Optimal Export Subsidies in an International Mixed Duopoly

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Abstract

Adopting a third-country trade model of an international mixed duopoly that consists of a labor-managed firm and a capitalistic profit-maximizing firm, this paper analyzes the optimal export subsidy in a Cournot duopoly and that in a Bertrand duopoly. It also examines the effects of a change in export subsidy on firms' exports and prices. One remarkable finding, among others, is that the optimal export subsidy for the labor-managed firm is negative in a Cournot duopoly and positive in a Bertrand duopoly, which contradicts the widely-known results derived from the duopolistic trade models that consider only capitalistic profit-maximizing firms.

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1. INTRODUCTION

Establishing a third-country trade model of an international duopoly (or oligopoly), Brander and Spencer (1985) have found that when firms engage in Cournot competition, an increase in export subsidy results in an increase in the export of the subsidy-giving country and a decrease in that of the rival country (hereafter, the B-S subsidy efficacy) and the optimal export subsidy is positive (hereafter, the B-S subsidy policy), while Eaton and Grossman (1986) have demonstrated that when firms export goods under Bertrand competition, a raise in export subsidy has the result that both of the firms' prices increase (the E-G subsidy efficacy) and the optimal export subsidy is negative (the E-G subsidy policy). Their findings have had a great impact on the trade theory and have been adopted by many analysts. However, their models have considered duopolies that consist only of capitalistic profit-maximizing firms.

By contrast, constructing a third-country trade model of an international mixed duopoly that consists of a labor-managed firm and a capitalistic profit-maximizing firm (hereafter, LMF and PMF, respectively), Mai and Hwang (1989) have analyzed the effects of a change in export subsidy for the labor-managed firm in Cournot competition and found that an increase in export subsidy for a LMF reduces its export and increases export of a PMF (hereafter, the M-H subsidy efficacy). Further, extending the M-H model so as to consider product differentiation, Okuguchi (1991) has demonstrated that while the effects of a change in export subsidy for a LMF on exports of LMF and PMF are the same as those shown by Mai and Hwang (1989) when firms adopt Cournot strategies, a change in export subsidy for a LMF has a positive effect on both the prices of LMF and PMF (hereafter, the O subsidy efficacy) when firms employ Bertrand strategies. Though these results are of some interest because they run contrary to the well-established and widely-accepted results of the B-S efficacy and the E-G efficacy, the arguments are not complete since the researchers have never investigated the optimal export subsidies in a Cournot mixed duopoly and those in a Bertrand mixed duopoly.

Apparently, since the B-S and E-G results are all based on a third-country trade model of an international duopoly that is composed of only PMFs, they cannot be applied to any international mixed duopoly without reexamination. Though Mai and Hwang (1989) and Okuguchi (1991) have reexamined both the B-S and E-G subsidy efficacy in international mixed duopolies, they have reanalyzed neither the B-S subsidy policy nor the E-G subsidy policy in an international mixed duopoly. For example, Mai and Hwang (1989) have suggested that the LMC government might have an incentive to use export taxes, but never explicitly analyzed the optimal export subsidy level of the LMC. Therefore, it is not certain whether the B·S and the E·G subsidy policies are also correct in Cournot and Bertrand international mixed duopolies, respectively. In this paper, we analyze the optimal levels of export subsidies as well as their efficacies in Cournot and Bertrand international mixed duopolies.

The rest of the paper is organized as follows. In the next section, we present a third-country trade model of an international mixed duopoly that consists of a PMF in a capital-oriented country (hereafter, COC) and a LMF in a labor-managed country (hereafter, LMC). In Section 3, adopting such a model, we analyze the effects of changes in the export subsidies of the CC and the LMC on the exports of the PMF and the LMF in Cournot and Bertrand industries, respectively. In Section 4, we investigate the optimal export subsidies of the CC and the LMC in Cournot and Bertrand industries, respectively. In Section 5, we present some concluding remarks.

2. Basic Model and Assumptions

Consider an international mixed duopoly that consists of a PMF in a COC and a LMF in a LMC. Both firms export all their products to a third-country market where they engage in Cournot or Bertrand competition. Governments of the COC and the LMC give, respectively, specific subsidies to exports of the PMF and LMF in their countries. It is assumed that while the COC government determines its export subsidy so as to maximize total welfare, the LMC government sets its export subsidy so as to maximize welfare per labor.

