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Competition, Partial Privatization and Welfare: A General Analysis

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Considering partial privatization of a public firm, this paper investigates the relative merits in terms of welfare between the Bertrand and Cournot outcomes in a mixed duopoly. To our surprise, social welfare may be higher under Cournot competition than under Bertrand if the public firm is partially privatized. This result stands in stark contrast to the previous literature, which asserts that Bertrand competition is socially more desirable than Cournot if the public firm is completely privatized or completely state-owned.

Keywords: partial privatization, Bertrand competition, Cournot competition, welfare
JEL classification: L13, L32, L33

1 Introduction

Comparing the welfare ranking under the two mostly commonly used competition, *i.e.*, Bertrand and Cournot competition, has attracted a lot of attention in the IO and trade literature. Since welfare maximization is often the goal of a government policy, it is important for a government to understand the welfare ranking among different competition modes when making

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trade or industrial policies. For example, Eaton and Grossman (1986) employ a duopoly model to show that the optimal export subsidy is positive (negative) if the two firms engage in Cournot (Bertrand) competition. It indicates that the competition mode, being Cournot or Bertrand, is crucial to the sign of the optimal export subsidy. Similar results can also be found in Cheng (1988).

We reexamine the classic Bertrand–Cournot comparison by considering a profit-maximizing private firm competing with a partially privatized public firm in a differentiated duopoly. We shall show that the welfare ranking under Cournot or Bertrand competition varies with the degree of the privatization. It implies that Cournot competition could be more socially desirable than Bertrand competition when the public firm is partially privatized. This result stands in sharp contrast to the finding in Singh and Vives (1984) (Ghosh and Mitra, 2010) which suggests that Bertrand competition is necessarily superior to Cournot competition in terms of social welfare if the public firm is completely privatized (completely state-owned).

Studies on relative merits between Bertrand and Cournot competition in a differentiated duopoly can be dated back to Singh and Vives (1984). They show that Bertrand competition is more socially desirable when the two goods are substitutes. Tanaka (2001a,b), Tasnádi (2006), among others, find similar results. On the contrary, some studies find Cournot competition may result in higher social welfare if firms do R&D before production (Delbono and Denicolò, 1990; Qiu, 1997; Symeonidis, 2003), compete under a spatial framework (Liang, Hwang, and Mai, 2006), or engage in outsourcing before production (Arya, Mittendorf, and Sappington, 2008). More recently, Chang, Hwang, and Peng (2017) find that Cournot competition is more socially desirable than Bertrand if one firm can license its product innovation to the other.

All these papers employ a pure duopoly model with two private firms in the market. In the real world, a mixed duopoly market structure with one state-owned public firm competing against one private firm is popular in many industries, see, for example, the electricity, airline, transportation, media, and banking sectors (Matsumura, 1998). Studies on the relative merits between Cournot and Bertrand competition in this type of market are relatively few. Ghosh and Mitra (2010) and Matsumura and Ogawa (2012) are two major papers along this line of research. Assuming the public firm in a mixed duopoly market is completely state-owned, Ghosh and Mitra (2010) examine the relative merits of Bertrand and Cournot competition to

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show that Bertrand is more desirable than Cournot in terms of social welfare. Matsumura and Ogawa (2012) assume the same and investigate the endogenous choice of price and quantity contracts in a mixed duopoly. They also find that social welfare is higher under Bertrand price than Cournot quantity competition. From the welfare rankings derived by these two papers and Singh and Vives (1984), we can conclude that Bertrand competition is socially more desirable than Cournot if the public firm is completely privatized or completely state-owned. The purpose of our paper is to show that the above welfare ranking may not hold if the public firm is partially privatized. Specifically, even if Bertrand competition is socially more desirable than Cournot competition in the case that the public firm is completely privatized or completely state-owned, the ranking may be reversed if the public firm becomes partially privatized. This result suggests that other than R&D, licensing, outsourcing, and spatial competition, privatization level of a public firm also plays an important role when evaluating social welfare levels between Bertrand and Cournot competition.

The remainder of this paper is organized as follows. Section 2 introduces our model setup. Section 3 investigates and explains the equilibrium under Cournot competition. Section 4 examines the Bertrand equilibrium. Section 5 compares the welfare levels under the two competition modes. Section 6 concludes the paper.

