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# The relationship between privatization and corporate taxation policies

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**Abstract**
We investigate how the corporate (profit) tax rate affects the optimal degree of privatization in a mixed duopoly with a minimal profit constraint for the private firm. We show that the profit tax rate directly affects the behavior of the partially privatized firm, and therefore affects the behavior of the private firm through strategic interactions. Regardless of whether the constraint is binding, the optimal degree of privatization increases with the corporate tax rate. The reason is that an increase of corporate tax rate reduces the profits flowing to foreign investors, which mitigates the welfare losses of privatization. Furthermore, the optimal degree of privatization decreases (increases) with the foreign ownership share in the private firm if the constraint is ineffective (effective). This result suggests that a minimal profit constraint can be crucial in the optimal privatization policy.

**Keywords** Profit tax · Minimal profit constraint · Foreign ownership · Optimal public ownership

**Mathematics Subject Classification** D43 · H44 · L33

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## 1 Introduction

Privatization policy and corporate taxation policy are two important issues for governments. In many industries, we observe a considerable number of public enterprises coexisting with private enterprises (mixed oligopolies).[1] In planned and transitional economies such as China, Vietnam, and Russia, the presence of the public enterprises is further significant, with many state enterprises competing against private enterprises (Cai and Li 2011; Huang and Yang 2016; Huang et al. 2017; Fridman 2018). The optimal privatization policies in these mixed oligopolies attract extensive attention.[2] Corporate tax, one of the main taxes in many developed, developing, and transitional economies, changes firms' behavior under imperfect competition, thus affecting the privatization policy of the government, particularly in the presence of foreign competition. To improve the current understanding of how privatization and corporate taxation policies are connected, this study investigates their relationship in a mixed duopoly with the consideration of foreign penetration.

On markets where public firms compete against private firms, Matsumura (1998) shows that the optimal degree of privatization is neither zero nor one under moderate conditions in domestic duopoly markets. In addition, the literature on mixed oligopolies has investigated several important issues of privatization under the framework of free entry markets (Matsumura and Kanda 2005; Cato and Matsumura 2012; Chen 2017; Fujiwara 2007; Sato and Matsumura 2019b), international markets (Chang 2005, 2007; Lin and Matsumura 2012), demand-boosting activities (Han and Ogawa 2012), vertical related markets (Chang and Ryu 2015; Matsumura and Matsushima 2012; Wu et al. 2016) and so forth.

Another strand of the literature on mixed oligopolies discusses the relationship between tax-subsidy and privatization policies. Mujumdar and Pal (1998) show that production tax affects the behavior of private firms, which in turn affects the behavior of public firms through strategic interactions.[3] White (1996) investigates the optimal subsidy policy and finds that the privatization policy is irrelevant under the optimal subsidy policy (privatization neutrality theorem).[4]Cato and Matsumura (2015) discuss the relationship between the optimal import tariff and the optimal degree of privatization and show that a higher tariff rate reduces (increases) the

[1] Examples of public and semi-public enterprises include the United States Postal Service, Deutsche Post AG, and Japan Post in the overnight delivery industry; NTT in the telecom industry; Areva, Electricite de France, and Petro China Company in the energy industry; Volkswagen and Renault in the automotive industry; and Japan Postal Bank, Kampo, Korea Development Bank, Korea Investment Corporation, and the Industrial and Commercial Bank of China in the financial industry.

[2] For examples of mixed oligopolies and recent developments in this field, see (Pal and Saha 2014; Fridman 2018; Futagami et al. 2019; Sato and Matsumura 2019a; Escrihuela-Villar and Gutiérrez-Hita 2019), and the works cited therein.

[3] For a related discussion in free entry markets, see Cato and Matsumura (2019).

[4] Cato and Matsumura (2013) show that the privatization neutrality theorem holds in free entry markets by considering an optimal production subsidy and entry license tax. However, this theorem is not robust, because it does not hold unless the private firm has zero foreign ownership, both public and private firms have the same cost function, and there is no excess burden of taxation. See Matsumura and Tomaru (2012, (2013) and Lin and Matsumura (2018).

optimal degree of privatization in free entry (non-free entry) markets.[5] Tomaru and Wang (2018) find that the optimal subsidy yields efficient production allocation if privatization is not implemented. Lin and Matsumura (2018) show the privatization neutrality does not hold in the presence of cost asymmetry between public and private enterprises. However, no study has investigated corporate tax policy.

In this study, we propose a mixed duopoly model in which a state-owned public firm competes against a private firm with foreign investment. By introducing corporate tax policy and a minimal profit constraint for the private firm, we investigate the relationship between privatization and corporate tax policies.[6] In a private oligopoly, corporate tax does not affect firms' output levels. However, the corporate tax rate directly affects the output level of a partially privatized firm and thus, affects the output of the private firm through strategic interactions. We then investigate how the tax rate affects the optimal degree of privatization. We find that regardless of whether the constraint is binding, the optimal degree of privatization increases with the corporate tax rate. The main reason for this result is as follows. Privatization of the public firm generates two counteracting welfare effects: an efficiency enhancing effect which shifts production from the public firm to the private firm, and a profit grabbing effect which raises the profits flowing to the foreign investors. The government then strategically chooses the degree of privatization that balances these two effects. An increase in the corporate tax rate reduces the profit grabbing effect and thus induces the government to realize a higher degree of privatization.

We also investigate the relationship between foreign ownership share in the private firm and the optimal privatization policy. Foreign ownership in private firms plays an important role in mixed oligopolies because it affects the behavior of the public firm directly, therefore affecting the behavior of private firms through strategic interactions between the public and private firms.[7] How the effect of foreign ownership share on privatization changes with corporate taxation policy and minimal profit constraint is another issue worthy of discussion under a mixed oligopoly. We show that without the minimal profit constraint, the optimal degree of privatization decreases with the level of foreign ownership share in the private firm. However, the inverse is true when the minimal after-tax profit constraint is effective. This result suggests that the minimal after-tax profit constraint of the private firm may be crucial for the optimal privatization policy. Several studies have explored the impact of foreign ownership on privatization policy (Wang and Chen 2011; Wang and Tomaru 2015; Bárcena-Ruiz et al. 2020), but under different frameworks from ours. Thus, our paper is a novel contribution to the existing literature.

Our paper makes two important contributions to the existing literature on privatization policy. First, we introduce corporate taxation in the model of

[5] Chang (2005, (2007) also provides important contributions in terms of the relationship between the optimal degree of privatization and various other policies such as industrial and trade policies.

[6] We assume that if the minimal profit constraint is not satisfied, the private firm exits or does not enter the market.

