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Optimal export policy with upstream price competition

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Abstract

We constructed a third-market model with a vertical trading structure in which input suppliers engage in the homogeneous price competition *à la* Dastidar (1995). We show that in the case of downstream Bertrand competition, a non-monotonic export policy may appear, that is, the optimal export policy can change like a *tax–subsidy–tax* as the degree of product-substitutability rises. We also show that when the number of domestic input suppliers is at an intermediate level, the conventional result in which the optimal policy is an export subsidy (tax) if downstream is Cournot (Bertrand) rivalry remains. We further discuss welfare comparisons between downstream Cournot and Bertrand cases.

Key words: Upstream price competition; Export subsidy/tax; Non-monotonic policy; Product substitutability

JEL classification: F12; F13; L13; D43

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1 Introduction

Vertical trade links are a prominent feature of modern international trade. As production fragmentation rises, each country specializes in producing particular inputs or in a production stage, and the vertical trading chain reaches many countries (Hummels et al., 2001). Additionally, the progress of trade liberalization, such as the growing economic integration and a reduction in trade costs enables firms to purchase inputs internationally. With progress in the globalization in production, the use of imported-inputs has been expanding and trade in inputs plays a central role in goods trade (Ali and Dadush, 2011; World Trade Organization (WTO), 2009, 2013). According to the WTO (2009, 2013), trade in intermediate inputs (excluding fuel) occupied 40% of total trade in 2008, and the share of intermediate inputs in non-fuel exports was over 50% during 2000–2011.

Considering vertical trade forced the conventional argument on trade policies to change. Such a change of argument is outstanding in discussions on export policy because when the input market is imperfectly competitive, the rent-shifting effect of export subsidies/taxes is due not only to foreign downstream rivals, but also upstream input-suppliers. Bernhofen (1997) shows that when a monopoly input-supplier exists outside the country, an export subsidy makes input demand less elastic and enables the monopoly supplier to set a higher input price, so the government's incentives to subsidize weakens.[1] Although Bernhofen (1997) sheds light on the fact that a horizon-

[1]Some studies emphasize different factors that affect the recommended export policy. Ishikawa and Spencer (1999) employ a more general setting in which upstream and downstream markets consist of many firms, and show that the government's decision of whether to subsidize or tax is influenced by the number of firms. Chang and Sugeta (2004) consider Nash-bargaining between an upstream monopolist

tal (vertical) rent-shifting effect points to a subsidy (tax), it assumes a homogeneous Cournot duopoly in the third market. In contrast, Chou (2011) extends Bernhofen's model to a differentiated duopoly and demonstrates that product substitutability affects the optimal export policy. In a differentiated Cournot duopoly, if the degree of product substitutability is small and the upstream monopolist has uniform pricing, horizontal competition is gentle and the vertical rent-shifting effect dominates the horizontal one. Then, the optimal export policy can become a tax, despite Cournot rivalry. Moreover, input market integration is also important. Kawabata (2010) shows that in a third-market model with a differentiated duopoly, if each exporter has an input supplier and the input market is integrated, the horizontal rent-shifting effect dominates the vertical one, and thus, the recommended export policy can be a subsidy, despite downstream Bertrand rivalry.[2]

Existing works demonstrate that in vertical trade, horizontal and vertical rent-shifting effects due to export policies can be influenced by market structures, product substitutability, and price discrimination in inputs; hence, they provide new insights into the conventional wisdom on export policy.[3] However, they assume that the upstream input market is a monopoly or input suppliers engage in quantity competition, so the implications of *price competition* in the input market tend to be overlooked. When one recognizes the fact that a Cournot industry is not observed so much in the

and downstream firms in a differentiated duopoly, and show that bargaining power affects export policies. Hwang et al. (2007) demonstrate that the degree of the returns to scale of the production function for the downstream monopolist affects the government's decision in the case of upstream monopoly.

[2]In a similar model setting, Kawabata (2012) focuses on the role of cost asymmetries among downstream firms and considers export policies for both upstream and downstream firms.

[3]Takauchi (2010) also examines the policy interaction between export subsidy/tax and requirements for the rules of origin in a trade model with a vertical production structure.

real world,[4] it is significant to consider upstream price competition.

This paper considers the implications of upstream price competition for the recommended export policy. To achieve this aim, in a third market model with differentiated products, we incorporate Dastidar (1995)-type price competition into the input market, and show that if the downstream has Bertrand rivalry, the optimal export policy can be *tax–subsidy–tax*, corresponding to the degree of product substitutability. In the downstream Bertrand case, the domestic firm's exports are U-shaped for product substitutability. Hence, a rise in the degree of substitutability when it is at a low level reduces the domestic firm's exports and worsens its competitive position, such that it weakens the incentives for taxation. Conversely, a high degree of substitutability raises domestic firm's exports, and incentives for taxation become strong. The optimal export policy has a "tax–subsidy–tax" shape, so it becomes a tax when substitutability is both low and high. When the actual level of substitutability is low, though practitioners accidentally recognize that the degree of substitutability is high, because the realized policy is a tax, the welfare loss may be small. In contrast, if practitioners recognize that the degree of substitutability is slightly higher than its actual level, the policy opposite to the optimal policy exists and the welfare loss may be considerable. This implies that in implementing export policies, a case exists in which "a large error is permissible, while a small error is not allowable," and indicates that the common knowledge that "great mistakes are impermissible" is not always true. We believe that our result gives a new insight into the context of trade policy.

[4]For example, using annual data during 1961–90 for seventy Japanese manufacturing industries, Flath (2012) empirically shows that whereas the Cournot specification is the most likely for 5 industries, the Bertrand specification is the most likely for 35 industries.

We also show that the conventional results in Brander and Spencer (1985) and Eaton and Grossman (1986)—that is, the optimal export policy is a subsidy (tax) if exporters compete in a Cournot (Bertrand) fashion—holds if the number of domestic input-suppliers is at an intermediate level. Because a larger number of domestic input suppliers can enhance welfare by increasing demand for input and exports, the incentives to subsidize become stronger. On the one hand, in the downstream Bertrand case, since the incentive to tax is stronger than that in the Cournot case, it requires a larger number of input-suppliers than in the Cournot case to realize a positive subsidy. In the downstream Bertrand case, the threshold number of domestic input suppliers in which optimal export policy is a subsidy is larger than that in Cournot case. Hence, if the number of domestic input-suppliers is at an intermediate level, the optimal policy in the case of downstream Bertrand (Cournot) is a tax (subsidy).

The rest of the paper is organized as follows. Section 2 presents the model and section 3 derives the equilibrium outcomes in both the downstream Bertrand and Cournot cases. Section 4 offers conclusions.