2 Model Setup

Assume that there are two firms in the market: one partially privatized public firm (hereafter "the public firm") and one private firm. The objective of the former is to maximize the weighted average of social welfare and its own profit, whereas the latter aims to maximize its own profit. The two firms produce horizontally differentiated products at a marginal cost, c.

Assume that the inverse demands are linear and symmetric with the following properties:

$$p^* = f\left(q^*, q\right), \quad p = f\left(q, q^*\right), f_1 \equiv \partial p^*/\partial q^* = \partial p/\partial q < 0,$$
$$f_2 \equiv \partial p^*/\partial q = \partial p/\partial q^* < 0, \quad \text{and} \quad |f_1| > |f_2|.$$

Variables with an asterisk indicate they are associated with the public firm. From the two inverse demands, we can derive the corresponding demands

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and their corresponding own- and cross-price effects as follows:

$$q^* = h\left(p^*, p\right), \quad q = h\left(p, p^*\right) \text{ with the following properties:}$$
$$h_1 \equiv \partial q^* / \partial p^* = \partial q / \partial p = f_1 / \left(f_1^2 - f_2^2\right) < 0, \quad \text{and}$$
$$h_2 \equiv \partial q^* / \partial p = \partial q / \partial p^* = -f_2 / \left(f_1^2 - f_2^2\right) > 0.$$

The utility function regarding to the above-mentioned demands is borrowed from Singh and Vives (1984) and has the following properties: For a given total output level, utility is lower if the two products are more unevenly distributed. This is called as the uneven distribution effect (UDE). Moreover, for a given output distribution ratio, utility increases with the total output. This is called as the total output effect (TOE). These two effects will be employed to explain welfare effects of privatization and to compare welfare under Cournot or Bertrand competition for a given privatization level.

The objective functions of the public firm and the private one can be expressed respectively as follows:[1]

$$V^*\left(q^*; q\right) = \lambda\pi^* + (1-\lambda)SW, \tag{1}$$
$$\pi\left(q; q^*\right) = (p-c)q, \tag{2}$$

where $\lambda \in [0, 1]$ indicates the privatization level of the public firm, $\pi^* = (p^* - c)q^*$ is the profit of the public firm, and social welfare (SW) which consists of profits of the firms and consumer surplus, can be written as follows:

$$SW = U\left(q^*, q\right) - c\left(q^* + q\right). \tag{3}$$

We assume that the two firms play either Bertrand or Cournot competition. In what follows, we shall first derive the equilibrium under Cournot competition followed by that under Bertrand competition.

3 Cournot Competition

By substituting the inverse demands into (1) and (2), then differentiating them with respect to q^* and q respectively, we can derive the first-order

[1] On Oct. 7 2021, Chairman of the Financial Supervisory Commission, Tien-Mu Huang, mentioned that the objectives of commercial banks should go beyond profits. For the details of the statement, please refer to https://udn.com/news/story/7239/5800783.

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conditions for profit maximization for the two firms as follows:

$$\frac{\partial V^*}{\partial q^*} = \left(p^* - c\right) + \lambda f_1 q^* = 0, \tag{4}$$

$$\frac{\partial \pi}{\partial q} = (p - c) + f_1 q = 0. \tag{5}$$

The second-order and the stability conditions are all satisfied given the linear demands and constant marginal costs.

From (4) and (5), we can derive the slopes of the reaction functions of the public firm (R^{*C}) and of the private firm (R^C) respectively as follows:

$$\frac{\partial q}{\partial q^*}\,|_{R^{*C}} = -\frac{(1+\lambda) f_1}{f_2} < 0, \quad \text{and} \quad \frac{\partial q}{\partial q^*}\,|_{R^C} = -\frac{1}{2}\frac{f_2}{f_1} < 0. \tag{6}$$

In addition, by differentiating (4) with respect to q and λ and rearranging it, we have:[2]

$$\frac{\partial q}{\partial \lambda}\,|_{R^{*C}} = -\frac{f_1 q^*}{f_2} \leq 0. \tag{7}$$