[7] See (Corneo and Jeanne 1994; Fjell and Pal 1996; Bárcena-Ruiz and Garzón 2005a, b; Lin and Matsumura 2012), and Xu et al. (2016). Ghosh and Sen (2012) and Ghosh et al. (2015) discuss foreign firms and foreign ownership in differentiated product markets and provide important contributions.

privatization. Corporate taxation is the third largest source of federal revenue in the U.S. and the central government in Japan and the largest tax revenue source for the Tokyo Metropolitan government in Japan. The corporate tax rate in China averaged 29 percent from 1997 until 2018, reaching an all-time high of 33 percent in 1998 and a record low of 25 percent in 2008 (Urban Institute & Brookings Institute, and Trading Economics).[8] By investigating the relationship between these two important policies, our paper provides a better understanding of how they are connected and how they interact. We also show that privatization and corporate tax policies play a complementary role in the absence/presence of the minimal after-tax profit constraint as well as when both policies are endogenous. It is worth noting that the minimal after-tax profit constraint affects the relationship between the optimal privatization policy and the share of foreign ownership of the private firm, leading to opposite policy implications with and without the constraint. Our paper greatly enriches the existing literature and generates insightful policy implications for governments.

The rest of this paper proceeds as follows. Section 2 formulates the mixed duopoly model. Section 3 investigates how the corporate tax rate affects the optimal privatization policy. Section 4 introduces the minimal profit constraint. Section 5 endogenizes both the degree of privatization and the corporate tax rate. Section 6 concludes the paper.

## 2 The model

We consider a mixed duopoly model in which one state enterprise, firm 0, and one private enterprise, firm 1, compete against each other.[9] Firm 0 is owned by domestic (local) investors, including the government.[10] The foreign ownership share in firm 1 is $\beta \in [0, 1]$. Firms produce homogeneous products for which the inverse demand function is $p(Q)$, where $p$ is the price and $Q$ is the total output. We assume that $p$ is twice continuously differentiable and $p' < 0$ as long as $p > 0$. Each firm $i$'s cost

[8] For a discussion on privatization, capital income taxation, and foreign ownership of private firms, see Huizinga and Nielsen (2001).

[9] Our results hold in more general mixed oligopolies with $n$-private firms as long as all private enterprises are identical. Introducing heterogeneity among private firms significantly complicates the analysis. For discussions on heterogeneity among private firms, see Kim et al. (2019) and Haraguchi and Matsumura (2020c).

[10] The assumption that the investors in privatized firms are domestic is standard in the literature (Cato and Matsumura 2012; Chang 2005, 2007; Chang and Ryu 2015; Lee et al. 2018; Wu et al. 2016; Xu et al. 2016, 2017), and may be realistic. On the other hand, foreign investors may hold stakes in private firms. For example, the foreign private ownership share in the Postal Bank is about one-fifth of the Mitsubishi UFJ Financial Group. For discussions on foreign investors in privatized firms, see Lin and Matsumura (2012) and Sato and Matsumura (2019b).

function is $c_i(q_i)$ where $q_i$ is firm $i$'s output. We assume that it is twice differentiable, $c_i' > 0$, and $c_i'' \geq 0$.[11]

Firm $i$'s profit is $\pi_i = pq_i - c_i(q_i)$. The government imposes a corporate (profit) tax $t \in [0, 1)$ and the after-tax profit of firm $i$ is $(1-t)\pi_i$.[12]

Domestic (local) welfare $W$ is given by

$$W = \underbrace{\int_0^Q p(z)dz - pQ}_{\text{consumer surplus}} + \underbrace{(1-t)\pi_0 + (1-\beta)(1-t)\pi_1}_{\text{domestic industry profit}} + \underbrace{t(\pi_0 + \pi_1)}_{\text{tax revenue}}.$$

Following Matsumura (1998), the public firm's objective is a convex combination of welfare and its own after-tax profit, $\Omega = \alpha(1-t)\pi_0 + (1-\alpha)W$, where $\alpha \in [0, 1]$ represents the degree of privatization.[13] In the case of full nationalization (i.e., $\alpha = 0$), firm 0 maximizes welfare. In the case of full privatization (i.e., $\alpha = 1$), firm 0 maximizes its after-tax profit. The private firm's objective is its after-tax profit.

The complete information game runs as follows. In the first stage, the government chooses the degree of privatization to maximize local welfare. In the second stage, both firms simultaneously and independently choose their outputs. We

[11] This model formulation of the cost function covers several popular settings in the literature on mixed oligopolies. For example, if firms 0 and 1 have the same quadratic cost function, this formulation covers De Fraja and Delbono's (1989) model. De Fraja and Delbono (1989) assume that public and private firms have identical cost functions. However, our model also covers the widely used setup that allows the cost difference between public and private firms (Matsumura and Shimizu 2010; Kawasaki et al. 2020). If $c_0'' = c_1'' = 0$ and $c_0' > c_1'$, then the formulation transforms to Pal (1998) model, another important model in the literature on mixed oligopolies. See also Mujumdar and Pal (1998) and Haraguchi and Matsumura (2020a, (2020b). Moreover, our model contains the linear-quadratic cost function discussed by Haraguchi and Matsumura (2020d). As Matsumura and Okamura (2015) show, constant marginal cost and quadratic cost models can yield opposite policy implications in mixed oligopolies, which is why we believe that the formulation covering these models is important.

[12] If $\pi_i$ is negative, then the firm reduces the tax burden of other profitable departments, thus reducing the tax payment. Therefore, we can see that firm $i$'s after-tax profit is $(1-t)\pi_i$, even when it is negative. In our analysis, the equilibrium profit of firm 1 is non-negative but that of firm 0 can be negative if $\alpha$ is small, $\beta$ is large, and $c_i''$ is small.

Although we focus on a single market, public and semi-public firms often have several departments and compete over multiple markets. For example, Japan Post competes against private firms in the overnight delivery market, and owns Japan Post Bank that competes against private banks in the banking industry and Kampo that competes against private life-insurance companies in the insurance market. Thus, even if Japan Post has deficits in the overnight delivery market, it may be able to survive. In fact, Japan post has deficits in the overnight delivery sector for many years but profits from the banking and insurance departments have been able to offset these poor results. Moreover, it has a department which operates in a monopolistic framework with no influential competitors and another which competes with several strong private competitors. Similar structures are often observed in public and semi-public firms in mixed oligopolies.

Sinopec, the largest state-owned oil refiner in China, also operates in various business sectors within the oil industry, such as oil exploration, petroleum refining & chemical production, and retail & station operation. The petroleum refining and chemical production segment, operated by Sinopec Engineering (Group) Co., Ltd, had deficits in 2005 and 2006, when competing with Petro China. However, the profit from retail & station operation by Sinopec Fuel Oil Sales Co., Ltd. not only covered the deficit of the petroleum refining business but also made the group's overall business profitable.