2 Model

We consider a third-market model with upstream price competition. The downstream market consists of two final goods producers, firms H and F; firm i $(= H, F)$ is located in country i. We call country H (F) as the Home (Foreign) country. Each firm i exports its product to the third market.[5] The demand and inverse demand functions in the third

[5]For simplicity, we omit trade costs in this analysis.

market are $q_i = \frac{(1-b)a-p_i+bp_j}{1-b^2}$ and $p_i = a - q_i - bq_j$ for $i, j = H, F$; $i \neq j$, where $a > 0$, p_i, and q_i are the price and quantity supplied by firm i, and b ($\in [0, 1)$) measures the degree of product substitutability. Home and Foreign products are perfect substitutes, where $b = 1$ and are independently consumed such that $b = 0$. We assume that firms have identical production technology, and is linear, where one unit of input is used to produce one unit of the final good. We also assume that any other production costs are normalized to zero, that is, the firm's production cost is the price of a purchased input, r. To focus on the government's incentives to choose a policy, we examine the case where only the Home country subsidizes.[6] Firms' profits are $\Pi_H \equiv (p_H - r + s_H)q_H$ and $\Pi_F \equiv (p_F - r)q_F$, where s_H is a per-unit subsidy/tax and s_H is a subsidy (tax) when it is positive (negative).

In the upstream world market, there are n (≥ 2) symmetric input suppliers (hereafter called the *supplier*). Each supplier k ($\in \{1, ..., n\}$) produces homogeneous inputs and offers them at a price of r_k. We denote supplier k's and aggregate demand for inputs by q_k and Q ($= q_H + q_F$), respectively. Since firm i purchases inputs from the supplier offering the lowest price, the demand for supplier k is $q_k = Q(r_{\min})/n_{\min}$ if the supplier offers the minimum price $r_k = r_{\min}$, where $n_{\min}$ is the number of suppliers offering the minimum price; the demand is $q_k = 0$ if it does not offer the minimum price. We assume that the cost for supplier k to produce inputs takes a quadratic form and specify it as $(c/2)q_k^2$, where c (> 0) denotes production efficiency. The profit of supplier k is $\pi_k = q_k r_k - (c/2)q_k^2$.

[6] Ishikawa and Spencer (1999) and Hwang et al. (2007) also consider unilateral intervention.

We consider that there are m ($\in [0, n]$) suppliers in the Home country and the others belong to a country other than Home and Foreign countries. The welfare of the Home country is

$$W_H \equiv \Pi_H + m\pi_k - s_H q_H. \tag{1}$$

The game consists three stages: in the first stage, the Home government decides the level of s_H. In stage two, the input price r is determined through supplier price competition. In the final stage, each firm decides the price (quantity) of its product. We solve the game by backward induction.

Since we assume that suppliers produce homogeneous inputs with a quadratic cost, there is a range of Nash equilibria (Dastidar, 1995). Thus, we need to employ some criterion for selecting equilibrium prices. We use the *payoff-dominance* criterion. This approach is similar to that in Cabon-Dhersin and Drouhin (2014). Moreover, some studies focus on a collusive price to narrow the set of Nash equilibria (e.g., Dastidar, 2001 and Gori et al., 2014). This criterion is also similar to our approach. We assume a collusive price higher than or equal to an upper bound of the set of Nash equilibria, while previous studies with the collusive price criteria make a restriction for the parameters in which the collusive price is in the set of Nash equilibria.

Finally, we explain how to select a price with the payoff dominance criterion in the set of Nash equilibria. We assume symmetric suppliers, so that in any pure strategy Nash equilibrium in the upstream market, each supplier chooses the same price. We denote the set of prices each supplier chooses in Nash equilibrium by $[\underline{r}, \bar{r}]$. In addition, we denote a collusive price that maximizes the suppliers' joint profits by r_{col}. Because

we assume a range of parameters where $\bar{r} \leq r_{col}$, the input price each supplier selects must be equal to $\bar{r}$ because, $\bar{r}$ provides the highest profit of suppliers in the set of Nash equilibria.

3 Results

3.1 Downstream Bertrand

We first consider the case where the downstream has Bertrand rivalry. In the third stage of the game, the FOC to maximize the profit of firm i $(= H, F)$, $\partial \Pi_i / \partial p_i = 0$, yields its exports $q_i(r, s_H)$ and total sales $Q(r, s_H)$.

In the second stage, the input-price r is determined through Dastidar (1995)-type price competition.[7] In pure strategy Nash equilibria, two conditions, $\pi_k(n, r, s_H) = [Q(r, s_H)/n]r - (c/2)[Q(r, s_H)/n]^2 \geq 0$ and $\pi_k(n, r, s_H) \geq \pi_k(1, r, s_H) = Q(r, s_H)r - (c/2)[Q(r, s_H)]^2$, must be satisfied: the first is the condition that suppliers *do not raise* their prices and yields the lower bound $\underline{r} = \frac{(2a+s_H)c}{2[(2-b)(1+b)n+c]}$; the second is the condition that suppliers *do not reduce* their prices and gives the upper bound $\bar{r} = \frac{(2a+s_H)(1+n)c}{2[(2-b)(1+b)n+(1+n)c]}$. Thus, in equilibrium, the input-price must lie between $\underline{r}$ and $\bar{r}$. Moreover, from the symmetry in suppliers, the collusive price r_{col} is given by $r_{col} = \text{argmax}_r\, \pi_k(n, r, s_H) = \frac{[(2-b)(1+b)n+2c](2a+s_H)}{4[(2-b)(1+b)n+c]}$. These prices yield the following.

Lemma 1. *(i)* $r_{col} > \underline{r}$. *(ii)* $r_{col} \geq \bar{r}$ *if and only if* $c \leq c_B \equiv [(2-b)(1+b)n]/(n-1)$.

Proof. (i) Simple algebra yields $r_{col} - \underline{r} = \frac{(2-b)(1+b)n(2a+s_H)}{4[(2-b)(1+b)n+c]} > 0$. (ii) Since $r_{col} - \bar{r} =$

[7] See Dastidar (1995), pp. 27–28. Moreover, Delbono and Lambertini (2016a, 2016b) employ Dastidar (1995)-type price competition. See also Cabon-Dhersin and Drouhin (2014), pp. 432–433, for equilibrium price selection.

$\frac{(2-b)(1+b)n(2a+s_H)[-c(n-1)+(2-b)(1+b)n]}{4[(2-b)(1+b)n+c][(2-b)(1+b)n+(1+n)c]}$, $r_{col} \geq \bar{r}$ iff $c \leq \frac{(2-b)(1+b)n}{n-1} \equiv c_B$. Q.E.D.

Lemma 1 states that $r_{col} \in (\underline{r}, \bar{r})$ for $c > c_B$. Thus, the second stage input price is a collusive price, $r = r_{col}$, for $c > c_B$. However, if $r = r_{col}$, the conditions determining the sign of optimal export policy in the downstream Bertrand case (part 2 of Proposition 1) becomes highly complicated. To avoid unnecessary complexity in the analysis and to obtain clear-cut conditions, we assume $c \leq c_B$. When we put this restriction on c, the second stage input price is $r = \bar{r}$.

