Rent-shifting export subsidies with an integrated intermediate-good market *

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Abstract

This paper examines the implication of trade in intermediate goods for strategic trade policy under the law of one price in the intermediate-good market. With Cournot competition in both upstream and downstream markets, the existence of intermediate-good trade might enhance the rent-shifting effect of export subsidies by raising the world input price and the foreign rival's cost. When the number of domestic downstream firms is smaller than that of foreign firms, the profit increase caused by this cost-raising effect dominates the leakage of subsidies to intermediate-good producers and the beggar-thy-neighbor nature of the export subsidy is strengthened.

Keyword: Export subsidies; Integrated market; Raising rival's cost; Strategic trade policy; Trade in intermediate goods; Vertical oligopoly

JEL classification: F12; F13

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1 Introduction

In the past few decades, the global economy has experienced a significant growth of trade in intermediate goods and a fragmentation of production processes. These developments have attracted considerable attention in theoretical and empirical studies.[1] The literature on strategic trade policy has been extended to include trade in intermediate goods. Such studies focus on the interactions between the final and intermediate-good markets and consider how an increase in vertical specialization or outsourcing affects the strategic behavior of firms and the rent-shifting effect of trade policies. For instance, Ishikawa and Spencer (1999) considers the third-market Cournot oligopoly with Cournot competition in the domestic input market and shows that the import of intermediate goods typically reduces the welfare-enhancing effect of export subsidies.[2]

However, it is somewhat surprising that most previous studies in this area assume segmentation of the intermediate-good market. There are very few analyses conducted under the assumption of an integrated market. The assumption of segmented markets, i.e., international price discrimination for intermediate goods, requires that final-good producers cannot purchase intermediate goods from a foreign market at a cheaper price. Of course, there are cases where segmentation of the input market exists. High transportation costs and international differences in standards of inputs are well-known reasons. In addition, vertical integration divides the market between inside and outside firms. However, these technical and institutional barriers have been reduced by the international coordination of standards and the prevalence of 'downsizing'. In addition, the recent prevalence of offshore sourcing often is characterized as the global activity of a firm seeking cheaper inputs. These phenomena suggest that the integrated world market is a more appropriate assumption for some types of standardized components, such as semiconductor chips and machinery parts.

In this paper, we examine the implications of the integration of the intermediate-good mar-

[1] Feenstra (1998) and Jones (2000) provide recent surveys of the empirical and theoretical work.

[2] Previous research also includes Spencer and Jones (1991, 1992), Chang and Chen (1994), Spencer and Raubitschek (1996), Ishikawa and Lee (1997), Krishna and Morgan (1998), Chen, Ishikawa and Yu (2003), and many others.

ket for strategic trade policy, and we complement previous research. Extending Ishikawa and Spencer (1999), we consider that domestic and foreign final-good producers conduct Cournot competition in a third country and purchase inputs from the integrated (i.e., world) market where domestic and foreign input producers behave as Cournot competitors. Export subsidies to domestic final products promote the demand for inputs and typically raise the input price. Such an increase in the world input price produces two rent shifts. One is the 'leakage effect' of subsidies from domestic final-good producers to foreign intermediate-good producers, which typically weakens the incentive to subsidize exports. The other is the 'cost-raising effect', which produces another rent shift from foreign final-good producers to domestic final-good producers by raising the foreign rival's cost. The latter effect favors the use of export subsidies.

The scale of these two opposing effects depends on the relative number of final-good producers. We show that the 'cost-raising effect' dominates the 'leakage effect' when the number of domestic downstream firms does not exceed that of foreign downstream firms. Therefore, in this case, trade in intermediate goods strengthens the welfare-enhancing role of export subsidies under an integrated input market, whereas this role is weakened under segmented markets.

It should be mentioned that Bernhofen (1997) examined the optimal export policy with and without price discrimination for the input price. However, he assumed linear demand and a foreign monopoly input producer, and he fixed the number of each firm as one. The welfare-enhancing nature of export subsidies is known to be sensitive to the number of domestic and foreign firms. Allowing generalities in the demand function and the number of firms, we show that the rent shifts caused by export subsidies through trade in intermediate goods are also sensitive to the number of final-good producers.

