i offers lifetime employment, then it sets a quantity level $q_i^* > 0$ and employs the number of workers necessary to achieve q_i^*. In addition, firm i makes a lifetime employment contract with the workers. In stage two, each firm simultaneously and noncooperatively chooses its actual quantity $q_i > 0$.

Firm S chooses q_S^* and q_S in order to maximize economic welfare, which is consumers' surplus plus total profits (producers' surplus):

$$W = \begin{cases} \int_0^Q P(x)dx - r(q_S) - w(q_S) - r(q_J) - w(q_J) - 2f & \text{if } q_S \geq q_S^* \\ \int_0^Q P(x)dx - r(q_S) - w(q_S^*) - r(q_J) - w(q_J) - 2f & \text{if } q_S \leq q_S^* \end{cases} \tag{1}$$

where r represents the capital cost function, w is the labor cost function, and $f > 0$ is the fixed cost. We assume that both firms face the same cost function and the marginal cost of production is rising, *i.e.* $r' > 0$, $r'' > 0$, $w' > 0$ and $w'' > 0$. This assumption is also made in many mixed oligopoly models (*e.g.*, see, Harris and Wiens, 1980; Ware, 1986; Delbono and Rossini, 1992; Nett, 1993; Delbono and Scarpa, 1995; Fjell and Pal, 1996; White, 1996; Pal and White, 1998; Poyago-Theotoky, 1998; Fjell and Heywood, 2002; Bárcena-Ruiz and Garzón, 2003; Matsumura and Kanda, 2005; Wang and Wang, 2009; Ohnishi, 2015).

On the other hand, firm J chooses q_J^* and q_J in order to maximize income per capital:

$$v_{\mathrm{J}} = \begin{cases} \dfrac{P(Q)q_{\mathrm{J}} - w(q_{\mathrm{J}}) - f}{k(q_{\mathrm{J}})} & \text{if } q_{\mathrm{J}} \geq q_{\mathrm{J}}^* \\ \dfrac{P(Q)q_{\mathrm{J}} - w(q_{\mathrm{J}}^*) - f}{k(q_{\mathrm{J}})} & \text{if } q_{\mathrm{J}} \leq q_{\mathrm{J}}^* \end{cases} \tag{2}$$

where k denotes the capital input function. We assume that both firms have the same technology and the marginal capital input is rising, *i.e.* $k' > 0$ and $k'' > 0$. We use subgame perfection to solve this game.

Equilibrium

In this section, we begin by giving some lemmas before providing the equilibrium of the model. First, we consider firm S's best response. If firm S's marginal cost of production is $r' + w'$, its reaction function is defined by

$$R_{\mathrm{S}}^n(q_{\mathrm{J}}) = \arg\max_{q_{\mathrm{S}} \geq 0} \left[\int_0^Q P(x)dx - r(q_{\mathrm{S}}) - w(q_{\mathrm{S}}) - r(q_{\mathrm{J}}) - w(q_{\mathrm{J}}) - 2f \right] \tag{3}$$

However, if firm S offers lifetime employment and lowers its marginal cost of production to r', its reaction function is defined by

$$R_{\mathrm{S}}^l(q_{\mathrm{J}}) = \arg\max_{q_{\mathrm{S}} \geq 0} \left[\int_0^Q P(x)dx - r(q_{\mathrm{S}}) - w(q_{\mathrm{S}}^*) - r(q_{\mathrm{J}}) - w(q_{\mathrm{J}}) - 2f \right] \tag{4}$$

Hence, if firm S chooses q_S^* and offers lifetime employment, its best reply is

$$R_{\mathrm{S}}(q_{\mathrm{J}}) = \begin{cases} R_{\mathrm{S}}^n(q_{\mathrm{J}}) & \text{if } q_{\mathrm{S}} > q_{\mathrm{S}}^* \\ q_{\mathrm{S}}^* & \text{if } q_{\mathrm{S}} = q_{\mathrm{S}}^* \\ R_{\mathrm{S}}^l(q_{\mathrm{J}}) & \text{if } q_{\mathrm{S}} < q_{\mathrm{S}}^* \end{cases} \tag{5}$$

