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International mixed triopoly, privatization and subsidization: Complementary goods

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Abstract

This paper examines the effects of production subsidies regarding privatization in an international mixed market where one state-owned firm coexists with domestic private and foreign private firms. The firms produce complementary goods. The paper considers four games: unsubsidized international mixed triopoly, subsidized international mixed triopoly, unsubsidized international private triopoly, and subsidized international private triopoly. The first two games are international mixed triopoly games in which a state-owned public firm, a domestic private firm and a foreign private firm coexist with each other, and the second two games are international private triopoly games in which the state-owned public firm is privatized. This paper demonstrates that if optimal production subsidies are used before and after privatization in an international mixed market with complementary goods, then privatization decreases domestic social welfare.

Keywords: Complementary goods; International mixed triopoly; Privatization; Subsidy

JEL classification: C72; D21; F23; L32

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1. Introduction

The seminal analysis by White (1996) investigates the effects of production subsidies in a Cournot mixed oligopoly market regarding privatization and presents the following results. First, if production subsidies are utilized only before privatization, there is a reduction in social welfare. Second, if production subsidies are utilized before and after privatization, privatization does not change social welfare. In addition, Ohnishi (2012) investigates the role that production subsidies play in a Bertrand mixed market and demonstrates that the results are essentially the same as those of Cournot mixed market models by White (1996). In general, many firms compete not only against domestic firms but also against foreign firms. Pal and White (1998) investigate the effects of privatization in the presence of strategic trade policies within an international mixed market where one state-owned firm compete against domestic private and foreign private firms. The oligopolists produce a homogeneous good. Pal and White demonstrate that if the government sets a domestic production subsidy optimally, then privatization always improves domestic social welfare.

In the real world, we can find a large number of examples of complementary goods such as coffee and sugar, cars and petrol, salad and salad dressing, black pens and red pens, and computer hardware and computer software. Therefore, we examine the effects of privatization in an international mixed market with complementary goods where one state-owned firm coexists with domestic private and foreign private firms. We consider four games: unsubsidized international mixed triopoly, subsidized international mixed triopoly, unsubsidized international private triopoly, and subsidized international private triopoly. In the first two games, we examine international mixed triopoly behavior in which a state-owned public firm, a domestic private firm and a foreign private firm coexist with each other, and in the second two games, we examine international private triopoly behavior in which the state-owned public firm is privatized. There are no import tariffs. The main purpose of this paper is to examine the effects of domestic production subsidies in an international mixed triopoly model with complementary goods regarding privatization.

The remainder of this paper is organized as follows. In Section 2, we describe the basic setting considered in this work. Section 3 solves and compares the four games. Finally, Section 4 concludes the paper.

2. Basic setting

There are three firms: a domestic private firm (firm D), a foreign private firm (firm F) and a state-owned public firm (firm S). The firms produce complementary goods. Throughout this paper, subscripts D, F and S represent firm D, firm F and firm S, respectively. In addition, when i , j and k are used to refer to firms in an expression, they should be understood to refer to D, F and S with $i \neq j \neq k$. We do not consider the possibility of entry or exit.

The inverse demand function is given by

$$p_i = a - q_i + b(q_j + q_k), \quad (1)$$

where $a \in (0, \infty)$ is a constant, and $b \in (0, 1)$ is a measure of the degree of complementarity among products. For the sake of simplicity, we assume $b = 0.5$. The firms have identical technologies represented by a quadratic cost function: $C(q_i) = c + q_i^2/2$. We assume $c = 0$, since entry decisions are not considered.

There is a continuum of consumers of the same type, and the representative consumer maximizes consumer surplus: $CS = U(q_D, q_F, q_S) - p_D q_D - p_F q_F - p_S q_S$, where q_i is the amount of good i and p_i is its price. The function $U(q_D, q_F, q_S)$ is quadratic: $U(q_D, q_F, q_S) = a(q_D + q_F + q_S) - (q_D^2 + q_F^2 + q_S^2 - q_D q_F - q_D q_S - q_F q_S)/2$.

Firm D's profit is given by

$$\pi_D = q_D \left[a - q_D + \frac{1}{2}(q_F + q_S) \right] - \frac{1}{2}q_D^2 + s q_D, \quad (2)$$

where s is the subsidy for each unit of output.