[13] For empirical evidence on the welfare-related rather than the profit-maximizing objectives of public enterprises, see Seim and Waldfogel (2013) and Ogura (2018).

solve this game by backward induction and the equilibrium concept is the subgame perfect Nash equilibrium. We assume interior solutions in the last stage subgames (i.e., we assume that both firms produce positive output in the quantity competition stage).[14]

## 3 Equilibrium

First, we solve the second stage game given the degree of privatization, $\alpha$. Firm 0 chooses $q_0$ to maximize $\Omega$ (i.e., weighted sum of welfare and its own after-tax profit), which yields the first-order condition as

$$\alpha(1-t)p'q_0 + (1-\alpha t)(p - c_0') - \beta(1-\alpha)(1-t)p'q_1 = 0. \tag{1}$$

We assume that the second-order condition is satisfied.[15]

Firm 1 determines $q_1$ to maximize its after-tax profit. The first-order condition of firm 1 is

$$p - c_1' + p'q_1 = 0. \tag{2}$$

We assume that $p' + p''q_i < 0$ $(i = 0, 1)$, which ensures that firm 1's reaction curve is downward sloping, and that the second-order condition is satisfied. Firm 0's reaction curve can be upward sloping, and we can show that the stability condition is satisfied regardless of whether firm 0's reaction curve is upward or downward sloping (Matsumura 2003).

These two first-order conditions yield the equilibrium outputs in the second stage. Let $q_0^S(\alpha)$, $q_1^S(\alpha)$, and $Q^S(\alpha)$ be the equilibrium outputs of firm 0, firm 1, and the total level, respectively, in the second-stage subgame, where the superscript S denotes the second stage. Totally differentiating (1) and (2), we obtain

$$\frac{\partial q_0^S}{\partial \alpha} = -\frac{(p''q_1 + 2p' - c_1'')X_1}{X_2} < 0, \frac{\partial q_1^S}{\partial \alpha} = \frac{(p''q_1 + p')X_1}{X_2} > 0, \frac{\partial Q^S}{\partial \alpha} = -\frac{(p' - c_1'')X_1}{X_2} < 0, \tag{3}$$

where

$$X_1 = \frac{p'(1-t)\cdot[q_0 + \beta(1-t)q_1]}{1-\alpha t} < 0, \tag{4}$$

$$X_2 = (p' - c_1'')X_3 + (p''q_1 + p')\cdot[\alpha(1-t)p' - (1-\alpha t)c_0'' + \beta(1-\alpha)(1-t)p'] > 0, \tag{5}$$

[14] For this assumption, we exclude the case in which $c_0'' = c_1'' = 0$ and $c_0' = c_1'$. Note that in this case, a corner solution in the quantity competition stage emerges (i.e., $q_1 = 0$ in equilibrium) when $\alpha = 0$. Moreover, $\alpha$ is equal to zero in equilibrium in this case (Matsumura 1998).

[15] This second-order condition holds if $|p''|$ is small relative to $|p'|$ or $c_0''$ is sufficiently large.

$$X_3 = \alpha(1-t)(p''q_0 + p') - \beta(1-\alpha)(1-t)p''q_1 + (1-\alpha t)(p' - c_0'') < 0. \tag{6}$$

The results presented in (3) are standard in the literature on mixed oligopolies.[16]

Next, we investigate how $t$ affects the equilibrium outputs in the second stage given $\alpha$. Totally differentiating (1) and (2), we obtain

$$\frac{\partial q_0}{\partial t} = -\frac{(p''q_1 + 2p' - c_1'')X_4}{X_2}, \quad \frac{\partial q_1}{\partial t} = \frac{(p''q_1 + p')X_4}{X_2}, \quad \frac{\partial Q}{\partial t} = -\frac{(p' - c_1'')X_4}{X_2}, \tag{7}$$

where

$$X_4 = \frac{p'(1-\alpha)\cdot[-\alpha q_0 + \beta(1-\alpha)q_1]}{1-\alpha t}. \tag{8}$$

If $\alpha = 1$, then $X_4 = 0$. Therefore, neither $q_0$ nor $q_1$ depends on $t$, which implies neutrality of the profit tax if both firms are private.

From (1), we find that if $\alpha < 1$ and $p > c_0'$ ($p < c_0'$), then $X_4 > 0$ ($X_4 < 0$).[17] Therefore, from (4), (5), (7), and (8), we obtain the following lemma.

**Lemma 1** *(i) Suppose that $\alpha < 1$. Then $q_0^S$ and $Q^S$ are increasing (decreasing) in $t$ and $q_1^S$ is decreasing (increasing) in $t$ if $p > c_0'$ ($p < c_0'$). (ii) If $\alpha = 1$, then $q_0^S$, $q_1^S$, and $Q^S$ are independent of $t$.*

We explain the intuition behind Lemma 1. As $t$ increases, the weight of $\pi_1$ in $W$ increases, and the difference between domestic welfare and total welfare (including the surplus of foreign investors) decreases. Moreover, as $t$ increases, the weight of $\pi_0$ in firm 0's payoff decreases. For these two effects, as $t$ increases, the behavior of firm 0 is closer to marginal cost pricing that maximizes total welfare given $q_1$ and $\alpha$. Therefore, if $p > c_0'$ ($p < c_0'$), then a marginal increase in $t$ makes firm 0 more (less) aggressive. This is why $q_0^S$ is increasing (decreasing) in $t$ and $q_1^S$ is decreasing (increasing) in $t$ as long as $p > c_0'$ ($p < c_0'$).

Although $t$ does not directly affect the payoff of firm 1, $t$ affects $q_0$ and thus affects $q_1$ through strategic interactions. Because firm 1's reaction curve is downward sloping, the change in $q_1$ has the opposite sign as the change in $q_0$. Because the direct effect dominates this strategic effect, the change in $Q$ has the same sign as the change in $q_0$.

This mechanism does not work when $\alpha = 1$ because firm 0 does not care about the outflow of firm 1's profit to foreign investors and consumer surplus; thus, $q_0^S$, $q_1^S$, and $Q^S$ are independent of $t$ (i.e., neutrality of the profit tax).

Next, we investigate how $\beta$ affects the equilibrium outputs in the second stage given $\alpha$. Totally differentiating (1) and (2), we obtain

$$\frac{\partial q_0}{\partial \beta} = -\frac{(p''q_1 + 2p' - c_1'')X_5}{X_2} \geq 0, \frac{\partial q_1}{\partial \beta} = \frac{(p''q_1 + p')X_5}{X_2} \leq 0, \frac{\partial Q}{\partial \beta} = -\frac{(p' - c_1'')X_5}{X_2} \geq 0, \tag{9}$$

[16] Because we assume the second-order condition on the stage of quantity competition for firm 0, we obtain $d\Omega^2/d^2q_0 = X_3 < 0$.