Furthermore, as in Okuguchi (1991), we assume that the LMF and the PMF produce differentiated goods, and we investigate optimal export subsidies in an international duopoly with product differentiation for two cases: (i) firms adopt an output strategy (Cournot duopoly), and (ii) firms take a price strategy (Bertrand duopoly). To solve the problems noted above, we adopt a two-stage game model: in the first stage, governments set their respective optimal export subsidies and in the second stage firms decide their outputs (= export levels) uncooperatively.

The Case of Cournot Competition

In this subsection, we focus on a Cournot mixed duopoly that consists of a PMF and a LMF whose products are all exported to a third country. Suppose that each firm produces its good by using fixed capital and variable labor, and that markets for capital and labor are both perfectly competitive and internationally segregated from each other. It is also assumed that respective export subsidies for firms are set before firms decide outputs and are kept constant.

Then, the total profit π^C of the PMF in the Cournot mixed duopoly is defined as

$$(1) \qquad \pi^C = p(x,X)x - r\bar{k} - wl(x) + sx,$$

where p is the price of the PMF, $p(x,X)$ is its inverse demand function, x and X are outputs of the PMF and the LMF, respectively, $r\bar{k}$ is the fixed capital cost, l is the labor input of the PMF, $l(x)$ is the labor inverse function derived from the production function $x = f(l,\bar{k})$, w is a wage rate, and s is a specific export subsidy for the PMF that is set and given by the government of the COC. Meanwhile, income per unit of labor Y^C for the LMF is given by

$$(2) \qquad Y^C = \frac{\Pi^C}{L} + W = \frac{P(x,X)X - R\bar{K} + SX}{L(X)},$$

where capital letters are the variables and functions for the LMF that correspond to those for the PMF. Here, note that since the profit per labor of the LMF is given by $\frac{P(x,X)X - R\bar{K} + SX}{L(X)} - W$, then maximization of income per labor and maximization of profit per labor are equal to each other for a LMF because W is constant.

Regarding the inverse demand functions of the PMF and the LMF in a Cournot duopoly, it is assumed that they respectively satisfy

(3) $p_1 < 0,\ p_2 \leq 0,\ P_1 \leq 0$ and $P_2 < 0,$

where 1 and 2 in the subscript imply partial differentiation with respect to the first and second arguments. Further, we regard zero labor input as corresponding to zero output of products and the marginal product of labor as positive and strictly decreasing. Therefore, the labor inverse functions, $l(x)$ and $L(X)$, have the following features, respectively:

(4) $l(0) = 0,\ l'(x) > 0,\ l''(x) > 0,\ xl'(x) - l(x) > 0,$

$L(0) = 0,\ L'(X) > 0,\ L''(X) > 0,\ XL'(X) - L(X) > 0.$

The features of (4) play very significant roles in the following analysis, as has been indicated by Mai and Hwang (1989) and Okuguchi (1991). In a Cournot industry each firm sets its output, given the rival's output. Therefore, the PMF decides x so as to maximize π, given X, and the LMF chooses X so as to maximize Y, given x.

The Cournot-Nash equilibrium in the second stage is a pair of x and X that simultaneously satisfies

(5) $p_1 x + p - wl'(x) + s = 0,$

(6) $(P_2 X + P + S)L(X) - (PX - r\bar{K} + SX)L'(X) = 0,$

where (5) is the first-order condition (and a reaction function) of the PMF and (6) is the first-order condition (and a reaction function) of the LMF. It is assumed that the industry equilibrium is locally stable and that the firms' reaction curves are both downward sloping in a Cournot duopoly (that is, products of the two firms are strategically substitutive for each other). Hence, we have, as many papers have shown,

(7) $$F_1^C < 0,\ F_2^C < 0,\ I_1^C < 0,\ I_2^C < 0,\ F_1^C I_2^C - F_2^C I_1^C > 0,$$

$$F_1^C < F_2^C < 0, \quad I_2^C < I_1^C < 0,$$

where $F^C(x,X)$ and $I^C(x,X)$ correspond to the left-hand sides of (5) and (6), respectively. Under the conditions of $F_1^C < 0$ and $I_2^C < 0$ in (7), the second-order conditions for (5) and (6) hold, respectively.