Firm S seeks to maximize economic welfare with respect to its own output level, given firm J's output level. Therefore, the equilibrium needs to satisfy the following conditions: The first-order condition for (3) is

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$$P - r' - w' = 0 \tag{6}$$

and the second-order condition is

$$P' - r'' - w'' < 0 \tag{7}$$

On the other hand, the first-order condition for (4) is

$$P - r' = 0 \tag{8}$$

and the second-order condition is

$$P' - r'' < 0 \tag{9}$$

Furthermore, we obtain

$$R_S^n{}'(q_J) = -\frac{P'}{P' - r'' - w''} \tag{10}$$

and

$$R_S^l{}'(q_J) = -\frac{P'}{P' - r''} \tag{11}$$

From $P' < 0$, we can state the following lemma.

Lemma 1: Under Cournot competition, $R_S^n(q_J)$ and $R_S^l(q_J)$ both slope downward.

Second, we consider firm J's best response. If firm J does not offer lifetime employment, its reaction function is defined by

$$R_J^n(q_S) = \arg\max_{q_J \geq 0} \left[\frac{P(Q)q_J - w(q_J) - f}{k(q_J)} \right] \tag{12}$$

However, if firm J offers lifetime employment and produces $q_J \leq q_J^*$, its reaction function is defined by

$$R_J^l(q_S) = \arg\max_{q_J \geq 0} \left[\frac{P(Q)q_J - w(q_J^*) - f}{k(q_J)} \right] \tag{13}$$

Therefore, if firm J chooses q_J^* and offers lifetime employment, its best response is

$$R_J(q_S) = \begin{cases} R_J^n(q_S) & \text{if } q_J > q_J^* \\ q_J^* & \text{if } q_J = q_J^* \\ R_J^l(q_S) & \text{if } q_J < q_J^* \end{cases} \tag{14}$$

Firm J seeks to maximize income per capital by adjusting its output level, given firm S's output level. Therefore, the equilibrium needs to satisfy the following conditions: The first-order condition for (12) is

$$(P'q_J + P - w')k - (Pq_J - w - f)k' = 0 \tag{15}$$

and the second-order condition is

$$(P''q_J + 2P' - w'')k - (Pq_J - w - f)k'' < 0 \tag{16}$$

On the other hand, the first-order condition for (13) is

$$(P'q_J + P)k - (Pq_J - w^* - f)k' = 0 \tag{17}$$

and the second-order condition is

$$(P''q_J + 2P')k - (Pq_J - w^* - f)k'' < 0 \tag{18}$$

In addition, we have

$$R_J^n{}'(q_S) = -\frac{P''q_J k + P'(k - q_J k')}{(P''q_J + 2P' - w'')k - (Pq_J - w^* - f)k''} \tag{19}$$

and

$$R_J^l{}'(q_S) = -\frac{P''q_J k + P'(k - q_J k')}{(P''q_J + 2P')k - (Pq_J - w - f)k''} \tag{20}$$

From $k'' > 0$, we obtain $k - q_J k' < 0$, and therefore $P''q_J k + P'(k - q_J k')$ is positive. We now present the following lemma.

Lemma 2: Under Cournot competition, $R_J{}^n(q_S)$ and $R_J{}^l(q_S)$ both slope upward.

Third, we give a useful characterization of lifetime employment as a strategic commitment. From (1), it is obvious that lifetime employment never increases firm S's marginal cost of production. If firm S does not offer lifetime employment, the first-order condition for welfare maximization is (6). On the other hand, if firm S provides lifetime employment and lowers its marginal cost of production, the first-order condition for welfare maximization is (8). Here, w' is positive. Therefore, $P - r' - w'$ must be negative in order to satisfy (6). Thus, the offer of lifetime employment by firm S increases welfare-maximizing output level.

The case for firm J is also similar, and therefore we can state the following lemma.

Lemma 3: Firm *i*'s optimal output is higher when it offers lifetime employment than when it does not.