[17] From (1), we obtain $(p - c_0') = [((1-t)p')/(1-\alpha t)]\cdot[-\alpha q_0 + \beta(1-\alpha)q_1]$. Thus, $p > c_0'$ if and only if $-\alpha q_0 + \beta(1-\alpha)q_1 < 0$. Therefore, $X_4 > 0$ if and only if $p > c_0'$.

where

$$X_5 = -(1-t)(1-\alpha)p'q_1 \geq 0. \tag{10}$$

The equality in (10) holds if and only if $\alpha = 1$.

From (5), (9), and (10), we obtain the following lemma.

**Lemma 2** *(i) If $\alpha < 1$, then $q_0^S$ and $Q^S$ are increasing in $\beta$ and $q_1^S$ is decreasing in $\beta$. (ii) If $\alpha = 1$, then $q_0^S$, $q_1^S$ , and $Q^S$ are independent of $\beta$.*

Again, from (1) we find that $\beta$ directly affects the behavior of firm 0 unless $\alpha = 1$. An increase in $\beta$ increases the outflow of firm 1's profit to foreign investors. To reduce this outflow, firm 0 increases its output as $\beta$ increases. Although $\beta$ does not directly affect firm 1's payoff, $\beta$ affects $q_0$ and thus affects $q_1$ through strategic interactions. Since firm 1's reaction curve is downward sloping, the change in $q_1$ has the opposite sign as the change in $q_0$. Because the direct effect dominates this strategic effect, the change in $Q$ has the same sign as the change in $q_0$.

We now investigate the first stage. The first-order condition for the government is

$$\frac{dW^S}{d\alpha} = \frac{\partial W}{\partial q_0}\frac{dq_0^S}{d\alpha} + \frac{\partial W}{\partial q_1}\frac{dq_1^S}{d\alpha} = -\frac{1}{1-\alpha t}\frac{X_1 p'}{X_2}X_6 = 0, \tag{11}$$

where

$$X_6 = -\alpha(1-t)[\beta(1-t)q_1 + q_0](p''q_1 + 2p' - c_1'') + (1-\alpha t)q_1(p''q_1 + p'). \tag{12}$$

We assume that the second-order condition is satisfied. Let $\alpha^E$ be the equilibrium degree of privatization.

Because $X_1 < 0$ and $X_2 > 0$, (11) is satisfied if and only if $X_6 = 0$. When $\alpha = 0$, $X_6 = q_1(q_1p'' + p') < 0$, and thus, $dW^S/d\alpha > 0$ at $\alpha = 0$. Therefore, we obtain $\alpha^E > 0$. Prior studies on mixed oligopolies also show this result (full nationalization of one firm is not optimal) in various contexts, and our finding suggests that this well-known result holds with the addition of a profit tax.[18]

When $\alpha = 1$, we get,

$$\begin{aligned} X_6 = (1-t)\{&[q_1 - q_0 - \beta(1-t)q_1]p''q_1 + [q_1 - 2q_0 - 2\beta(1-t)q_1]p' \\ &+ [\beta(1-t)q_1 + q_0]c_1''\}. \end{aligned}$$

Then $\alpha^E = 1$ if and only if $[q_1 - q_0 - \beta(1-t)q_1]p''q_1 + [q_1 - 2q_0 - 2\beta(1-t)q_1]p' + [\beta(1-t)q_1 + q_0]c_1'' \leq 0$. In other words, $\alpha^E < 1$ if and only if $[q_1 - q_0 - \beta(1-t)q_1]p''q_1 + [q_1 - 2q_0 - 2\beta(1-t)q_1]p' + [\beta\ (1-t)q_1 + q_0]c_1'' > 0$.

Suppose that $\alpha^E < 1$; then, we obtain $\alpha^E$ from $X_6 = 0$. Totally differentiating $X_6 = 0$ at the equilibrium point, we obtain

[18] However, the optimal degree of privatization can be zero in different contexts such as in a free entry market (Matsumura and Kanda 2005), in the presence of an excess cost of public funds (Sato and Matsumura 2019b), and if the government chooses a privatization policy over time (Sato and Matsumura 2019a).

$$\frac{d\alpha^E}{dt} = -\frac{\partial X_6/\partial t}{\partial X_6/\partial \alpha}. \tag{13}$$

We obtain the following result.

**Proposition 1** *The optimal degree of privatization $\alpha^E$ increases with the corporate tax rate $t$ as long as $\alpha^E < 1$.*

***Proof*** See the Appendix. □

We explain the intuition behind Proposition 1. As firm 0 becomes more privatized, firm 1 produces more output, which improves welfare. However, as part of these profits accrue to foreign investors, higher profits flow out of the domestic economy with increased privatization, which is harmful for local welfare. This trade off determines the optimal privatization policy. The outflow of profits declines as the corporate tax rate increases; thus, the negative effect of privatization declines. Consequently, the optimal degree of privatization increases.

We now discuss how $\beta$ affects the optimal degree of privatization. Totally differentiating $X_6 = 0$ at the equilibrium point, we obtain

$$\frac{d\alpha^E}{d\beta} = -\frac{\partial X_6/\partial \beta}{\partial X_6/\partial \alpha} = -\frac{-\alpha(1-t)^2 q_1(p''q_1 + 2p' - c_1'')}{\partial X_6/\partial \alpha} < 0. \tag{14}$$

From (14), we obtain the following result.

**Proposition 2** *The optimal degree of privatization $\alpha^E$ decreases with the foreign ownership share $\beta$ as long as $\alpha^E < 1$.*

***Proof*** See the Appendix. □

Lin and Matsumura (2012) show this result with a linear demand assumption when $t = 0$. Proposition 2 states that this result also holds with nonlinear demand. The larger the $\beta$, the more is the outflow of the profit of firm 1 to foreign investors. Therefore, the government chooses a smaller $\alpha$ to restrict this outflow.

Finally, we present a result that is useful for the discussion in Sect. 5. Let $W^E(t)$ denote the equilibrium local welfare in this game.