Firm F's profit is given by

$$\pi_F = q_F \left[a - q_F + \frac{1}{2}(q_D + q_S) \right] - \frac{1}{2}q_F^2. \quad (3)$$

Firm S's profit is given by

$$\pi_S = q_S \left[a - q_S + \frac{1}{2}(q_D + q_F) \right] - \frac{1}{2}q_S^2 + s q_S, \quad (4)$$

and domestic social welfare is given by

$$W = CS + \pi_S + \pi_D - s(q_S + q_D), \quad (5)$$

where firm F's profit is excluded from domestic social welfare. The government determines s to maximize (5).

3. Results

We consider the following four regimes: unsubsidized international mixed triopoly, subsidized international mixed triopoly, unsubsidized international private triopoly, and subsidized international private triopoly.

3.1. Unsubsidized international mixed triopoly

We present the Cournot equilibrium values when there is no subsidy:

$$q_D^M(0) = q_F^M(0) = \frac{70}{133}a, \quad q_S^M(0) = \frac{84}{133}a, \quad (6)$$

$$p_D^M(0) = p_F^M(0) = \frac{140}{133}a, \quad q_S^M(0) = \frac{119}{133}a, \quad (7)$$

$$\pi_D^M(0) = \pi_F^M(0) = \frac{150}{361}a^2, \quad \pi_S^M(0) = \frac{132}{361}a^2, \quad (8)$$

$$CS^M(0) = \frac{32}{361}a^2, \quad (9)$$

$$W^M(0) = \frac{314}{361}a^2. \quad (10)$$

Notice that $q_S^M(0)$ is higher than $q_D^M(0)$ and $q_F^M(0)$. Also notice that firm S makes a strictly positive profit.

3.2. Subsidized international mixed triopoly

We consider the international mixed triopoly game when the government considers setting a production subsidy. The game has two stages. In the first stage, the government sets the production subsidy to maximize domestic social welfare. In the second stage, triopolists simultaneously and independently choose their output levels. We solve for the subgame perfect equilibrium through backward induction. Starting from the second stage, we obtain the

second-stage Cournot equilibrium outputs for a given subsidy:

$$q_D^M(s) = \frac{14a+11s}{28}, \quad q_F^M(s) = \frac{14a+3s}{28}, \quad q_S^M(s) = \frac{14a+7s}{28}. \quad (11)$$

Next, we consider the first stage of the game. In the first stage, the government takes into account how firms will react to the subsidy s and sets s to maximize (5). We obtain the welfare-maximizing subsidy as follows:

$$s^{M*} = \frac{12}{13}a. \quad (12)$$

Notice that s^{M*} is strictly positive. Therefore, we obtain the following subgame perfect equilibrium values:

$$q_D^M(s^{M*}) = \frac{157}{182}a, \quad q_F^M(s^{M*}) = \frac{109}{182}a, \quad q_S^M(s^{M*}) = \frac{133}{182}a, \quad (13)$$

$$p_D^M(s^{M*}) = \frac{73}{91}a, \quad p_F^M(s^{M*}) = \frac{109}{91}a, \quad p_S^M(s^{M*}) = a, \quad (14)$$

$$\pi_D^M(s^{M*}) = \frac{73947}{66248}a^2, \quad \pi_F^M(s^{M*}) = \frac{35643}{66248}a^2, \quad \pi_S^M(s^{M*}) = \frac{1539}{1352}a^2, \quad (15)$$

$$CS^M(s^{M*}) = \frac{54219}{66248}a^2, \quad (16)$$

$$W^M(s^{M*}) = \frac{106137}{66248}a^2. \quad (17)$$

Note that $W^M(s^{M*})$ is higher than $W^M(0)$. We present the following proposition.

Proposition 1: If optimal domestic subsidies are used in an international mixed triopoly with complementary goods, then $q_D^M(s^{M*}) > q_D^M(0)$, $q_F^M(s^{M*}) > q_F^M(0)$, and $q_S^M(s^{M*}) > q_S^M(0)$.