Our 'cost-raising effect' of export subsidies is derived from the 'cost-raising strategy' of Salop and Scheffman (1983, 1987). These authors show that the dominant firm might buy more intermediate goods than the level of cost minimization because a price increase caused by over-buying favors competition in the final-good market. Whereas they focus on the anti-competitive activity conducted by the dominant firm, we consider a Cournot competitive market and policy issues.

The rest of the paper is organized as follows. Section 2 describes the basic structure of the model. In section 3, we find the subgame perfect equilibrium and the comparative statics results of export subsidies. In section 4, we examine the optimal export policy and introduce the 'leakage' and 'cost-raising' effects. In section 5, the optimal policy decision under an integrated market is compared with that under segmented markets and without trade in an intermediate good. Section 6 presents concluding remarks.

2 Model Structure

The model structure is illustrated in Figure 1. With respect to the notations, we follow Ishikawa and Spencer (1999) for the comparison of the results. We consider two vertically related activities in a domestic and a foreign country. In the final-good or downstream stage, domestic firms (firm d) and foreign firms (firm f) produce homogeneous goods and compete in a third country market in a Cournot manner. Following the previous literature, we assume that the technology of downstream firms is of the Leontief type and that the production of one unit of final good requires one unit of intermediate product and one unit of labor. Final-good producers d and f need to purchase the intermediate good and they behave as price-takers in both the input and factor markets.[3]

The upstream stage is also characterized by Cournot competition. Domestic firms (firm h) and foreign firms (firm m) supply homogeneous intermediate goods to final-good producers. The technology of upstream production is expressed as constant marginal cost $c^k (k = h, m)$. We assume that the intermediate-good market is integrated and that the law of one price holds.

In this paper, we focus the domestic trade policy on the export of final products. Domestic government uses a specific subsidy s^d to the export of the final good, and a negative s^d means an export tax. The government is assumed to maximize domestic welfare, defined as the sum

[3]The price-taking behavior of a downstream firm is assumed, not only in trade papers cited in footnote 2, but also in the antitrust literature, e.g., Salinger (1988) and Ordover, Saloner and Salop (1990). This is because of the technical difficulty in formulating a vertical oligopoly model that includes the market power of both upstream and downstream firms. A monopsony model requires an *upward sloping* supply curve, but Cournot competition in the upstream stage implies a *vertical* supply curve of input, and the equilibrium price of input turns out to be zero. See Ishikawa and Spencer (1999, pp. 203-205) for further discussion.

of profits of domestic producers minus government expenditure.

There are three stages in this model. In stage 1, the domestic government sets the level of export subsidy s^d. In stage 2, upstream firms h and m simultaneously determine the production of the intermediate good. In stage 3, final-good producers d and f simultaneously determine their quantity, taking the input price as given.

3 Market Equilibrium and Comparative Statics

To find the subgame perfect equilibrium, we solve the game backwards in this section. We first obtain the downstream Cournot output in stage 3, expressed as the functions of the input price. Next, we derive the inverse demand for the intermediate good and then solve for Cournot competition in the upstream stage 2. Finally, we show some comparative statics results of export subsidies to aid the examination of the optimal policy decision in the next section.

3.1 The Final-good Market

There is a total of N firms producing final products. The number of firms in each country is expressed as n^d in the domestic country and n^f in the foreign country. Domestic firm d and foreign firm f produce output y^d and y^f, respectively. We define the aggregate output $Y \equiv Y^d + Y^f$ where $Y^i \equiv n^i y^i (i = d, f)$. The final-good price p is given by the inverse demand function $p = p(Y)$ in the third country where $p' < 0$. The wage in country i $(i = d, f)$ and the price of the input are defined as w^i and r, respectively.