**Lemma 3** *If $\beta > 0$, then $W^E(t)$ is increasing in $t$.*

***Proof*** See the Appendix. □

When $\beta = 0$, $W$ is independent of $t$ because corporate tax is only a transfer from domestic investors to the government. However, if $\beta > 0$, then $W$ is increasing in $t$ when $q_0$ and $q_1$ are exogenous, because a higher tax rate increases the transfer from foreign investors to the government and thus improves welfare. Lemma 3 states that this holds true even if $\alpha$ is endogenous, and thus $q_0$ and $q_1$ are endogenous.[19]

## 4 Minimal-Profit constraint

In the previous section, we assumed that the private firm stays in the market regardless of government policies. However, if the corporate tax rate is too high, the private firm may exit the market or may not enter the market. In this section, we impose the minimal after-tax profit constraint to the private firm, firm 1. Specifically, we assume that firm 1 enters the market if and only if

$$(1-t)\pi_1 \geq F, \tag{15}$$

where $F$ is a positive constant. We may interpret $F$ as the opportunity cost of staying in or entering the market. The investors of firm 1 may obtain the after-tax profit $F$ if firm 1 enters markets in other countries, and $F$ thus represents an opportunity cost as limited management resources need to be used for this market. We believe that this is a realistic assumption. Because $F$ is an opportunity cost, the tax revenue from firm 1 is $t(pq_1 - c_1)$, not $t(pq_1 - c_1 - F)$. $F$ may represent entry expenses that cannot be included in the deduction, such as illegal bribes to the local government. In this case, the after-tax profit of firm 1 is $(1-t)(pq_1 - c_1) - F$, not $(1-t)(pq_1 - c_1 - F)$.[20]

The game runs as follows. In the first stage, the government chooses $\alpha$. In the second stage, firm 1 chooses whether to enter the market. In the third stage, firms face Cournot competition when firm 1 enters.

If $F$ is sufficiently large, then the government chooses a public monopoly and $\alpha = 0$.[21] Otherwise, the government chooses $\alpha$ under the constraint (15). To examine the property of mixed oligopolies, we focus on the latter case. Henceforth, we restrict our attention to the case where $p - c_0' \geq 0$ in equilibrium.

The previous section provided the analysis of the third stage game. We now present results on the relationship between the private firm's profit and the degree of privatization. Let $\pi_1^S(\alpha)$ denote the equilibrium profit of firm 1 in the second-stage game.

**Lemma 4** *(i) The private firm's profit ( $\pi_1^S$) increases with the degree of privatization ( $\alpha$). (ii) Given $\alpha$, the private firm's after-tax profit ( $(1-t)\pi_1^S$) decreases with the corporate tax rate (t). (iii) Given $\alpha(<1)$ and t, the private firm's profit ( $\pi_1^S$) decreases with the foreign ownership share in firm 1 ($\beta$).*

***Proof*** See the Appendix. □

Lemma 4(ii) is quite intuitive, and we explain the intuition behind Lemma 4(i) and (iii). An increase in the degree of privatization makes the public firm (firm

[19] When $\beta > 0$, $t$ affects $W$ through two routes. One is the transfer effect mentioned above; the other is the effect of the change in $q_0$ and $q_1$. Lemma 3 implies that the former effect dominates the latter effect even when the two effects impact $W$ in the opposite directions, as long as $\alpha$ is endogenous.

[20] If $F$ is the deductible entry cost, the natural constraint becomes $(1-t)(\pi_1 - F) \geq 0$, and our analysis cannot be applied to this case.

[21] If $F$ represents a bribe, $F$ should be included in the local social welfare, and thus the government may prefer a mixed duopoly to a public monopoly even when $F$ is large.

0) less aggressive, which is beneficial for the private firm (firm 1). This yields Lemma 4(i). Similarly, a decrease in the foreign ownership share in the private firm makes the public firm (firm 0) less aggressive, which is beneficial for the private firm (firm 1). This yields Lemma 4(iii).

Lemma 4(i) states that $(1-t)\pi_1^S(\alpha)$ is increasing in $\alpha$. We define $\alpha^\dagger$ by $(1-t)\pi_1^S(\alpha^\dagger)=F$. Let $\alpha^C$ denote the equilibrium degree of privatization in this game (the superscript C indicates constraint).

If $\alpha^\dagger<\alpha^E$, then the constraint (15) is not binding. Therefore, $\alpha^C=\alpha^E$ and Propositions 1 and 2 hold. If $\alpha^\dagger\geq\alpha^E$, then the constraint (15) is binding. From the concavity of the welfare function, we obtain $\alpha^C=\alpha^\dagger$. From Lemma 4(ii), an increase in $t$ reduces $(1-t)\pi_1^S(\alpha)$ given $\alpha$ and $\beta$. To compensate for this reduction in firm 1's after-tax profit, the government must increase $\alpha$ (Lemma 4(i)). From Lemma 4(iii), an increase in $\beta$ reduces $(1-t)\pi_1^S(\alpha)$ given $\alpha$ and $t$. To compensate for this reduction in firm 1's after-tax profit, the government must increase $\alpha$ (Lemma 4(i)). These discussions lead to the following Proposition.

**Proposition 3** *Under the minimal after-tax profit constraint, the optimal degree of privatization ( $\alpha^C$) (i) increases with the corporate tax rate ($t$); (ii) increases with the foreign ownership share in private firm ( $\beta$) as long as the constraint is binding.*

Proposition 3(i) states that Proposition 1 is robust. The optimal degree of privatization increases with the corporate tax rate regardless of whether the minimal after-tax profit constraint exists. With the minimal after-tax profit constraint, the government must keep the after-tax profit in firm 1. A higher tax rate reduces the firm 1's profit. To compensate for this negative effect, the government must increase the degree of privatization, which makes firm 0 less aggressive and thus increases firm 1's profit.

Proposition 3(ii) states that Proposition 2 may not be robust. When the minimal after-tax profit constraint is (is not) effective, the optimal degree of privatization increases (decreases) with the foreign ownership share of the private firm. Therefore, we obtain the opposite policy implication with and without the constraint. With the minimal after-tax profit constraint, the government must keep the after-tax profit in firm 1. A larger foreign ownership share in firm 1 makes firm 0 more aggressive, which reduces firm 1's profit. To compensate for this negative effect, the government must increase the degree of privatization, which makes firm 0 less aggressive.

Propositions 2 and 3(ii) indicate a possible non-monotonic relationship between the foreign ownership share in the private firm ($\beta$) and the optimal degree of privatization ($\alpha^E$). When $\beta$ is small, $\pi_1$ is high; thus, the constraint (15) may not be binding. An increase in $\beta$ reduces $\alpha^E$ as long as the constraint is not binding (Proposition 2). An increase in $\beta$ reduces $\pi_1$, and the constraint (15) may be binding eventually. After that, a further increase in $\beta$ increases $\alpha^E$. Thus, a U-shaped relationship between $\alpha^E$ and $\beta$ may emerge.

## 5 Endogenous corporate tax

Our previous analysis was conducted under exogenous corporate taxation. However, the government may extract firms' profits by imposing specific industry taxes, requiring bribes, or through foreign currency control in a targeted industry. The government may strategically reduce the corporate tax rate for specific firms or industries in order to attract firms, as we discussed in Introduction. Therefore, in this section, we discuss the outcome under the framework of endogenized $t$ and $\alpha$.