Assumption 1. $0 < c \leq c_B$.

On the other hand, even though $c > c_B$, our main result (Proposition 1) does not qualitatively change. Even if $c > c_B$ (i.e., $r = r_{col}$) holds, the optimal policy can non-monotonically change with respect to product substitutability. Particularly, in a case where $n = 2$, we obtain a similar result as in part 2 of Proposition 1, even though $r = r_{col}$ holds. We state this result as "Proposition A1" in Appendix A. (See Fig. 5.)

In the first-stage, the Home government chooses s_H to maximize (1).[8] We use Kawabata (2010)'s decomposition to express the FOC for welfare maximization as follows:

$$\begin{aligned}\frac{\partial W_H}{\partial s_H} = & \overbrace{(p_H - r)\frac{\partial q_H}{\partial s_H}}^{\text{(i)}} + \overbrace{q_H \frac{\partial p_H}{\partial s_H}}^{\text{(ii)}} + \overbrace{\left[-\left(q_H - m\left(\frac{Q}{n}\right)\right)\frac{\partial r}{\partial s_H}\right]}^{\text{(iii)}} \\ & + \underbrace{\frac{m}{n}\left(r - c\left(\frac{Q}{n}\right)\right)\frac{\partial Q}{\partial s_H}}_{\text{(iv)}} = 0.\end{aligned} \tag{2}$$

(2) consists of four effects of a subsidy:[9] (i) *the horizontal rent-shifting effect* on

[8] The SOC for welfare maximization always holds, i.e., $\partial^2 W_H(s_H)/\partial s_H^2 < 0$.
[9] See Kawabata (2010), pp. 119–120.

the Home country final product, which corresponds to the first term and is positive; (ii) *the terms of trade effect* for the Home country final product, which corresponds to the second term and is negative; (iii) *the rent extraction effect* from suppliers, which corresponds to the third term and is negative if $(q_H - m(Q/n)) > 0$; and (iv) *the efficiency gain effect* from an increase in input production, which corresponds to the forth term and is positive if $m > 0$.[10] (i) and (ii) are the *horizontal* effects of a subsidy, whereas (iii) and (iv) are the *vertical* effects. Terms (iii) and (iv) are both increasing for the number of domestic suppliers. An increase in m weakens the negative effect (i.e., tax incentive) in the third term, (iii), and strengthens the positive effect (i.e., subsidy incentive) in the fourth term, (iv): $\frac{\partial(\text{third term})}{\partial m} = \frac{c(1+n)(2a+s_H)}{2[(2-b)(1+b)n+(1+n)c]^2} > 0$ and $\frac{\partial(\text{fourth term})}{\partial m} = \frac{c(n-1)(2a+s_H)}{2[(2-b)(1+b)n+(1+n)c]^2} > 0$.

From (2), (A1), and (A2),[11] we calculate the optimal export policy as

$$s_H^B = \frac{2a(1-b)(2+b)n}{D}[2(2+b)cm - (b^3+b^2+c)n - c], \tag{3}$$

where $D \equiv 2[4(2-m+2n)+4b(1+n)-b^2(3+b)(1-m+n)]cn+(3+b)c^2(1+n)^2+8(1+b)(2-b^2)n^2 > 0$. The variables with "$B$" ("$C$") denote the SPNE outcomes in the case of Bertrand (Cournot) rivalry.

Let us first refer to a result in an existing study, which was obtained by a specific combination of the number of suppliers in our model. When there is no domestic supplier and the upstream is monopoly: $m = 0$ and $n = 1$; from (3), the optimal export policy is a tax. This finding matches that of Chou (2011), who finds that even

[10] $(r - (c/n)Q) > 0$ holds.
[11] We depict (A1) and (A2) in Appendix B.

if there is an upstream monopolist outside the exporter, Eaton and Grossman (1986)'s result does not change.

Remark 1. (Chou, 2011) *If $m = 0$ and $n = 1$, $s_H^B < 0$.*

If $m = 0$, the forth term in (2) disappears, and hence, the negative effects of the second and third terms dominate the positive effects of the first term.

Using (3), we establish the following proposition, the proof of which is given in Appendix A.

Proposition 1. *Suppose that the third-country downstream market has differentiated Bertrand rivalry and the Assumption 1 holds. Then:*

1. $s_H^B > 0$ *if* $m > m_B \equiv \frac{(b^3+b^2+c)n+c}{2(2+b)c}$; $s_H^B = 0$ *if* $m = m_B$; *and* $s_H^B < 0$ *if* $m < m_B$.
2. *If* $m \in (m_l, \min\{m_h, n\})$, *then there exist two thresholds,* b_1 *and* b_2, *such that* $s_H^B > 0$ *for* $b_1 < b < b_2$, *and* $s_H^B < 0$ *for* $0 \leq b < b_1$ *or* $b_2 < b < 1$. *Here,* $m_h \equiv m_B|_{b=1} = [n(3+c)]/6c$ *and* $m_l \equiv m_B|_{b=b_l}$, *where* b_l *(*$\in (0,1)$*) is a minimizer of* m_B.

Proposition 1 offers two important assertions. The first is that there is a threshold in the number of domestic suppliers that makes the optimal policy a subsidy. The second one demonstrates that the optimal policy can non-monotonically change, that is, *tax–subsidy–tax*, as the degree of substitutability between final goods becomes large. Fig. 1 illustrates the second part of Proposition 1. (See also Panel (b) in Fig. 2.)

We explain the first assertion as follows. For a given number of suppliers n, an increase in the number of domestic suppliers m strengthens the positive effect of the

forth term in (2), whereas it can weaken the (negative) effect of the third term. This makes the motive to subsidize stronger.[12]

[Figure 1 around here]

[Figure 2 around here]

To explain the logic behind the second assertion, for given c and n, let us consider three different sizes of m. Panels (a)–(c) in Fig. 2 illustrate the optimal export policy corresponding to each size of m. When m is small, the third term in (2) (tax incentive) is large and the fourth term (subsidy incentive) is small. Then, the optimal policy is a tax (see Panel (a), in the "$m = 3$" case). In contrast, when m is large, the magnitudes in the third term (tax incentive) is small and those in the fourth term (subsidy incentive) is large. Then, the Home government considers domestic suppliers to be important and offers a subsidy to firm H to promote exports and domestic input production (see Panel (c), in the "$m = 7$" case). The limit case where $b = 1$ implies homogeneous Bertrand competition in the downstream market, and hence, the firm's rent vanishes. Thus, the optimal policy approaches 0 as b approaches 1, regardless of the size of m.