This result implies that the public firm's reaction curve rotates inward at the pivot of the vertical axis and becomes steeper as λ increases, as shown by R_0^{*C}, R_1^{*C} and R_2^{*C} in Figure 1. Furthermore, the private firm's reaction curve, R^C, is irrelevant to λ by (5). From these reaction curves, we can draw the equilibrium output path with respect to λ in Figure 1. If $\lambda = 1$, we have two private (and symmetric) firms in the market and the equilibrium is at C_2 which is on the 45^{o} line. By contrast, if $\lambda = 0$, we have one pure public firm and one private firm in the market and the equilibrium is at C_0. Proceeding as before, we can derive C_0C_2 as the equilibrium output path for $\lambda \in [0, 1]$ under Cournot competition. This equilibrium output path C_0C_2 can help us understand the welfare effect of privatization. As the marginal costs of the two firms are assumed to be equal, we can use TOE and UDE to explain the welfare effect of privatization. Let us start from the equilibrium with no privatization, *i.e.*, C_0. As the public firm starts privatization, the output equilibrium moves from C_0 toward C_1. The total output declines. Though this causes a welfare loss, the distribution becomes more equalized

[2] If $q^* = 0$, it is straightforward to show that (7) is zero, implying that the intercept on the vertical axis of (4) is not affected by a change of the privatization level. Moreover, if $q^* > 0$, it is found that (7) is negative, indicating that (4) becomes steeper as the privatization level increases.

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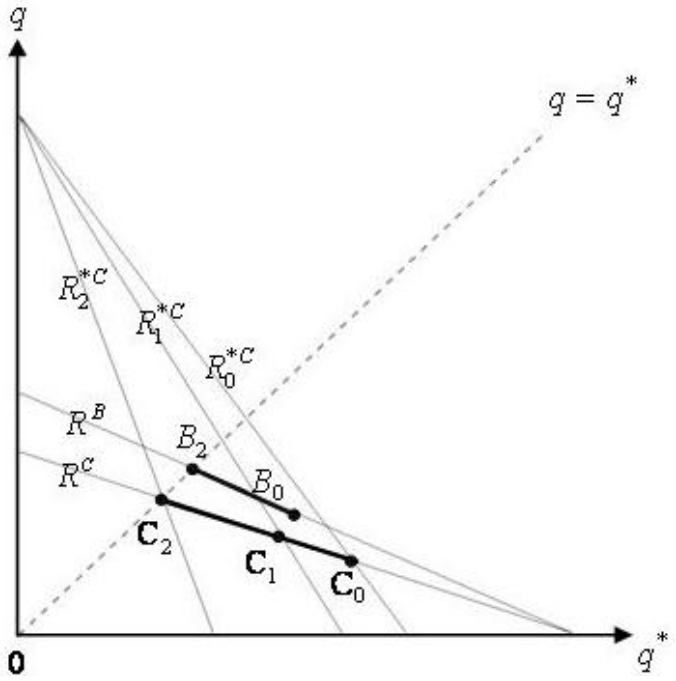


Figure 1: Equilibria under Bertrand and Cournot competition

which results in a welfare gain. As the loss dominates the gain, social welfare decreases with the privatization level.

4 Bertrand Competition

We now proceed to the Bertrand case. By substituting the demand functions into (1) and (2), and then differentiating them with respect to p^* and p respectively, we can derive the first-order conditions for profit maximization of the two firms under Bertrand competition as follows:

$$\frac{\partial V^*}{\partial p^*} = \left(p^* - c\right) h_1 + \lambda q^* + (1-\lambda)(p-c)h_2 = 0, \tag{8}$$

$$\frac{\partial \pi}{\partial p} = (p-c)h_1 + q = 0. \tag{9}$$

The second-order and the stability conditions are satisfied.

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Equations (8) and (9) are respectively the reaction functions for the public and the private firms under the Bertrand regime. They are expressed in terms of prices. By substituting $p^* = f(q^*, q)$ and $p = f(q, q^*)$ into (8) and (9), we can express the reaction functions in terms of q^* and q , and derive their slopes as follows:

$$\frac{\partial q}{\partial q^*}\Big|_{R^{*B}} = -\frac{\left(f_1^2 + \lambda f_1^2 - f_2^2\right)}{\lambda f_1 f_2} < 0, \quad \text{and}$$
$$\frac{\partial q}{\partial q^*}\Big|_{R^B} = -\frac{f_1 f_2}{2f_1^2 - f_2^2} < 0. \tag{10}$$