We consider the following game in which the government chooses both the corporate tax and the privatization policies. In the first stage, the government chooses $t$ and $\alpha$. In the second stage, firm 1 enters the market if and only if (15) is satisfied. In the third stage, firms face Cournot competition when firm 1 enters the market.

Consider the final stage. Suppose that firm 1 enters the market. In Sect. 3, we derived the equilibrium output. From Lemma 3, we find that the constraint (15) is binding as long as $\beta > 0$. Again, we focus on the case where a mixed duopoly is better than a public monopoly for local welfare. The government chooses $t$ and $\alpha$ under the constraint (15).[22]

As we show in Sect. 3, $\alpha^E > 0$ even when the constraint (15) is not binding. An increase in $\alpha$ relaxes the constraint, and thus the welfare improving effect of an increase in $\alpha$ is larger with the constraint than without the constraint. Thus, we obtain $\alpha^E > 0$.

We now present our result.

**Proposition 4** *Suppose that the government chooses both the degree of privatization and the corporate tax rate in the first stage. Suppose that $\beta > 0$.[23] (i) The optimal degree of privatization is non-decreasing in $\beta$, and strictly increasing in $\beta$ if $\alpha^E < 1$. (ii) The optimal corporate tax rate is non-increasing in $\beta$ and strictly decreasing in $\beta$ if $\alpha^E < 1$.*

***Proof*** See the Appendix. □

Suppose that $\beta > 0$. Because the minimal profit constraint is always binding when both the corporate tax rate and the degree of privatization are endogenous, the changes in an exogenous variable that reduces the private firm's profits (in our model, an increase in $\beta$) enhances the privatization policy and the tax exemption policy in order to attract private firms. Governments often exempt foreign firms from corporate taxes. Our result is consistent with this causal observation.

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[22] As long as $\beta > 0$, the constraint is binding. If the constraint is not binding, the government can increase $W$ by a marginal increase in $t$. Moreover, at the equilibrium tax rate, $(1 - t)\pi_1$ must be decreasing in $t$ because otherwise, the government can improve welfare by a marginal increase in $t$.

[23] If $\beta = 0$, then the equilibrium pair of $(t, \alpha)$ is indeterminate and any pair of $(t, \alpha)$ that yields the optimal $q_0$ is the equilibrium pair of policies.

## 6 Concluding remarks

In this study, we investigate the relationship between the privatization policy and the corporate tax policy. We also investigate the effect of a foreign ownership share in the private firm on these policies and introduce a minimal after-tax profit constraint. We show that regardless of whether the minimal after-tax profit constraint is effective, the optimal degree of privatization increases with the corporate tax rate, and that the optimal degree of privatization decreases (increases) with the foreign ownership share in the private firm when the constraint is non-binding (binding).

In this study, in order to focus on the relationship between privatization and corporate tax policies, we consider a single market model. The corporate tax rate is usually common across industries, while the privatization policy differs. Investigating this problem requires a multi-market model. Extending our analysis to a multi-product model remains for future research.[24] Furthermore, the results of this study are based on the assumption that public and private firms compete on quantities in the market. Another direction is to check the robustness and generality of our results under the consideration of price competition.[25] Moreover, we assume that the cost function of the public firm is independent of the privatization policy. However, the privatization policy may affect the production efficiency of (partially) privatized firms (Chen 2017). This extension also remains for future research.

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## Appendix

***Proof of Proposition 1*** First, we show $\partial X_6/\partial \alpha > 0$ if $\alpha^E < 1$. Let

$$-\frac{1}{1-\alpha t}\frac{X_1 p'}{X_2} := X_7.$$

From (11), we obtain

[24] For an analysis of multi-market mixed oligopolies, see (Bárcena-Ruiz and Garzón 2017; Dong et al. 2018), and Haraguchi et al. (2018).

[25] In mixed oligopolies, price competition may emerge in endogenous competition structure models. See Matsumura and Ogawa (2012) and Din and Sun (2016).

$$W^{S''}(\alpha) = \frac{\partial X_7}{\partial \alpha} X_6 + X_7 \frac{\partial X_6}{\partial \alpha}.$$

Because $W^{S''}(\alpha) < 0$, $X_6 = 0$ at the equilibrium point, and $X_7 < 0$, we obtain $\partial X_6 / \partial \alpha > 0$.

Next, we show $\partial X_6 / \partial t < 0$ if $\alpha^E < 1$. We obtain

$$\begin{aligned}\frac{\partial X_6}{\partial t} = &- \alpha\{[q_1 - q_0 - \beta(1-t)q_1]p'' q_1 + [q_1 - 2q_0 - 2\beta(1-t)q_1]p' + [\beta(1-t)q_1 + q_0]c_1''\} \\ &- \alpha[-\beta(1-t)q_1(p'' q_1 + 2p') + (1-t)\beta q_1 c_1''].\end{aligned}$$

As we show after (11), $\alpha^E < 1$ if and only if

$$[q_1 - q_0 - \beta(1-t)q_1]p'' q_1 + [q_1 - 2q_0 - 2\beta(1-t)q_1]p' + [\beta(1-t)q_1 + q_0]c_1'' > 0.$$

Thus, from the assumption that $p'' q_1 + p' < 0$ and $c_1'' \geq 0$, we obtain $\partial X_6 / \partial t < 0$ when $\alpha^E < 1$. These two facts and (13) imply Proposition 1. □

***Proof of Proposition 2*** In the proof of Proposition 1, we have already shown that $\partial X_6 / \partial \alpha > 0$ if $\alpha^E < 1$. This and (14) imply Proposition 2. □

***Proof of Lemma 3*** Suppose that $t$ increases marginally, from $t_a$ to $t_b$. We will show that this change increases $W$.

Suppose that $\alpha^E < 1$ and $p - c_0' > 0$ when $t = t_a$. Given $\alpha$, this change increases the resulting $q_0$ (Lemma 1(i)). Suppose that the government increases $\alpha$ to keep the resulting $q_0$ unchanged. Note that $q_1$ remains unchanged if $q_0$ remains unchanged because neither $t$ nor $\alpha$ affects $q_1$ directly, and both affect $q_1$ through the change in $q_0$. Because $q_0^S(\alpha, t)$ is decreasing in $\alpha$ (and thus $q_0^S(\alpha, t) < q_0^S(1, t)$ for any $\alpha < 1$ and $t \in [0, 1)$) and $q_0^S(1, t)$ is independent of $t$, the government can choose such an $\alpha$ as long as $\alpha^E < 1$. Because $Q$, $q_0$, and $q_1$ remain unchanged, CS, $\pi_0$, and $\pi_1$ remain unchanged. Thus, $W$ increases by $\beta(t_b - t_a)\pi_1$. Given $t_b$, the above $\alpha$ is not the optimal $\alpha$. Nevertheless, $W$ increases with an increase in $t$, and much more if the government chooses the optimal $\alpha$.