Lemma 3 says that if firm *i* offers lifetime employment, then its optimal output increases.

We now discuss the equilibrium of the model. First, suppose that only firm S can offer lifetime employment. Lemma 3 states that firm S's optimal output is higher when it offers lifetime employment than when it does not. Firm S's Stackelberg leader quantity is higher than its Cournot quantity without lifetime employment. In addition, $W = \int_0^Q P(x)dx - r(q_S) - w(q_S) - r(q_J) - w(q_J) - 2f$ is continuous and concave. $R_J^n(q_S)$ gives firm J's optimal quantity for each quantity of firm S. Therefore, firm S sets q_S^* higher than its Cournot quantity without lifetime employment and provides lifetime employment. If only firm S offers lifetime employment, economic welfare is more than in the Cournot game without lifetime employment.

Second, suppose that only firm J is allowed to offer lifetime employment. Lemma 3 states that firm J's optimal output is higher when it offers lifetime employment than when it does not. Firm J's Stackelberg leader output exceeds its Cournot output without lifetime employment. Furthermore, $v_J = [P(Q)q_J - w(q_J) - f] / k(q_J)$ is continuous and concave with respect to q_J. $R_S^n(q_J)$ gives firm S's optimal output for each output of firm J. Hence, if only firm J offers lifetime employment, its income per capital is more than in the Cournot game without lifetime employment.

Third, suppose that each firm chooses q_i^* and offers lifetime employment. From (5) and (14), we see that each firm's reaction function has a flat at q_i^*. $W = \int_0^Q P(x)dx - r(q_S) - w(q_S) - r(q_J) - w(q_J) - 2f$ is continuous and concave. Hence, firm S can increase economic welfare by reducing q_S^*. Firm S maximizes economic welfare by reducing q_S^* to a point of $R_S^n(q_J)$. Economic welfare is higher when only firm S offers lifetime employment than when both firms offer lifetime employment. In addition, $v_J = [P(Q)q_J - w(q_J) - f] / k(q_J)$ is also continuous and concave. Therefore, firm J can increase income per capital by reducing q_J^*. Firm J maximizes income per capital by reducing q_J^* to $R_J^n(q_S)$. Hence, firm J's income per capital is higher when only firm J offers lifetime employment than when both firms offer lifetime employment.

Our solution concept is subgame perfection, and all information is common knowledge. Thus, there is an equilibrium in which someone offers lifetime employment because cycling of choices is impossible.

Consider an equilibrium in which only firm S offers lifetime employment. Firm S's welfare-maximizing output is higher when it offers lifetime employment than when it does not. Therefore, $\partial v_J / \partial q_S$ is negative by perfect substitute goods. At this equilibrium, economic welfare is higher than in the Cournot game without lifetime employment, while firm J's income per capital is lower than in the Cournot game without lifetime employment.

Finally, consider an equilibrium in which only firm J offers lifetime employment. Increasing firm J's output improves economic welfare, given firm S's output. Firm S's optimal strategy needs to yield at least this economic welfare.

We now present the main result of this study.

Proposition 1: There exist two equilibria: (i) firm S's unilateral offer solution and (ii) firm J's unilateral offer solution. At (i), economic welfare is higher than in the Cournot game without lifetime employment while firm J's income per capital is lower than in the Cournot game without lifetime employment. At (ii), economic welfare and firm J's income per capital both are higher than in the Cournot game without lifetime employment.

Proposition 1 indicates that lifetime employment as a strategic commitment has a beneficial effect on both firm S and firm J.

Conclusion

We have examined a mixed market model in which a state-owned public firm competes with a joint-stock private firm and have shown that there are two equilibrium solutions: the state-owned firm's unilateral offer equilibrium and the joint-stock firm's unilateral offer equilibrium. Ohnishi (2015) examines a three-stage mixed duopoly model in which first a state-owned public firm moves and subsequently a joint-stock firm moves. We can note that the result of our simultaneous-move game is the same as that of Ohnishi's (2015) sequential-move game.

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