When m is intermediate, the role of b becomes more significant. In differentiated Bertrand rivalry, it is well-known that firms' output is U-shaped for b.[13] From this fact, firm H's exports tend to increase as b goes over a certain level. The positive effect of the fourth term depends on total sales (outputs), so it is also U-shaped for b. On the one hand, since the positive effect of the first term depends on the prices of both the input and the final product, it is not necessarily U-shaped for b. In contrast to the

[12] $\partial s_H^B / \partial m > 0$. See Appendix D.

[13] Substituting $s_H = 0$ into q_H of (A1), we can immediately find this characteristic.

positive effect of the fourth term, the negative effects of the second and third terms can be inverted-U shaped for b. That is, if b affects the U-shape of the outputs of firm H, the tax-incentive decreases as b increases when it is below a certain level because the domestic firm's exports decrease. However, the incentive for taxation increases as b goes above a certain level because the domestic firm's exports increase in this case.

A rise in m reduces the magnitude of the third term. On the one hand, if m is not large relative to n, the magnitude of the third term is not necessarily small because the vertical rent-extraction can derive from $n-m$ non-domestic suppliers. This implies that under a certain size of m, a change in the negative effects (second and third terms) due to an increase in b can dominate a change in the positive effects (first and fourth terms). When m is intermediate, a reduced tax dominates if b is a smaller value. Within such a range of b, the optimal policy can change from a tax to subsidy as b increases. If b goes above a certain level and it enters the dominant area of "an increase in the tax incentive," the optimal policy can change from a subsidy to a tax as b increases (see Panel (b), in the "$m = 5$" case).

In particular, the second part of Proposition 1 has a significant policy implication because the non-monotonicity in the optimal export policy (*tax–subsidy–tax*) implies that *a big mistake does not matter, but a small mistake can be fatal.* The optimal taxes can appear from two regions of a lower b and a higher b. Thus, even if practitioners incorrectly recognize that "b is high" when its actual value is low, because they choose an export tax, the welfare loss may not be so large. In contrast, if there is a small gap between the practitioner's recognition of b and its actual value, he or she may

unfortunately adopt the policy that is not recommended. This possibly yields a serious welfare-loss.

3.2 Downstream Cournot

We next consider the case where the downstream has Cournot rivalry. To distinguish between the Bertrand and Cournot cases, we mark the variables in the Cournot case with a star ("$*$"). In the third stage of the game, the FOC for the profit maximization of firm i $(= H, F)$, $\partial \Pi_i / \partial q_i = 0$, yields its exports $q_i^*(r, s_H)$ and total sales $Q^*(r, s_H)$. In the second-stage, the input-price r^* is determined in a similar manner as in the previous section and it yields the second-stage outcomes (see Appendix B, (A3)).

From (2), (A3), and (A4),[14] the optimal export policy in the Cournot case is

$$s_H^C = \frac{2a(2-b)n}{E}[b^2 n - (1-b)(1+n)c + 2(2-b)cm], \tag{4}$$

where $E \equiv 2\left[((1-b)(5+b)+3)(1+n) + ((4-b)b-4)m\right]cn + (3-2b)c^2(1+n)^2 + 8(2-b^2)n^2 > 0$. Here, we assume that $m < \min\{m_0, n\}$. (For m_0, see Appendix C.)

Using (4), we obtain the following proposition, the proof of which is given in Appendix A.

Proposition 2. *Suppose that the third country downstream market is a differentiated Cournot rivalry. Then: (I) (i) If $b > \widetilde{b}$, or (ii) $m > m_C$ and $b < \widetilde{b}$, then $s_H^C > 0$. (II) If $m = m_C$ and $b < \widetilde{b}$, then $s_H^C = 0$. (III) If $m < m_C$ and $b < \widetilde{b}$, then $s_H^C < 0$. Here, $m_C \equiv \frac{(1-b)(1+n)c - b^2 n}{2(2-b)c}$, $\widetilde{b} \equiv \frac{-(1+n)c + \sqrt{c(1+n)[c(1+n)+4n]}}{2n}$, and $0 < \widetilde{b} < 1$.*

[Figure 3 around here]

[14] Appendix B illustrates (A3) and (A4).

Fig. 3 illustrates Proposition 2 in the b-m plane. We start by examining the case where $m = 0$, in which the fourth term in (2) disappears and the vertical effect is equal to the "vertical rent-extraction effect" (tax incentive). When $m = 0$, the export policy depends on b. A smaller b corresponds to weaker competition between firms, and thus, the horizontal rent-shifting effect (i.e., the positive effect of the first term in (2)) is weak. In such case, the vertical rent-extraction effect is dominant, so the optimal policy is a tax. Conversely, if b is close to unity, competition between firms is keener and the horizontal rent-shifting effect is stronger. Then, the optimal policy becomes a subsidy. This result represents Chou's (2011) argument.

Remark 2. (Chou, 2011) *Suppose $m = 0$ and $n = 1$. If $b < (\geq)\ -c + \sqrt{c(2+c)}$, then $s_H^C < (\geq)\ 0$.*

Since an increase in m strengthens the positive effect of the fourth term and weakens the negative effect of the third term, the tax incentives can become weaker and subsidy incentives can become stronger as m increases. Therefore, when the size in m is large relative to n, the optimal policy becomes a subsidy (see Fig. 3). This corresponds to Kawabata's (2010) result, which is compatible with a specific combination of $m = 1$ and $n = 2$ in our model.

Remark 3. (Kawabata, 2010) *If $m = 1$ and $n = 2$, $s_H^C > 0$.*

Combining propositions 1 and 2, we establish the following proposition, the proof of which is given in Appendix A.

Proposition 3. *(I) Suppose $b > \widetilde{b}$. (i) If $m < m_B$, then $s_H^B < 0$ and $s_H^C > 0$; (ii) if $m > m_B$, then $s_H^B > 0$ and $s_H^C > 0$. (II) Suppose $b < \widetilde{b}$. (i) If $m < m_C$, then $s_H^B < 0$ and $s_H^C < 0$; (ii) if $m_C < m < m_B$, then $s_H^B < 0$ and $s_H^C > 0$; (iii) if $m > m_B$, then $s_H^B > 0$ and $s_H^C > 0$.*

Proposition 3 shows the condition for which the conventional results hold (parts (i) in (I) and (ii) in (II)): when the number of domestic suppliers is intermediate, downstream Bertrand rivalry yields a tax and Cournot rivalry yields a subsidy in vertical structure with upstream price competition (see also Fig. 3).

We find this result because in the Bertrand case, the threshold value of m that makes the optimal export policy a subsidy is larger than that in the Cournot case (i.e., $m_C < m_B$). In the case of downstream Bertrand rivalry, if there is no upstream sector, the negative effect of the second term in (2) (tax incentive) dominates the positive effect of the first term (subsidy incentive), and thus the optimal export policy is a tax (Eaton and Grossman, 1986). Additionally, if there is an upstream market and $m = 0$ holds, because the vertical rent-extraction effect in the third term points to a tax, the optimal policy is a tax for any level of product substitutability (Chou, 2011). In both cases of downstream Bertrand and Cournot competition, an increase in m weakens the negative effect of the third term (tax incentive) and strengthens the positive effect of the fourth term (subsidy incentive), but the tax incentives in the Bertrand case are stronger than that in the Cournot case. Therefore, $m_C < m_B$ holds.