Suppose that $\alpha^E < 1$ and $p - c_0' \leq 0$ when $t = t_a$. Given $\alpha$, this change decreases the resulting $q_0$ (Lemma 1(i)). Suppose that the government decreases $\alpha$ to keep the resulting $q_0$ unchanged. Because $q_0^S(\alpha, t)$ is decreasing in $\alpha$ and $\alpha^E > 0$, $q^S(0, t_a) > q_0^S(\alpha^E, t_a)$. Due to the continuity of $q^S(\alpha, t)$, there exists an $\alpha'$ such that $q_0^S(\alpha', t_b) = q_0^S(\alpha^E, t_a)$ if $t_b - t_a$ is sufficiently small. Because $Q$, $q_0$, and $q_1$ remain unchanged, CS, $\pi_0$, and $\pi_1$ remain unchanged. Thus, $W$ increases by $\beta(t_b - t_a)\pi_1$. $\alpha'$ is not the optimal $\alpha$. Nevertheless, $W$ increases with the increase in $t$, and much more if the government chooses the optimal $\alpha$.

Suppose that $\alpha^E = 1$ when $t = t_a$. Suppose that the government keeps $\alpha^E = 1$ after the change in $t$, which does not affect $Q$, $q_0$, and $q_1$ (Lemma 1(ii)). Thus, $W$ increases by $\beta(t_b - t_a)\pi_1$ through the change in $t$. □

***Proof of Lemma 4*** From (3), we find that an increase in $\alpha$ increases $q_1$ and reduces $Q$. Both increase $\pi_1^S$. No other effect on $\pi_1$ exists. Therefore, $\pi_1^S$ is increasing in $\alpha$.

This implies Lemma 4(i).

We obtain

$$\frac{\partial[(1-t)\pi_1]}{\partial t} = -\pi_1 + (1-t)p'q_1\frac{\partial q_0}{\partial t} + (1-t)(p'q_1 + p - c_1)\frac{\partial q_1}{\partial t}. \tag{16}$$

The first term in (16) is negative, the second term is non-positive if $p \geq c_0'$ (Lemma 1) and the third term is zero from (2). These imply Lemma 4(ii).

Lemma 2 states that an increase in $\beta$ decreases $q_1$ and increases $Q$ as long as $\alpha < 1$. Both reduce $\pi_1^S$. No other effect on $\pi_1$ exists. Therefore, $\pi_1^S$ is decreasing in $\beta$. This implies Lemma 4(iii). □

***Proof of Proposition 4*** Given that the constraint is binding when the government chooses the optimal $\alpha$ and $t$ simultaneously, we take the total derivative of the constraint (i.e., $(1-t)\pi_1 = F$).

$$\begin{aligned}
&-(pq_1 - c_1)dt + (1-t)p'q_1 dQ + (1-t)(p - c_1')dq_1 = 0,\\
&-(pq_1 - c_1)dt + (1-t)p'q_1 dq_0 = 0,\\
&-\pi_1 dt + (1-t)p'q_1\left[-\frac{X_1(p''q_1 + 2p' - c_1'')}{X_2}\right]d\alpha\\
&+(1-t)p'q_1\left[-\frac{X_4(p''q_1 + 2p' - c_1'')}{X_2}\right]dt\\
&+(1-t)p'q_1\left[-\frac{X_5(p''q_1 + 2p' - c_1'')}{X_2}\right]d\beta = 0.
\end{aligned}$$

From these, we obtain

$$\frac{d\alpha^E}{d\beta} = -\frac{X_5}{X_1}, \tag{17}$$

$$\frac{dt^E}{d\beta} = -\frac{(1-t)p'q_1X_5(p''q_1 + 2p' - c_1'')}{X_2\pi_1 + (1-t)p'q_1X_4(p''q_1 + 2p' - c_1'')}. \tag{18}$$

From (10), $X_5$ is non-negative and positive if $\alpha < 1$. Since $X_1 < 0$, we obtain Proposition 4(i).

Since $X_5 \geq 0$ and the equality holds if and only if $\alpha = 1$, the numerator in (18) is non-negative and strictly positive if $\alpha < 1$. Then, we show that the denominator in (18) is positive, which implies Proposition 4(ii).

Because $X_2$, $\pi_1$ and $(1-t)p'q_1(p''q_1 + 2p' - c_1'')$ are positive, the denominator in (18) is positive if $X_4 \geq 0$. From the discussion in footnote 17 and $X_4$ in (8), we obtain

$$X_4 = \frac{p'(1-\alpha)\cdot[-\alpha q_0 + \beta(1-\alpha)q_1]}{1-\alpha t} = \frac{(p - c_0')(1-\alpha)}{1-t}.$$

This is positive because we assume $p \geq c_0'$. □

## References


Bárcena-Ruiz JC, Dong Q, Wang LFS (2020) Foreign-owned firms and partial privatisation of state holding corporations. Jpn Econ Rev 71(2):287–301

Bárcena-Ruiz JC, Garzón MB (2005a) Economic integration and privatization under diseconomies of scale. Euro J Political Econ 21(1):247–267

Bárcena-Ruiz JC, Garzón MB (2005b) International trade and strategic privatization. Rev Dev Econ 9(4):502–513

Bárcena-Ruiz JC, Garzón MB (2017) Privatization of state holding corporations. J Econ 120(2):171–188

Cai D, Li J (2011) To list or to merge? Endogenous choice of privatization methods in a mixed market. Jpn Econ Rev 62(4):517–536

Cato S, Matsumura T (2012) Long-run effects of foreign penetration on privatization policies. J Instit Theor Econ 168(3):444–454

Cato S, Matsumura T (2013) Long-run effects of tax policies in a mixed market. FinanzArchiv 69(2):215–240

Cato S, Matsumura T (2015) Optimal privatisation and trade policies with endogenous market structure. Econ Rec 91(294):309–323

Cato S, Matsumura T (2019) Optimal production tax in a mixed market with an endogenous market structure. Manch Sch 87(4):578–590

Chang WW (2005) Optimal trade and privatization policies in an international duopoly with cost asymmetry. J Int Trade Econ Dev 14(1):19–42

Chang WW (2007) Optimal trade, industrial, and privatization policies in a mixed duopoly with strategic managerial incentives. J Int Trade Econ Dev 16(1):31–52

Chang WW, Ryu HE (2015) Vertically related markets, foreign competition and optimal privatization policy. Rev Int Econ 23(2):303–319