Then, the profit functions of firms d and f are:

$$\pi^d = [p - (r + w^D - s^d)]y^d \text{ and } \pi^f = [p - (r + w^F)]y^f. \tag{1}$$

With given input and factor prices, the first-order conditions for firms d and f are:

$$p + p'y^d - (r + w^D - s^d) = 0 \text{ and } p + p'y^f - (r + w^F) = 0. \tag{2}$$

We assume that the following second-order and stability conditions hold globally:

$$2p' + p''y^i < 0,\ \gamma^i \equiv n^i + 1 - \sigma^i E > 0\ (i = d, f) \text{ and } \psi \equiv N + 1 - E > 0, \tag{3}$$

where $\sigma^i \equiv Y^i/Y$ is the share of country i's products in the third country ($i = d, f$) and $E \equiv -p''Y/p'$ is the elasticity of the slope of inverse demand.[4] Note that firm i's output is a strategic substitute (complement) when $\gamma^i > 1 (< 1)$. The first-order conditions (2) define the Cournot output $y^i(r, s^d, w^F)(i = d, f)$.

Totally differentiating (2) and from (3), we obtain the partial derivatives of $y^i(r, s^d, w^F)$:

$$y^d_{s^d} = -\frac{\gamma^f}{p'\psi} > 0,\ y^f_{s^d} = \frac{n^d(\gamma^f - 1)}{n^f p'\psi},\ Y_{s^d} = -\frac{n^d}{p'\psi} > 0, \tag{4}$$

$$y^d_{w^F} = -\frac{n^f(\gamma^d - 1)}{n^d p'\psi},\ y^f_{w^F} = \frac{\gamma^d}{p'\psi} < 0,\ Y_{w^F} = \frac{n^f}{p'\psi} < 0, \tag{5}$$

$$y^d_r = \frac{1 + n^f \delta E/Y}{p'\psi},\ y^f_r = \frac{1 - n^d \delta E/Y}{p'\psi},\ Y_r = \frac{N}{p'\psi} < 0, \tag{6}$$

where the subscripts denote the partial derivatives and $\delta \equiv y^d - y^f$.

Equations (4) to (6) are standard results in Cournot competition. Export subsidies to firm d always increase the domestic and total production of the final good. Foreign output decreases if and only if firm f views its output as a strategic substitute (i.e., $\gamma^f > 1$). Similarly, an increase in the foreign wage necessarily reduces the foreign and total outputs, and firm d raises its output if and only if y^d is a strategic substitute. A rise in the world price of intermediate goods reduces production in both countries if $\delta E = 0$, which holds when the demand function is linear or when each firm has an identical marginal cost.

3.2 The Intermediate-good Market

We next consider the intermediate-good market. There are n^h input producers in the domestic country and n^m in the foreign country. The total number of producers is $N^u \equiv n^h + n^m$. Domestic firm h and foreign firm m produce outputs x^h and x^m of the intermediate good, respectively. The aggregate output is defined as $X \equiv X^h + X^m$, where $X^k \equiv n^k x^k (k = h, m)$. Each upstream firm fully anticipates the total demand for input $Y(r, s^d)$ derived from the

[4] These conditions are common in the literature. The second condition is used to sign the comparative statics results and the last is needed for the uniqueness and stability of equilibrium. See Seade (1980) and Spencer and Raubitschek (1996).

downstream competition. Let $r = r(X, s^d)$ be the inverse demand for intermediate goods. From (4), (6) and the market-clearing condition $X = Y(r, s^d)$, the partial derivatives of the input demand are:

$$r_x = \frac{1}{Y_r} < 0,\ r_{xx} = -\frac{Y_{rr}}{(Y_r)^3} \text{ and } r_s = -\frac{Y_{s^d}}{Y_r} = \frac{n^d}{N} > 0, \tag{7}$$

where $r_x \equiv \partial r/\partial X$, $r_{xx} \equiv \partial^2 r/\partial X^2$, and $r_s \equiv \partial r/\partial s^d$. From (7), the input demand function is downward sloping and r is linear if p is linear.[5] Subsidies to firm d shift the input demand curve upward by n^d/N, which represents the relative number of domestic final-good producers.