Welfare comparison. For a large m, the Home country welfare in the case of downstream Bertrand competition can be higher than that in the case of downstream Cournot

competition. Fig. 4 shows this in the b-m plane. We examine this result here.

[Figure 4 around here]

Let us first focus on the fact that a larger m improves the Home country's welfare, regardless of the competition mode in the downstream market. ($\partial W_H^l/\partial m > 0$, $l = B, C$. See Appendix D.) Since the incentives to subsidize become stronger as m increases, s_H^l increases with m ($\partial s_H^l/\partial m > 0$). A higher subsidy (lower tax) shifts input demand upward. This demand expansion allows suppliers to set a higher price, so an increase in m raises the input price ($\partial r^l/\partial m > 0$). Additionally, a higher subsidy raises total sales (or exports) because it increases the domestic firm's exports more than it reduces the foreign firm's exports ($\partial Q^l/\partial m > 0$). Hence, an increase in m promotes the domestic firm's exports, magnifies input demand, raises the input price, and improves welfare.

On the one hand, the competition is tougher in Bertrand rivalry rather than in Cournot rivalry, so the effects of export promotion (restriction) tend to work stronger in the Bertrand case. When m is small enough, the export policy is always a tax in the Bertrand case. Then, since the suppliers' part of the profit (i.e., $m\pi_k$) is small and the export activity of firm H is dampened, the welfare level in the Bertrand case can be lower than that in the Cournot case. In contrast, when m is large enough and the export policy is a subsidy in the Bertrand case, because the suppliers' part of the profit is large and the effects of export promotion are also stronger, the welfare level can be higher than that in the Cournot case[15] (see Fig. 4).

[15] However, when b is sufficiently close to 1, since the firms' profit is close to 0 in the Bertrand case, the welfare level in the Cournot case exceeds that in the Bertrand case.

4 Conclusion

This paper incorporates Dastidar (1995)-type price competition in the intermediate input into a standard export rivalry model with a vertical structure and studies the nature of the optimal export policy. Although input-suppliers have a quadratic cost and the equilibrium input price has a certain range, by adopting a similar approach as Cabon-Dhersin and Drouhin (2014) (i.e., payoff-dominance criterion) do, we narrow the range of input prices to a single equilibrium price and consider differentiated Bertrand and Cournot competition in the downstream third market.

We first show that in the case of downstream Bertrand competition, the optimal export policy can be *tax–subsidy–tax*, corresponding to the degree of product substitutability. This non-monotonicity in the export policy gives the following policy implication: there is a case in which *a large mistake can be permissible, but a small mistake can be impermissible.* The optimal export policy becomes a tax when the degree of substitutability is both low and high. Hence, when the degree of substitutability is low, even if the practitioner accidentally recognizes that its level is high, the realized policy be an export tax and the optimal and realized policies are consistent. Therefore, a large mistake is permissible. However, if the practitioner's recognition of product substitutability is slightly higher than that of the actual level, the realized policy be an export subsidy, which is the opposite to the optimal policy. Hence, a small mistake may be impermissible.

We also demonstrate that if the number of domestic input suppliers is intermediate, the conventional results, that is, the optimal export policy is a tax (subsidy) when

exporters compete in a Bertrand (Cournot) fashion, holds. A larger number of domestic input suppliers strengthens subsidy incentives, so in both the Bertrand and Cournot cases, the optimal export policy becomes a subsidy when the number of domestic suppliers is large enough. Because the tax incentive in Bertrand competition is stronger than that in Cournot competition, to switch the optimal export policy from a tax to a subsidy in the case of downstream Bertrand competition, it is necessary to have a larger number of domestic suppliers compared to the Cournot case.

In this paper, we considered upstream price competition in a standard third-market export-rivalry model. On the one hand, it may be possible to extend our model to a two-way trade environment. In such a situation, examining the role of upstream price competition may be an interesting consideration. However, this argument is beyond the scope of our analysis and is left for future work.

Appendices

Appendix A. Proofs and Proposition A1.

Proof of Proposition 1. From (3), solving $s_H^B = 0$ for m, we have $m_B = [nb^3 + nb^2 + c(1+n)]/[2(2+b)c]$. Then, we obtain the first assertion.

Next, we consider the second assertion. Differentiating m_B wrt b, we get

$$\frac{\partial m_B}{\partial b} = \frac{2nb^3 + 7nb^2 + 4nb - c(1+n)}{2c(2+b)^2}.$$

To prove the non-monotonicity of s_H^B, we show that m_B is a convex function and its first derivative wrt b takes a negative value at $b = 0$ and a positive value at $b = 1$. First,

we have $\partial^2 m_B/\partial b^2 = [(4+12b+6b^2+b^3)n+c(1+n)]/[(2+b)^3c] > 0$. Second, we have $\partial m_B/\partial b|_{b=0} = -c(1+n)/(8c) < 0$. Finally, we have $\partial m_B/\partial b|_{b=1} = (13n-cn-c)/(18c)$, which is a decreasing function for c. Since we assume $c \leq c_B$, $\partial m_B/\partial b|_{b=1}$ takes the minimum value at $c = c_B$. Substituting $c = c_B$, we have $\partial m_B/\partial b|_{b=1,\, c=c_B} = (11n-15-b-bn+b^2+b^2n)/[18(2-b)(1+b)] > 0$. The inequality is satisfied since we assume $n \geq 2$. Hence, $\partial m_B/\partial b|_{b=1} > 0$.

From these and the continuity of m_B, there exists a unique $b_l \equiv \text{argmin}_b\, m_B$ in $(0,1)$ such that for any $b < b_l$, m_B decreases with b, and for any $b > b_l$, m_B increases with b.

Here, we define $m_h = \min\{m_B|_{b=0}, m_B|_{b=1}\}$, where $m_B|_{b=0} > m_B|_{b=1}$ if $4n/(1+n) < c < c_B$; $m_B|_{b=0} \leq m_B|_{b=1}$ if $0 < c \leq 4n/(1+n)$. Since $n - m_B|_{b=0} = (3n-1)/4 > 0$, we have $n > m_h$.

From the discussion above, we have some $m' \in (m_l, \min\{m_h, n\})$ such that $s_H^B > 0$ for $b_1 < b < b_2$, and $s_H^B < 0$ for $0 \leq b < b_1$ or $b_2 < b < 1$. Q.E.D.