3.3. Unsubsidized international private triopoly

In the subsection, we solve for the Cournot equilibrium outcomes of the unsubsidized private triopoly game. Each triopolist chooses q_i to maximize its own profits. We obtain the following Cournot-Nash equilibrium outcomes:

$$q_D^P(0) = q_F^P(0) = q_S^P(0) = \frac{1}{2}a, \quad (18)$$

$$p_D^P(0) = p_F^P(0) = p_S^P(0) = a, \quad (19)$$

$$\pi_D^P(0) = \pi_F^P(0) = \pi_S^P(0) = \frac{3}{8}a^2, \quad (20)$$

$$CS^P(0) = 0, \quad (21)$$

$$W^P(0) = \frac{3}{4}a^2. \quad (22)$$

We compare the subsidized international mixed triopoly outcomes with those of the unsubsidized international private triopoly.

Proposition 2: If optimal domestic subsidies are used before but not after privatization of firm S in an international mixed triopoly with complementary goods, then $W^M(s^{M*}) > W^P(0)$.

Notice that optimal domestic subsidies make the international mixed triopoly game better for the government than the unsubsidized international private triopoly.

3.4. Subsidized international private triopoly

In this subsection, we follow the methodology of Subsection 3.2. Starting from the second stage, we present the second-stage Cournot equilibrium outputs for a given subsidy:

$$q_D^P(s) = q_S^P(s) = \frac{7a + 6s}{14}, \quad q_F^P(s) = \frac{7a + 2s}{14}. \quad (23)$$

The first stage of the game is considered. In stage one, the government takes into account how firms will react to the subsidy s and determines s to maximize (5). The welfare-maximizing subsidy is obtained as follows:

$$s^{P*} = \frac{7}{12}a. \quad (24)$$

Note that s^{P*} is strictly positive. We now obtain the following subgame perfect equilibrium outcomes:

$$q_D^P(s^{P^*}) = q_S^P(s^{P^*}) = \frac{3}{4}a, \quad q_F^P(s^{P^*}) = \frac{7}{12}a, \quad (25)$$

$$p_D^P(s^{P^*}) = p_S^P(s^{P^*}) = \frac{11}{12}a, \quad p_F^P(s^{P^*}) = \frac{7}{6}a, \quad (26)$$

$$\pi_D^P(s^{P^*}) = \pi_S^P(s^{P^*}) = \frac{27}{32}a^2, \quad \pi_F^P(s^{P^*}) = \frac{49}{96}a^2, \quad (27)$$

$$CS^P(s^{P^*}) = \frac{1}{72}a^2, \quad (28)$$

$$W^P(s^{P^*}) = \frac{119}{144}a^2. \quad (29)$$

We compare the two subsidized games and present the following two propositions.

Proposition 3: In the two subsidized games,

$$\begin{aligned} q_D^M(s^{M^*}) &> q_D^P(s^{P^*}), \quad q_F^M(s^{M^*}) < q_F^P(s^{P^*}), \quad q_S^M(s^{M^*}) > q_S^P(s^{P^*}), \\ q_D^M(s^{M^*}) + q_F^M(s^{M^*}) + q_S^M(s^{M^*}) &> q_D^P(s^{P^*}) + q_F^P(s^{P^*}) + q_S^P(s^{P^*}), \\ \pi_D^M(s^{M^*}) + \pi_S^M(s^{M^*}) &> \pi_D^P(s^{P^*}) + \pi_S^P(s^{P^*}), \\ \pi_D^M(s^{M^*}) - s^{M^*} q_D^M(s^{M^*}) + \pi_S^M(s^{M^*}) - s^{M^*} q_S^M(s^{M^*}) &> \pi_D^P(s^{P^*}) - s^{P^*} q_D^P(s^{P^*}) + \pi_S^P(s^{P^*}) - s^{P^*} q_S^P(s^{P^*}), \\ \pi_F^M(s^{M^*}) &> \pi_F^P(s^{P^*}), \text{ and} \\ CS^M(s^{M^*}) &> CS^P(s^{P^*}). \end{aligned}$$

This result is the same as Proposition 3.2 in Pal and White (1998) except the profits of firm F. We present the welfare effects of privatization when production subsidies are utilized before and after the action.

Proposition 4: In the two subsidized games, $W^M(s^{M^*}) > W^P(s^{P^*})$.

We find that the result of this proposition is quite different from Proposition 3.3 in Pal and White (1998).

4. Conclusion

We have examined the effects of domestic production subsidies in an international mixed triopoly model with complementary goods. We have shown that if optimal domestic subsidies are used before and after privatization, then domestic social welfare is decreased by privatization. We have investigated an international mixed market without import tariffs. In the near future, we will examine various international economic models where import tariffs exist.

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