The Case of Bertrand Competition

In a Bertrand mixed duopoly, the demand functions of the PMF and the LMF are expressed respectively as

(8) $$x = x(p,P), \quad X = X(p,P),$$

which are assumed to have the following features:

(9) $$x_1 < 0,\ x_2 \geq 0,\ x_1 + x_2 < 0, \quad X_1 \geq 0,\ X_2 < 0,\ X_1 + X_2 < 0.$$

Then, substituting x and X of (8) into (1) and (2), the objective functions of the PMF and the LMF in a Bertrand duopoly are rewritten respectively as

(10) $$\pi^B = px(p,P) - r\bar{k} - wl(x(p,P)) + sx(p,P),$$

$$(11) \qquad Y^B = \frac{PX(p,P) - R\bar{K} + SX(p,P)}{L(X(p,P))},$$

where B in the superscript expresses a Bertrand duopoly, and all other variables and functions are the same as those adopted in the previous subsections.

Therefore, the Bertrand-Nash equilibrium is given by a pair of p and P that simultaneously satisfies

$$(12) \qquad x + px_1 - wl'(x)x_1 + sx_1 = 0,$$

$$(13) \qquad (X + PX_2 + SX_2)L(X) - (PX - R\bar{K} + SX)L'(X)X_2 = 0,$$

where (12) is the first-order condition (and a reaction function) of the PMF and (13) is the first-order condition (and a reaction function) of the LMF. It is assumed, as in the previous subsection, that the stability conditions of the industry equilibrium are satisfied locally and that the firms' reaction curves are both up-ward sloping in the Bertrand duopoly. Then, denoting the left-hand sides of (12) and (13) by $F^B(p,P)$ and $I^B(p,P)$, respectively, we obtain

$$(14) \qquad F_1^B < 0,\ F_2^B > 0,\ I_1^B > 0,\ I_2^B < 0,\ F_1^B I_2^B - F_2^B I_1^B > 0,$$

$$F_2^B < |F_1^B|, \quad I_1^B < |I_2^B|.$$

Of course, $F_1^B < 0$ and $I_2^B < 0$ in (14) ensure the second-order conditions for (12) and (13), respectively.

3. EFFICACY OF STRATEGIC EXPORT SUBSIDIES

In this section we derive the effects of changes in export subsidies of the COC and the LMC on outputs (= exports) of the PMF and the LMF in a Cournot duopoly and in a Bertrand Duopoly. It is assumed that when one of the governments changes its export subsidy the other government keeps its export subsidy constant in all cases.

Efficacy of Export Subsidies in a Cournot Duopoly

First, to see the effects of a change in the COC's export subsidy on outputs of the PMF and the LMF, we derive, from (5) and (6),

$$\text{(15)} \qquad \begin{pmatrix} F_1^C & F_2^C \\ I_1^C & I_2^C \end{pmatrix} \begin{pmatrix} \dfrac{\partial x}{\partial s} \\ \dfrac{\partial X}{\partial s} \end{pmatrix} = \begin{pmatrix} -1 \\ 0 \end{pmatrix}.$$

Thus, taking (7) and (15) into consideration, we obtain

$$\text{(16)} \qquad \frac{\partial x}{\partial s} = -\frac{I_2^C}{D} > 0, \qquad \frac{\partial X}{\partial s} = \frac{I_1^C}{D} < 0,$$

where $D = F_1^C I_2^C - F_2^C I_1^C > 0$. Now, (16) is paraphrased as

Proposition 1. **An increase in export subsidy in the COC results in an increase in the export of the PMF in its country and a decrease in that of the LMF in its rival country, and *vice versa.***

Though this proposition might be regarded as the same as the B-S subsidy efficacy, the two are actually quite different from each other. While Proposition 1 is derived from a model of a mixed duopoly, the B-S subsidy efficacy has been derived from a duopoly model that considers only PMFs. The difference in the economic implication between the two models will become clearer when the effects of a change in export subsidy in the LMC on exports of the PMF and the LMF are analyzed.