Chen TL (2017) Privatization and efficiency: a mixed oligopoly approach. J Econ 120(3):251–268

Corneo G, Jeanne O (1994) Oligopole mixte dans un marche commun. Ann d'Economie et de Statistique 33:73–90

Din HR, Sun CH (2016) Combining the endogenous choice of timing and competition version in a mixed duopoly. J Econ 118(2):141–166

Dong Q, Bárcena-Ruiz JC, Garzón MB (2018) Partial privatization of state holding corporations. Manch Sch 86(1):119–138

De Fraja G, Delbono F (1989) Alternative strategies of a public enterprise in oligopoly. Oxf Econ Pap 41:302–311

Escrihuela-Villar M, Gutiérrez-Hita C (2019) On competition and welfare enhancing policies in a mixed oligopoly. J Econ 126(3):259–274

Fjell K, Pal D (1996) A mixed oligopoly in the presence of foreign private firms. Can J Econ 29(3):737–743

Fridman A (2018) Partial privatization in an exhaustible resource industry. J Econ 124(2):159–173

Fujiwara K (2007) Partial privatization in a differentiated mixed oligopoly. J Econ 92(1):51–65

Futagami K, Matsumura T, Takao K (2019) Mixed duopoly: differential game approach. J Public Econ Theory 21(4):771–793

Ghosh A, Mitra M, Saha B (2015) Privatization, underpricing and welfare in the presence of foreign competition. J Public Econ Theory 17(3):433–460

Ghosh A, Sen P (2012) Privatization in a small open economy with imperfect competition. J Public Econ Theory 14(3):441–471

Han L, Ogawa H (2012) Market-demand boosting and privatization in a mixed duopoly. Bull Econ Res 64(1):125–134

Haraguchi J, Matsumura T (2020a) Lack of commitment to future privatization policies may lead to worst welfare outcome. Econ Modell 88:181–187

Haraguchi J, Matsumura T (2020b) Implicit protectionism via state enterprises and technology transfer from foreign enterprises. Rev Int Econ 28(3):723–743

Haraguchi J, Matsumura T (2020c) Asymmetry among private firms and optimal privatization policy. Bull Econ Res 72(3):213–224

Haraguchi J, Matsumura T (2020d) Profit-enhancing entries in mixed oligopolies. MPRA Paper No. 99688

Haraguchi J, Matsumura T, Yoshida S (2018) Competitive pressure from neighboring markets and optimal privatization policy. Japan World Econ 46:1–8

Huang CH, Yang CH (2016) Ownership, trade, and productivity in Vietnam's manufacturing firms. Asia-Pacific J Account Econ 23(3):356–371

Huang Z, Li L, Ma G, Xu LC (2017) Hayek, local information, and commanding heights: decentralizing state-owned enterprises in China. Am Econc Rev 107(8):2455–2478

Huizinga H, Nielsen SB (2001) Privatization, public investment, and capital income taxation. J Public Econ 82(3):399–414

Kawasaki A, Ohkawa T, Okamura M (2020) Endogenous timing game in a mixed duopoly with partial foreign ownership and asymmetric increasing marginal costs. Aust Econ Pap 59(2):71–87

Kim SL, Lee SH, Matsumura T (2019) Corporate social responsibility and privatization policy in a mixed oligopoly. J Econ 128(1):67–89

Lee SH, Matsumura T, Sato S (2018) An analysis of entry-then-privatization model: welfare and policy implications. J Econ 123(1):71–88

Lin MH, Matsumura T (2012) Presence of foreign investors in privatized firms and privatization policy. J Econ 107(1):71–80

Lin MH, Matsumura T (2018) Optimal privatization and uniform subsidy policies: a note. J Public Econ Theory 20(3):416–423

Matsumura T (1998) Partial privatization in mixed duopoly. J Public Econ 70(3):473–483

Matsumura T (2003) Stackelberg mixed duopoly with a foreign competitor. Bull Econ Res 55(3):275–287

Matsumura T, Kanda O (2005) Mixed oligopoly at free entry markets. J Econ 84(1):27–48

Matsumura T, Matsushima N (2012) Airport privatization and international competition. Jpn Econ Rev 63(4):431–450

Matsumura T, Ogawa A (2012) Price versus quantity in a mixed duopoly. Econ Lett 116(2):174–177

Matsumura T, Okamura M (2015) Competition and privatization policies revisited: The payoff interdependence approach. J Econ 116(2):137–150

Matsumura T, Shimizu D (2010) Privatization waves. Manch Sch 78(6):609–625

Matsumura T, Tomaru Y (2012) Market structure and privatization policy under international competition. Jpn Econ Rev 63(2):244–258

Matsumura T, Tomaru Y (2013) Mixed duopoly, privatization, and subsidization with excess burden of taxation. Can J Econ 46(2):526–554

Mujumdar S, Pal D (1998) Effects of indirect taxation in a mixed oligopoly. Econ Lett 58(2):199–204

Ogura Y (2018) The objective function of government-controlled banks in a financial crisis. J Bank Financ 89:78–93

Pal D (1998) Endogenous timing in a mixed oligopoly. Econ Lett 61(2):181–185

Pal R, Saha B (2014) Mixed duopoly and environment. J Public Econ Theory 16(1):96–118

Sato S, Matsumura T (2019a) Dynamic privatization policy. Manch Sch 87(1):37–59

Sato S, Matsumura T (2019b) Shadow cost of public funds and privatization policies. North Am J Econ Financ 50:101026

Seim K, Waldfogel J (2013) Public monopoly and economic efficiency: evidence from the Pennsylvania liquor control board's entry decisions. Am Econ Rev 103(2):831–862

Tomaru Y, Wang LFS (2018) Optimal privatization and subsidization policies in a mixed duopoly: relevance of a cost gap. J Instit Theor Econ 174(4):689–706

Wang LFS, Chen TL (2011) Mixed oligopoly, optimal privatization, and foreign penetration. Econ Model 28(4):1465–1470

Wang LFS, Tomaru Y (2015) The feasibility of privatization and foreign penetration. Int Rev Econ Financ 39:36–46

White MD (1996) Mixed oligopoly, privatization and subsidization. Econ Lett 53(2):189–195

Wu SJ, Chang YM, Chen HY (2016) Imported inputs and privatization in downstream mixed oligopoly with foreign ownership. Can J Econ 49(3):1179–1207

Xu L, Lee SH, Matsumura T (2017) Ex-ante versus ex-post privatization policies with foreign penetration in free-entry mixed markets. Int Rev Econ Financ 50:1–7

Xu L, Lee SH, Wang LFS (2016) Free trade agreements and privatization policy with an excess burden of taxation. Japan World Econ 37–8:55–64