Proof of Proposition 2. From (4), solving $s_H^C \leq (\geq)\ 0$ wrt m, we have $m \leq (\geq)$ $m_C \equiv \frac{(1-b)(1+n)c-b^2n}{2(2-b)c}$. $m_C|_{b=0} = \frac{1+n}{4} > 0$, $\frac{\partial m_C}{\partial b} = -\frac{(4-b)bn+(1+n)c}{2(2-b)^2c} < 0$, and $m_C|_{b=1} = -\frac{n}{2c} < 0$, so $m_C = 0$ at some $b \in (0,1)$. Solving $m_C \geq 0$ wrt b, we obtain $b \leq \widetilde{b} \equiv \frac{-(1+n)c+\sqrt{c(1+n)[c(1+n)+4n]}}{2n} > 0$. Since $1-\widetilde{b} = \frac{(c+2n+cn)-\sqrt{c(1+n)[c(1+n)+4n]}}{2n}$ and $(c+2n+cn)^2 - \left(\sqrt{c(1+n)[c(1+n)+4n]}\right)^2 = 4n^2$, $0 < \widetilde{b} < 1$. Hence, if $b > \widetilde{b}$ then $s_H^C > 0$. When $b < \widetilde{b}$, $s_H^C < 0$ if $m < m_C$, and $s_H^C > 0$ if $m > m_C$. Q.E.D.

Proof of Proposition 3. From $m_B > 0$, $m_B - m_C = \frac{b^2[(4+2b-b^2)n+(1+n)c]}{2(2-b)(2+b)c} > 0$. Further, we obtain $m_0 - m_B = \frac{(16-10b^2-3b^3+b^4)n+(6-b-3b^2)(1+n)c}{2(2-b)(2+b)c} > 0$. From these and

Propositions 1 and 2, we obtain Proposition 3. Q.E.D.

The collusive input price case: $r = r_{col}$ (i.e., $c > c_B$).

Proposition A1. *Suppose $c > c_B$ and $2 = n > m_l^{col} \equiv \min_b m_{col}$, where $m_{col} \equiv \frac{2+b+b^3+c}{2(2+b)(1+b)(2+b)}$. Then:*

1. $s_H^{col} > 0$ if $m > m_{col}$; $s_H^{col} = 0$ if $m = m_{col}$; and $s_H^{col} < 0$ if $m < m_{col}$.

2. For $m'' \in (m_l^{col}, \min\{m_h^{col}, 2\})$, we have $s_H^{col} > 0$ for $b_1^{col} < b < b_2^{col}$, and $s_H^{col} < 0$ for $0 \leq b < b_1^{col}$ or $b_2^{col} < b < 1$, where $m_h^{col} \equiv m_{col}|_{b=1}$.

Proof. For simplicity, we assume $n = 2$. From Lemma 1, we have $r_{col} < \bar{r}$ if $c > c_B$. We assume the range of c. Then, the equilibrium input price is $r = r_{col}$. Substituting it into W_H and solving the first-order condition $\partial W_H / \partial s_H = 0$ for s_H, we obtain the optimal export policy as

$$s_H^{col} = \frac{2a(1-b)(2+b)(2+b+c-8m-8bm+2b^2m+b^3(1+2m))}{D_{col}},$$

where $D_{col} \equiv -60 - 28c - 3c^2 + 16m - b(64 + 18c + c^2 - 8m) + b^2(33 + 10c - 20m) + b^3(35 + 4c - 10m) + b^4(4m - 5) + b^5(2m - 3)$.

Solving $s_H^{col} = 0$ for m, we have

$$m = \frac{2 + c + b + b^3}{2(2+b)(2+b-b^2)} \equiv m_{col}.$$

Then, we obtain the first assertion.

To prove the second assertion, we show that m_{col} is a convex function and its first derivative for b takes a negative value at $b = 0$ and a positive value at $b = 1$.

First, we have

$$\frac{\partial^2 m_{col}}{\partial b^2} = \frac{24 + 60b + 54b^2 + 41b^3 + 39b^4 + 15b^5 - b^6 + (20 - 9b^2 + 8b^3 + 6b^4)c}{(4 + 4b - b^2 - b^3)^3}.$$

This function increases with c. Since we assume $c > c_B$, to calculate the minimum value of this function, we evaluate it at $c = c_B$. Then, we have

$$\left.\frac{\partial^2 m_{col}}{\partial b^2}\right|_{c=c_B} = \frac{104 - 4b - 18b^2 + 73b^3 + 24b^4 - 13b^5}{(1+b)^2(4-b^2)^3} > 0.$$

Hence, $\partial^2 m_{col}/\partial b^2 > 0$ always holds.

Next, we evaluate $\partial m_{col}/\partial b$ at $b = 0$ and $b = 1$. Then, we have $\partial m_{col}/\partial b|_{b=0} = -(1+c)/8 < 0$ and $\partial m_{col}/\partial b|_{b=1} = (28+c)/72 > 0$. Moreover, we have $\partial m_{col}/\partial b|_{b=0} - \partial m_{col}/\partial b|_{b=1} = (c-2)/24$, which increases with c. Hence, to evaluate it at $c = c_B$, we obtain the minimum value $(1 + b - b^2)/12$. Then, we obtain $\partial m_{col}/\partial b|_{b=0} > \partial m_{col}/\partial b|_{b=1}$. From these results and the continuity of m_{col}, there exists a unique $b_{col} \equiv \text{argmin}_b\, m_{col}$ in $(0, 1)$ such that for any $b < b_{col}$, m_{col} decreases with b, and for any $b > b_{col}$, m_{col} increases with b.

Here, let $m_l^{col} \equiv \min_b m_{col}$ and $m_h^{col} = m_{col}|_{b=1}$. From the discussion above, if $m_l^{col} < 2\ (= n)$, we have some $m'' \in (m_l^{col}, \min\{m_h^{col}, 2\})$ such that $s_H^{col} > 0$ for $b_1^{col} < b < b_2^{col}$, and $s_H^{col} < 0$ for $0 \le b < b_1^{col}$ or $b_2^{col} < b < 1$.

Finally, we show that at $c = 44/5$, three types of optimal policies occur: tax at $m = 0$, tax–subsidy–tax at $m = 1$, and subsidy at $m = 2$. Q.E.D.