In order to examine the effects of a change in the LMC's export subsidy on outputs of the PMF and the LMF, we solve

$$(17)\qquad \begin{pmatrix} F_1^C & F_2^C \\ I_1^C & I_2^C \end{pmatrix} \begin{pmatrix} \dfrac{\partial x}{\partial S} \\ \dfrac{\partial X}{\partial S} \end{pmatrix} = \begin{pmatrix} 0 \\ XL'(X) - L(X) \end{pmatrix}.$$

Therefore, considering (7) and (17), we obtain

$$(18)\qquad \frac{\partial x}{\partial S} = \frac{-\{XL'(X) - L(X)\}F_2^C}{D} > 0,$$

$$\frac{\partial X}{\partial S} = \frac{\{XL'(X) - L(X)\}F_1^C}{D} < 0,$$

which presents

Proposition 2. A rise in export subsidy of the LMC results in an increase in the export of the PMF in its rival country and a decrease in that of the LMF in its country, and *vice versa.*

Proposition 2 states the M·H subsidy efficacy, which has been also confirmed by Okuguchi (1991). This is in contrast to the B·S subsidy efficacy, according to which a rise in export subsidy results in an increase in the export of the subsidy-giving country and a decrease in that of the rival country, and *vice versa*. Propositions 1 and 2 combine to show that the equilibrium export of the LMF (PMF) always decreases (increases) with increases in export subsidies of the COC and LMC, and *vice versa*.

Efficacy of Export Subsidies in a Bertrand Duopoly

In this subsection, we also begin our analysis by deriving the effects of a change in export subsidy of the COC on exports of the COC and that of the LMC. Differentiating totally (12) and (13) with respect to s, we have

$$(19) \qquad \begin{pmatrix} F_1^B & F_2^B \\ I_1^B & I_2^B \end{pmatrix} \begin{pmatrix} \dfrac{\partial p}{\partial s} \\ \dfrac{\partial P}{\partial s} \end{pmatrix} = \begin{pmatrix} -x_1(p,P) \\ 0 \end{pmatrix}.$$

Hence, solving (19) and taking into account (14), we get

$$(20) \qquad \frac{\partial p}{\partial s} = \frac{-x_1 I_2^B}{\Delta} < 0, \qquad \frac{\partial P}{\partial s} = \frac{x_1 I_1^B}{\Delta} < 0,$$

where $\Delta = F_1^B I_2^B - F_2^B I_1^B > 0.$

Similarly, in order to obtain the effects of a change in export subsidy of the COC on exports of the COC and that of the LMC, differentiating totally (12) and (13) with respect to S, we have

$$(21)\qquad \begin{pmatrix} F_1^B & F_2^B \\ I_1^B & I_2^B \end{pmatrix} \begin{pmatrix} \frac{\partial p}{\partial S} \\ \frac{\partial P}{\partial S} \end{pmatrix} = \begin{pmatrix} 0 \\ \{XL'(X) - L(X)\}X_2(p,P) \end{pmatrix}.$$

Therefore, solving (21) and substituting (14) and (4) into the results, we get

$$(22)\qquad \frac{\partial p}{\partial S} = \frac{-\{XL'(X) - L(X)\}X_2 F_2^B}{\Delta} > 0,$$
$$\frac{\partial P}{\partial S} = \frac{\{XL'(X) - L(X)\}X_2 F_1^B}{\Delta} > 0.$$

Now, (20) and (22) combine to present

Proposition 3. Both the prices of the PMF and the LMF decrease with the export subsidy in the COC and increase with that of the LMC.

Proposition 3 is the same as the O subsidy efficacy. However, Okuguchi (1991) has never analyzed the effects of a change in the export subsidy of the COC on exports of the PMF and the LMF. Without such analysis, one cannot confirm the differences between the subsidy efficacy in a mixed duopoly and the E-G subsidy efficacy in a duopoly that consists of only the PMFs. The E-G subsidy efficacy has shown that the firms' prices always increase with the export subsidies of both countries. By contrast, Proposition 3 demonstrates that while both the prices of the PMF and the LMF increase with export subsidy in the LMC, they decrease with export subsidy in the

COC. In a mixed Bertrand duopoly, export subsidies in the COC and the LMC have different effects on the prices of the PMF and the LMF, respectively.