For simplicity, we depict only R^B in Figure 1. Like that under the Cournot regime, R^B is also independent of the level of privatization. By comparing slopes of reaction functions under the two regimes *i.e.* (6) and (10), we find that the reaction functions are steeper under Bertrand competition than under Cournot if $\lambda = 0$. It implies that, before privatization (*i.e.*, $\lambda = 0$), the public firm produces more under Cournot competition, but the private firm produces more under Bertrand competition as shown by C_0 and B_0 in Figure 1.[3] By contrast, after full privatization (*i.e.* $\lambda = 1$), both firms produce more under Bertrand competition than under Cournot as evidenced by C_2 and B_2 Proceeding as before, we can also derive the equilibrium output path B_0B_2 for $\lambda \in [0, 1]$ under the Bertrand regime in Figure 1. In addition, by differentiating (8) with respect to q^* and λ, and rearranging it, we obtain:

$$\frac{\partial q^*}{\partial \lambda}\Big|_{R^{*B}} = -\frac{(f_1 q^* - f_2 q)\, f_1}{\left(f_1^2 + \lambda f_1^2 - f_2^2\right)} < 0. \tag{11}$$

It indicates that the reaction function of the public firm shifts inward as λ increases, implying that both the TOE and the UDE decrease with λ. That is to say, although it's similar to those under Cournot competition, there is a welfare loss due to the TOE and a welfare gain from the UDE. However, the sizes of the two effects are different from those under the Cournot regime. Namely, the two effects change with λ in different rates under the two competition modes. If the welfare gain (loss) from the UDE (TOE) under Cournot is sufficiently larger (smaller) than that under Bertrand, the former is socially more desirable than the latter. We shall compare the social

[3] Please refer to Ghosh and Mitra (2010, p.73) for the detailed explanation of this result.

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desirability between Bertrand and Cournot competition using the standard horizontally differentiated products model in the following section.

5 Welfare comparison

To investigate the welfare ranking between Bertrand and Cournot competition, we follow Singh and Vives (1984) to specify the utility function as follows:

$$U\left(q, q^*\right) = \alpha\left(q + q^*\right) + f_1\left(q^2 + q^{*2}\right)/2 + f_2 q q^*, \tag{12}$$

where α denotes consumers' highest willingness to pay.

By substituting (12) into (3), we can decompose the social welfare into the TOE and the UDE as follows:

$$SW = \underbrace{\frac{\left[4(\alpha - c) + (f_1 + f_2)\left(q^* + q\right)\right]\left(q^* + q\right)}{4}}_{\substack{\text{Total Output Effect} \\ \text{(TOE)}}} - \underbrace{\frac{(f_2 - f_1)\left(q^* - q\right)^2}{4}}_{\substack{\text{Uneven Distribution Effect} \\ \text{(UDE)}}}. \tag{13}$$

It shows that social welfare increases (decreases) as the TOE (UDE) increases. By substituting the equilibrium outputs under Bertrand or Cournot competition into (13) respectively, we can derive their TOEs and UDEs. Moreover, we use TOE^{CB} to measure the difference of the TOEs (*i.e.*, $\text{TOE}^C - \text{TOE}^B$), UDE^{CB} the difference of the UDEs (*i.e.*, $\text{UDE}^C - \text{UDE}^B$), and SW^{CB} the social welfare difference under the two regimes. They are derived in the mathematical appendix.

We use Figure 2 to portray TOE^{CB}, UDE^{CB} and SW^{CB}. If the public firm is completely state-owned (privatized), the TOE effect is larger (smaller) under Cournot than under Bertrand competition, *i.e.*, $\text{TOE}^{CB} > (<)0$; but the UDE effect is non-negative, *i.e.*, $\text{UDE}^{CB} \geq 0$. The economic explanation for the first result is as follows. From (4), we can find that if $\lambda = 0$, the public firm should produce its output at $p^* = c$ under Cournot competition. However, from (8), the output under Bertrand competition is at $p^* > c$. It implies that if the public firm is completely state-owned the