[Figure 5 around here]

Appendix B. Second-stage outcomes

The second-stage outcomes in the downstream Bertrand case are:

$$\left.\begin{aligned} p_H &= \tfrac{2a(2+b)[(1-b^2)n+(1+n)c]-[4(1+b)n+(1+n)c]s_H}{2(2+b)[(2-b)(1+b)+(1+n)c]};\ r = \tfrac{(2a+s_H)(1+n)c}{2[(2-b)(1+b)n+(1+n)c]}, \\ q_H &= \tfrac{2a(1-b)(2+b)n+[2n(2-b^2)+(1+n)c]s_H}{2(1-b)(2+b)[(2-b)(1+b)n+(1+n)c]};\ Q = \tfrac{(2a+s_H)n}{(2-b)(1+b)n+(1+n)c}. \end{aligned}\right\} \quad \text{(A1)}$$

Comparative statics result for (A1):

$$\left.\begin{aligned} \tfrac{\partial p_H}{\partial s_H} &= \tfrac{-[4(1+b)n+(1+n)c]}{2(2+b)[(2-b)(1+b)+(1+n)c]} < 0;\quad \tfrac{\partial r}{\partial s_H} = \tfrac{(1+n)c}{2[(2-b)(1+b)n+(1+n)c]} > 0, \\ \tfrac{\partial q_H}{\partial s_H} &= \tfrac{2n(2-b^2)+(1+n)c}{2(1-b)(2+b)[(2-b)(1+b)n+(1+n)c]} > 0;\quad \tfrac{\partial Q}{\partial s_H} = \tfrac{n}{(2-b)(1+b)n+(1+n)c} > 0. \end{aligned}\right\} \quad \text{(A2)}$$

The second-stage outcomes in the Cournot case are:

$$\left.\begin{aligned} p_H^* &= \tfrac{2a(2-b)[(1+n)c+n]-[2(2-b^2)+(1-b)(1+n)c]s_H}{2(2-b)[(2+b)n+(1+n)c]};\ r^* = \tfrac{(2a+s_H)(1+n)c}{2[(2+b)n+(1+n)c]}, \\ q_H^* &= \tfrac{2a(2-b)n+[(1+n)c+4n]s_H}{2(2-b)[(2+b)n+(1+n)c]};\ Q^* = \tfrac{(2a+s_H)n}{(2+b)n+(1+n)c}. \end{aligned}\right\} \quad \text{(A3)}$$

Comparative statics result for (A3):

$$\left.\begin{aligned} \tfrac{\partial p_H^*}{\partial s_H} &= \tfrac{-[2(2-b^2)+(1-b)(1+n)c]}{2(2-b)[(2+b)n+(1+n)c]} < 0;\quad \tfrac{\partial r^*}{\partial s_H} = \tfrac{(1+n)c}{2[(2+b)n+(1+n)c]} > 0, \\ \tfrac{\partial q_H^*}{\partial s_H} &= \tfrac{(1+n)c+4n}{2(2-b)[(2+b)n+(1+n)c]} > 0;\quad \tfrac{\partial Q^*}{\partial s_H} = \tfrac{n}{(2+b)n+(1+n)c} > 0. \end{aligned}\right\} \quad \text{(A4)}$$

Appendix C. SPNE outcomes

Bertrand case:

$$q_H^B = \frac{a(2+b)n}{D}[2(2-b^2)n + c(1+2m+n)],$$

$$q_F^B = \frac{an}{D}[2(4+2b-b^2)n + c(4(1-m+n) + b(1-2m+n))],$$

$$r^B = \frac{ac(1+n)}{D}[(8+4b-3b^2-b^3)n+c(3+b)(1+n)];\ W_H^B = \frac{a^2n}{D}[(1-b)(2+b)^2n+2(3+b)cm].$$

The equilibrium profit of firm i is $\Pi_i^B = (1-b^2)\left(q_i^B\right)^2$, $i = H, F$. The supplier k's profit is $\pi_k^B = \frac{2n}{c(1+n)^2}\left(r^B\right)^2$, $k \in \{1, \ldots, n\}$.

Cournot case:

$$q_H^C = \frac{a(2-b)n[4n+(1+2m+n)c]}{E},$$

$$q_F^C = \frac{an}{E}[2(4-2b-b^2)n+(4-3b)(1+n)c-2(2-b)cm],$$

$$r^C = \frac{a(1+n)c}{E}[(8-4b-b^2)n+(3-2b)(1+n)c];\ W_H^C = \frac{a^2n[2(3-2b)cm+(2-b)^2n]}{E}.$$

The equilibrium profit of firm i is $\Pi_i^C = \left(q_i^C\right)^2$. The supplier k's profit is $\pi_k^C = \frac{2n}{c(1+n)^2}\left(r^C\right)^2$. Here, to ensure a positive quantity, we assume

$$m < m_0 \equiv \frac{2(4-2b-b^2)n+(4-3b)(1+n)c}{2(2-b)c}\ (>0),$$

which is equivalent to $q_F^C > 0$.

Appendix D. Comparative statics result for SPNE outcomes

From the derivative of the outcomes, we get

$$\frac{\partial s_H^B}{\partial m} = \frac{4a(1-b)(2+b)^2cn(2-b)(1+b)(8+4b-3b^2-b^3)n^2}{D^2} + \frac{4a(1-b)(2+b)^2cn[(14+9b-5b^2-2b^3)n(1+n)c+(3+b)(1+n)^2c^2]}{D^2} > 0,$$

$$\frac{\partial s_H^C}{\partial m} = \frac{4a(2-b)^2cn[(2+b)(8-4b-b^2)n^2+(14-5b-3b^2)n(1+n)c+(3-2b)(1+n)^2c^2]}{E^2} > 0,$$

$$\frac{\partial r^B}{\partial m} = \frac{2a(1-b)(2+b)^2c^2n(1+n)[(8+4b-3b^2-b^3)n+(3+b)c(1+n)]}{D^2} > 0,$$

$$\frac{\partial r^C}{\partial m} = \frac{2a(2-b)^2c^2n(1+n)[(8-4b-b^2)n+(3-2b)c(1+n)]}{E^2} > 0,$$

$$\frac{\partial Q^B}{\partial m} = \frac{4a(1-b)(2+b)^2cn^2[(8+4b-3b^2-b^3)n+(3+b)c(1+n)]}{D^2} > 0,$$

$$\frac{\partial Q^C}{\partial m} = \frac{4a(2-b)^2cn^2[(8-4b-b^2)n+(3-2b)c(n+1)]}{E^2} > 0,$$

$$\frac{\partial W_H^B}{\partial m} = \frac{2a^2cn[(8+4b-3b^2-b^3)n+(3+b)c(1+n)]^2}{D^2} > 0, \text{ and}$$
$$\frac{\partial W_H^C}{\partial m} = \frac{2a^2cn[(8-4b-b^2)n+(3-2b)c(1+n)]^2}{E^2} > 0.$$