4. Optimal Export Subsidy Policies

In this section, we analyze optimal export subsidies set by the COC and LMC governments under Cournot and Bertrand competition, respectively. Since neither the COC nor the LMC consumes goods in the third-country model, total welfare v in the COC and welfare per labor V in the LMC are defined respectively as

(23) $$v = \pi - sx,$$

(24) $$V = \frac{Y - SX}{L}.$$

Therefore, the government in the COC determines its export subsidy s so as to maximize v given by (23), and the government in LMC sets its export subsidy S so as to maximize V defined by (24). It is supposed that each government chooses its export subsidy, given the export subsidy of the rival country.

Optimal Subsidy Policy in a Cournot Duopoly

In a Cournot mixed duopoly, the total welfare v in the COC and the welfare per labor V in the LMC are specified respectively as

(23)' $$v^C = \pi^C(x,X) - sx,$$

(24)' $$V^C = Y^C(x,X) - \frac{SX}{L(X)}.$$

Hence, under the profit maximization conditions, (5) and (6), in the second stage, the first-order conditions for maximizing v^C and V^C are given respectively by

(25-1) $$\frac{\partial v^C}{\partial s} = \pi_2^C \frac{\partial X}{\partial s} - s\frac{\partial x}{\partial s} = 0,$$

(25-2) $$\frac{\partial V^C}{\partial S} = \frac{\partial Y^C}{\partial x}\frac{\partial x}{\partial S} - S\frac{\partial (X/L(X))}{\partial X}\frac{\partial X}{\partial S} = 0.$$

It is assumed that the second-order conditions of v^C and V^C maximization and the stability conditions of industry equilibrium are all satisfied. Then, considering (16) and $\pi_2^C = p_2 x < 0$ into (25-1) and substituting (4), (16) and $\frac{\partial Y^C}{\partial x} = \frac{p'(x+X)X}{L(X)} < 0$ into (25-2), we obtain respectively

(26) $$s = \frac{\pi_2 \frac{\partial X}{\partial s}}{\frac{\partial x}{\partial s}} > 0, \qquad S = \frac{\frac{\partial Y^C}{\partial x}\frac{\partial x}{\partial S}}{\frac{\partial (X/L(X))}{\partial X}\frac{\partial X}{\partial S}} < 0.$$

Therefore, (26) presents

Proposition 4. In a Cournot mixed duopoly, the optimal export subsidy of the COC is positive, but that of the LMC is negative (an export tax).

This proposition demonstrates that the optimal export subsidy policy in a Cournot mixed duopoly is contrary to the B-S subsidy policy in a Cournot duopoly where only

PMFs compete in the third-country market. The B-S subsidy policy has been taken to suggest that in a Cournot duopoly that consists of only two COCs, the optimal export policies of these countries are both export subsidies. However, Proposition 4 denies the B-S subsidy policy and shows that the optimal export policy of the COC is still the export subsidy, but that of the LMC is the export tax in a Cournot mixed duopoly. We can derive the optimal export tax S of the LMC and the optimal export subsidy s of the COC by solving (25-1) and (25-2) simultaneously.

Optimal Subsidy Policy in a Bertrand Duopoly

In a Bertrand mixed duopoly, the total welfare v in the COC and the welfare per labor V in the LMC are rewritten respectively as

(23)" $$v^B = \pi^B(p,P) - sx(p,P),$$

(24)" $$V^B = Y^B(p,P) - \frac{SX(p,P)}{L(X(p,P))}.$$

Therefore, considering the firms' first-order conditions in the second stage, we can derive the following first-order conditions:

(27-1) $$\frac{\partial v^B}{\partial s} = \pi_2 \frac{\partial P}{\partial s} - s(x_1 \frac{\partial p}{\partial s} + x_2 \frac{\partial P}{\partial s}) = 0,$$

(27-2) $$\frac{\partial V^B}{\partial S} = \frac{\partial Y^B}{\partial p}\frac{\partial p}{\partial S} - S\frac{(X_1 \frac{\partial p}{\partial S} + X_2 \frac{\partial P}{\partial S})\{L(X) - L'(X)X\}}{L(X(p,P))^2} = 0.$$

Of course, we also assume that all the second-order conditions of v^B and V^B maximization and the stability conditions of industry equilibrium hold.