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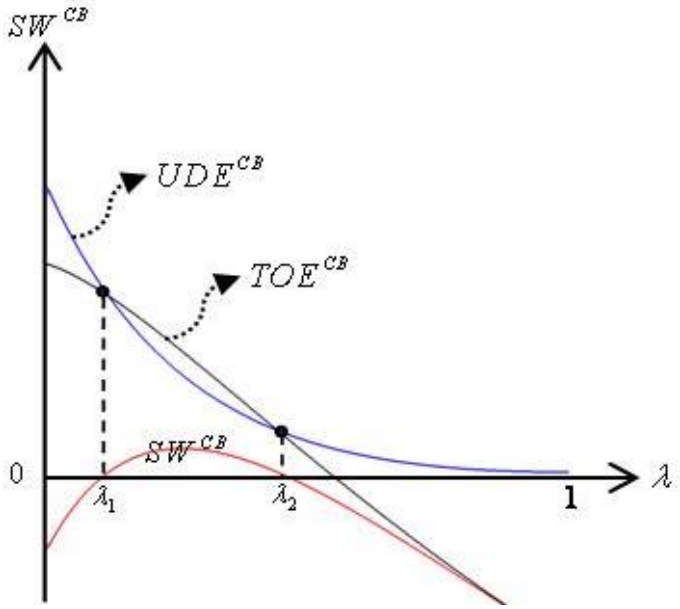


Figure 2: The welfare comparison between Bertrand and Cournot competition

total output is *larger* under Cournot than under Bertrand competition. This result has been reported in Ghosh and Mitra (2010, p.74). Furthermore, if the public firm is completely privatized, our result restores to that in Singh and Vives (1984), *i.e.*, the total output is *smaller* under Cournot than under Bertrand competition. Namely, as the privatization level increases, the decrease of TOE^C is *larger* than TOE^B. Moreover, the reason for $\text{UDE}^{CB} \geq 0$ is as follows. If $\lambda = 0$, the equilibrium output under Cournot (Bertrand) competition is at $C_0(B_0)$ in Figure 1, which implies $\text{UDE}^{CB} > 0$. As the output of the public (private) firm decreases (increases) with λ under Cournot competition, UDE^C decreases as the privatization level increases and becomes 0 when the public firm is completely privatized which corresponds to C_2 in Figure 1. By contrast, the prices of the public and private firms increase with λ and the increase of the former is higher than the latter under Bertrand competition. As a result, UDE^B decreases as the privatization level increases and becomes 0 when the public firm is completely privatized which corresponds to B_2 in Figure 1. As UDE^C decreases faster than UDE^B, UDE^{CB} must decrease with λ. This is also shown in Figure 2.

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Table 1: The numerical results of $SW^C - SW^B$

f_2 \ λ	0.3	0.4	0.5	0.6	0.7	0.8
-0.1	0.3097	0.2931	0.2444	0.1758	0.0952	0.0077
-0.2	0.3271	0.2779	0.1757	0.0411	-0.1124	-0.2761
-0.3	0.1535	0.0596	-0.0999	-0.2980	-0.5177	-0.7480

From Figure 2, we can find that if $\lambda = 0$, the negative UDE effect is sufficiently larger under Cournot competition, and makes Bertrand competition more socially desirable. This is the result in Ghosh and Mitra (2010) and Matsumura and Ogawa (2012). By contrast, if the public firm is fully privatized (*i.e.*, $\lambda = 1$), the model restores to Singh and Vives (1984) and so does the welfare ranking. Finally, it can be found that TOE^{CB} surpasses UDE^{CB} for λ between λ_1 and λ_2.[4] It implies that Cournot competition is socially more desirable than Bertrand under certain privatization levels. Given the above discussions, we construct the proposition as follows:

Proposition 1. Under a median range of privatization, Cournot competition could be socially more desirable than Bertrand competition in a mixed duopoly.

We employ a numerical example to support the finding in the proposition. Let $\alpha = 10$, $c = 1$, $f_1 = -1$, $f_2 \in [-0.1, -0.3]$ and $\lambda \in [0.3, 0.8]$. In Table 1, it is found that Cournot competition may be more socially desirable than Bertrand competition under partial privatization.

6 Concluding Remarks

This paper revisits the welfare ranking of Bertrand and Cournot competition by considering partial privatization in a differentiated mixed duopoly. We find that the level of privatization plays an important role in comparing the relative merits of the two competition modes. Under some median levels of privatization, Cournot competition could be more socially desirable than Bertrand. This result stands in stark contrast to the previous lit-

[4]The values of λ_1 and λ_2 are derivable from $SW^{CB} = 0$ which can be found in the appendix.