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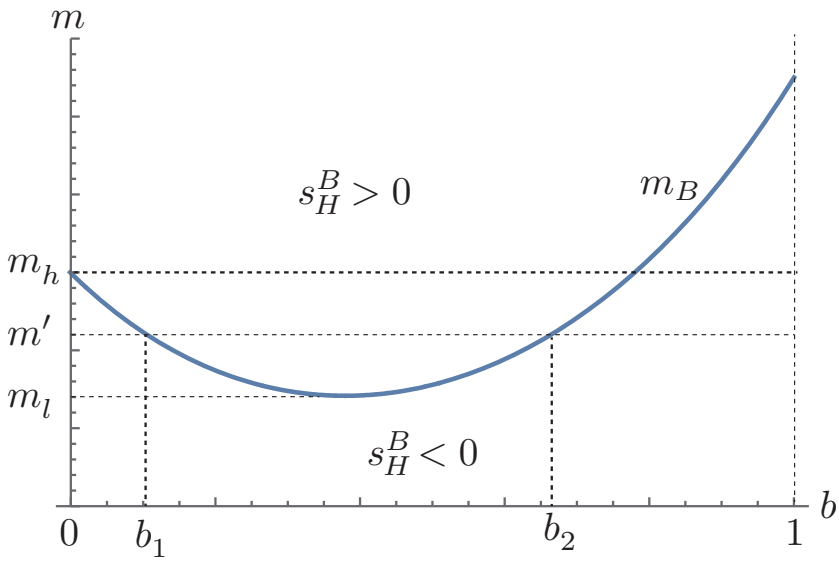
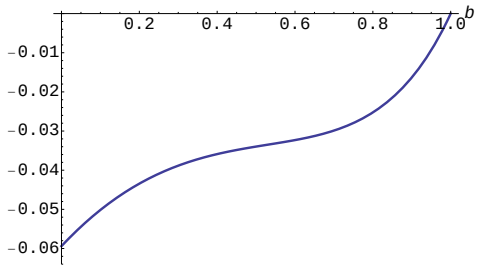
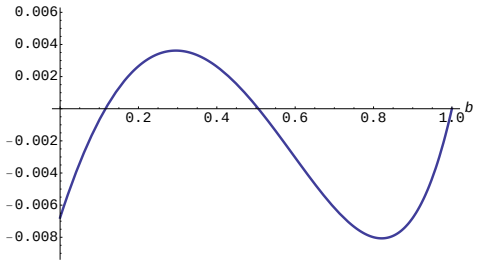


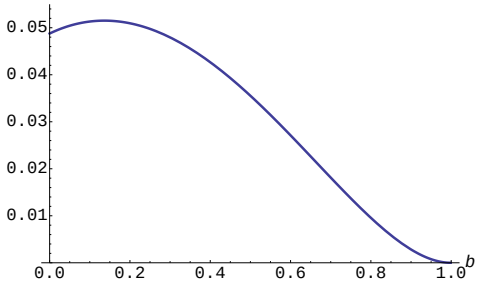
Figure 1: The area of the *non-monotonic export policy* under $c \leq c_B$.



Panel (a): $m = 3$ (tax).



Panel (b): $m = 5$ (tax–subsidy–tax).



Panel (c): $m = 7$ (subsidy).

Figure 2: Graph of s_H^B/a for b. ($c = 1.9$ and $n = 20$.)

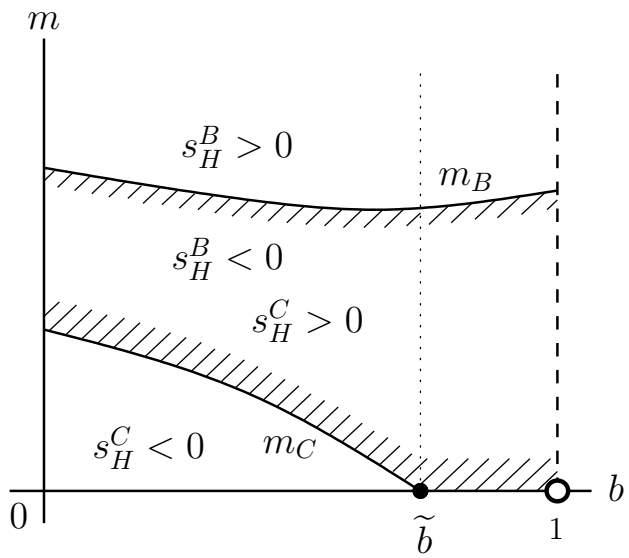


Figure 3: The area of "conventional results."

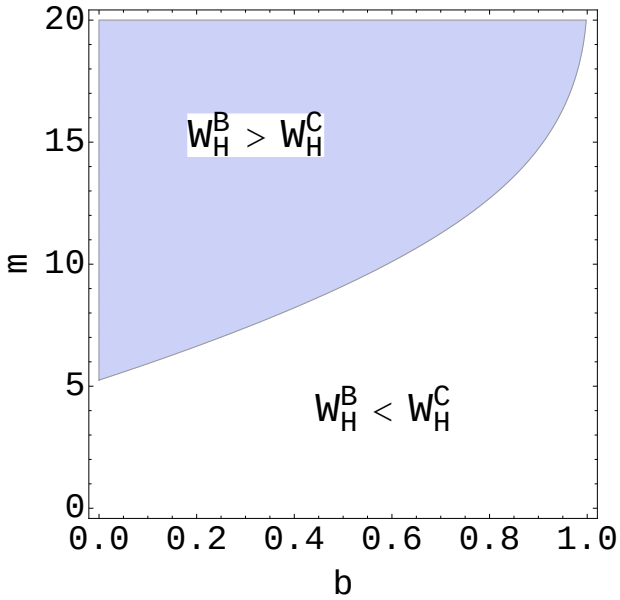


Figure 4: Welfare comparison. ($a = 1$, $c = 1.9$, and $n = 20$.)

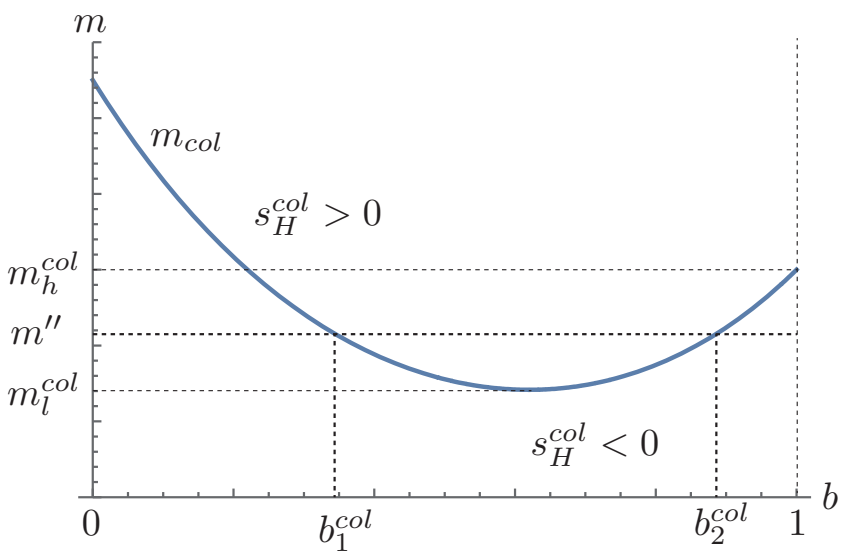


Figure 5: The area of *non-monotonic export policy* under $c > c_B$.