Note further that $\pi_2 = (p - wl'(l) + s)x_2 > 0$ holds since $(p - wl'(l) + s)$ is positive under the condition of (12) and that $\left| x_2 \frac{\partial P}{\partial s} \right| < x_1 \frac{\partial p}{\partial s}$ holds under the conditions of (9-1), (14) and (20). Hence, from (27-1) we obtain

$$(28) \qquad s = \frac{\pi_2 \frac{\partial P}{\partial s}}{x_1 \frac{\partial p}{\partial s} + x_2 \frac{\partial P}{\partial s}} < 0.$$

Next, adopting two abbreviations such as

$$A = \frac{(X_1 \frac{\partial p}{\partial S} + X_2 \frac{\partial P}{\partial S})\{L(X) - L'(X)X\}}{L(X(p,P))^2} \quad \text{and } B = \frac{\partial Y^B}{\partial p} \frac{\partial p}{\partial S},$$

we express (27-2) as

$$(29) \qquad S = \frac{B}{A}.$$

Then, substituting $(X_1 \frac{\partial p}{\partial S} + X_2 \frac{\partial P}{\partial S}) < 0$ (see (21) in Okuguchi (1991)) and (14) into A, we can demonstrate that A (the denominator of the right-hand side in (29)) is positive. Furthermore, since $(P+S)L(X) - (PX - R\bar{K} + SX)L'(X) > 0$ holds under the condition of (13), we have

$$\frac{\partial Y^B}{\partial p} = \frac{\{(P+S)L(X) - (PX - R\bar{K} + SX)L'(X)\}X_1}{L(X)^2} > 0.$$

This shows, together with (22), that B (= the numerator of the right hand side in (29)) is positive. Thus, considering the signs of A and B into (29), we get

(30) $$S > 0.$$

Therefore, we can paraphrase the arguments of (28) and (30) as follows:

Proposition 5. In a Bertrand mixed duopoly, the optimal export subsidy of the COC is negative (an export tax), while that of the LMC is positive.

Evidently, the optimal export policy in a Bertrand mixed duopoly that is proposed in Proposition 5 contradicts the E-G subsidy policy in a Bertrand duopoly that consists of only the PMFs in the COCs. While the E-G policy implies that the optimal export policy for every country is the export tax in a Bertrand duopoly with PMFs in the COCs, Proposition 5 indicates that the optimal export policy is the export tax for the COC, but it is the export subsidy for the LMC in a mixed Bertrand duopoly with a LMF of the LMC and a PMF of the COC. The optimal export tax of the COC and the optimal export subsidy of the LMC are S and s, respectively, which satisfy (27-1) and (27-2) at the same time.

5. CONCLUSIONS

This paper focuses on the analysis of optimal export policies of the COC and the LMC in Cournot and Bertrand mixed duopolies. It is supposed that the COC government aims to maximize the total welfare and the LMC government acts to maximize the welfare per labor. In order to derive the optimal export subsidies of the COC and the LMC in Cournot and Bertrand mixed duopolies, we used the new mixed duopoly trade models of Okuguchi (1991), which extended the original mixed duopoly trade model of Mai and Hwang (1989) so as to consider product differentiation.

As a result, we have been able to derive and present several interesting findings, which are summarized as propositions. It is shown that both the efficacy of export policy and the optimal export policy tool vary, depending on whether the duopoly in question is Cournot or Bertrand and whether or not it is a mixed duopoly. The B-S subsidy efficacy and the B-S subsidy policy are true only in a Cournot duopoly with only PMFs and the E-G subsidy efficacy and the E-G subsidy policy hold only in a Bertrand duopoly with only PMFs. The B-S subsidy efficacy and the B-S subsidy policy are denied in a Cournot mixed duopoly, and the E-G subsidy efficacy and the E-G subsidy policy lose their validity in a Bertrand mixed duopoly. Therefore, governments must pay careful attention when adopting the optimal export subsidies.

In this paper we have investigated mixed duopolies in a third-country market model. It is of great interest to discuss the efficacy of export policy and the optimal export policy tool by establishing a reciprocal trade model of a mixed duopoly. Moreover, one can extend the model so as to analyze the export policy tools in a Schtakerberg mixed duopoly or in a dynamic mixed duopoly. The propositions in this paper can then be reassessed from a new theoretical standpoint.

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