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erature, which asserts that Bertrand competition is socially more desirable than Cournot if the public firm is completely privatized or completely state-owned.

With regard to the rankings in terms of consumer surplus (CS) and producer surplus (PS) between the two competition modes, we find that $\mathrm{CS}^B < \mathrm{CS}^C$ and $\mathrm{PS}^B > \mathrm{PS}^C$ if the privatization level is low which are the same as those in Ghosh and Mitra (2010) and Matsumura and Ogawa (2012). On the other hand, if the privatization level is high, the two rankings are both reversed, becoming in parallel to those in Singh and Vives (1984).[5]

Mathematical Appendix

The purpose of this appendix is to derive the TOE^{CB}, UDE^{CB}, SW^{CB} and the values of λ_1 and λ_2 in Figure 2.

$$\begin{aligned}
\mathrm{TOE}^{CB} &= \mathrm{TOE}^C - \mathrm{TOE}^B \\
&= -\Big[(\alpha-c)^2 f_2 \left(\lambda f_2^2 + f_2^2 + 3\lambda f_1 f_2 + f_1 f_2 - 6\lambda f_1^2 - 2f_1^2\right) \\
&\quad (\lambda f_1 + \lambda f_2 - f_1 + f_2)\Big] \Big/ \Big[4\left(f_2^2 - 2\lambda f_1^2 - 2f_1^2\right)^2 \\
&\quad (f_1 + f_2)\Big] \gtreqless 0, \\
\mathrm{UDE}^{CB} &= \mathrm{UDE}^C - \mathrm{UDE}^B \\
&= -\frac{(\alpha-c)^2 f_2 (f_1 - f_2)(2f_1 - f_2)(1-\lambda)^2}{4\left(f_2^2 - 2\lambda f_1^2 - 2f_1^2\right)^2} \geq 0, \\
SW^{CB} &= SW^C - SW^B \\
&= -\Big[(\alpha-c)^2 f_2 \left(4\lambda f_1^3 - 6\lambda f_1^2 f_2 - f_1^2 f_2 - 4\lambda^2 f_1^3 + 2\lambda f_2^3\right. \\
&\quad \left. + f_1 f_2^2 + 3\lambda^2 f_1 f_2^2 - \lambda^2 f_1^2 f_2\right)\Big] \Big/ \Big[2\left(f_2^2 - 2\lambda f_1^2 - 2f_1^2\right)^2 \\
&\quad (f_1 + f_2)\Big] \gtreqless 0.
\end{aligned}$$

By setting $SW^{CB} = 0$, we can derive that:

[5] The proof of the results is straightforward and is available from the authors upon request.

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$$\lambda_1 = \Big[4f_1^3 + 2f_2^3 - 6f_1^2 f_2 - 2\sqrt{12f_1^4 f_2^2 - 16f_1^5 f_2 - 9f_1^2 f_2^4 + 8f_1^3 f_2^3 + 4f_1^6 + f_2^6}\Big] \Big/ \left[2\left(4f_1^3 - 3f_1 f_2^2 + f_1^2 f_2\right)\right],$$

$$\lambda_2 = \Big[4f_1^3 + 2f_2^3 - 6f_1^2 f_2 + 2\sqrt{12f_1^4 f_2^2 - 16f_1^5 f_2 - 9f_1^2 f_2^4 + 8f_1^3 f_2^3 + 4f_1^6 + f_2^6}\Big] \Big/ \left[2\left(4f_1^3 - 3f_1 f_2^2 + f_1^2 f_2\right)\right],$$

and $0 < \lambda_1 < \lambda_2 < 1$.

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市場競爭、部分民營化與社會福利: 一般性的分析

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本文建立一個混合寡占模型, 探討一家部分民營化的公營廠商及一家純民營廠商進行價格與數量競爭時福利水準的高低。我們的研究結果發現, 給定公營廠商部分民營化下, 兩家廠商從事數量競爭時的社會福利會較價格競爭爲高。此一發現與過去文獻中公營廠商爲純公 (民) 營時, 廠商進行價格競爭下的社會福利較數量競爭下高的結果有很大的不同。

關鍵詞: 部分民營化, 數量競爭, 價格競爭, 社會福利
JEL 分類代號: L13, L32, L33

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