The profit functions and the first-order conditions for upstream firm k ($k = h, m$) are:

$$\pi^k = (r - c^k)x^k \text{ and } r + r_x x^k - c^k = 0. \tag{8}$$

The following second-order and stability conditions are assumed to hold globally:

$$2r_x + r_{xx}x^k < 0,\ \gamma^{uk} \equiv n^k + 1 - \sigma^{uk}E^u > 0\ (k = h, m) \text{ and } \psi^u \equiv N^u + 1 - E^u > 0, \tag{9}$$

where $\sigma^{uk} = X^k/X$ is the share of country k's products in the world market and $E^u \equiv -r_{xx}X/r_x$ is the elasticity of the slope of inverse demand.

The first-order conditions (8) and the inverse demand $r = r(X, s^d)$ determine the Cournot output $x^h(s^d), x^m(s^d)$ and the equilibrium input price r. Putting r into $y^i(r, s^d, w^F)(i = d, f)$ and using the demand for the final good $p(Y)$, we obtain the equilibrium price and outputs of the final good.

3.3 Export Subsidies to the Domestic Final-good Producers

Before we examine the optimal export policy, it is useful to summarize the effects of export subsidies s^d on the outputs and profits of the firms in both stages. The proofs of the propositions in this section are given in Appendix. First, we obtain the following result with respect to the upstream stage:

Proposition 1 *When the subsidy to domestic final-good exports increases, the marginal cost of firm d always falls. In addition, if firms h and m have the same marginal cost or if the input*

[5] If $p'' = 0$, then (6) becomes $Y_r = N/p'(N + 1)$ and $Y_{rr} = 0$ holds.

demand is linear, then: (i) the outputs of firms h and m increase; (ii) the input price rises if and only if $1 > E^u$; and (iii) the profits of firms h and m increase if and only if $2 > E^u$.

From (4), an export subsidy to the domestic downstream firms increases the demand for input. The expansion of demand typically increases the outputs and price of the input, which causes the rise in the profits of the upstream producers. These results are intuitive and, indeed, Proposition 1 is also proved in Ishikawa and Spencer (1999) under the segmented market model. In the Appendix, we show that the comparative statics results for the effects of s^d on the output and price of the intermediate good are obtained by multiplying the corresponding expressions of Ishikawa and Spencer (1999) by r_s. In their model, the subsidy shifts the demand curve upward by ds^d, whereas, in our integrated market model, the demand expansion is mitigated to an extent equal to $r_s ds^d$ from (7) because firm d can purchase a cheaper intermediate good from the foreign market.

The total effects on the final-good market are rather complicated because the export subsidy s^d always reduces the marginal cost of firm d, but may increase or decrease that of firm f from Proposition 1. However, the results similar to equation (4) qualitatively hold:

Proposition 2 *When the subsidy to domestic final-good exports increases: (i) the total supply of the final good always increases; (ii) firm d increases its output if $y^d_r < 0$ or if $dr/ds^d > 0$ holds; (iii) firm f reduces its output if $dr/ds^d > 0$ and y^f is a strategic substitute; and (iv) firm f increases its output if $dr/ds^d < 0$ and if y^f is a strategic complement.*

Finally, we examine the changes in the profits of the downstream firms. An increase in the world input price turns to be a rise in the marginal cost of firm f, which reinforces the increase in the profit of firm d and the decrease in that of firm f caused by the export subsidy. Spencer and Raubitschek (1996) shows that the necessary and sufficient condition for a fall in firm d's marginal cost to increase its profit is $1 + \beta > 0$, where $\beta \equiv (\gamma^f - n^d)/\psi$. Then, we obtain the following proposition.

Proposition 3 *When the subsidy to domestic final-good exports increases: (i) the profit of firm d increases if $dr/ds^d > 0$ and $1 + \beta > 0$ hold; and (ii) the profit of firm f falls if $dr/ds^d > 0$.*

4 The Optimal Export Policy

We are now ready to analyze the optimal subsidy to the export of domestic final goods. Because all products of firm d are exported, domestic welfare W is expressed as the profits of domestic producers and net government revenue.

$$W \equiv n^d \pi^d + n^h \pi^h - s^d Y^d. \tag{10}$$

We assume the concavity of W in s^d. Then, the first-order condition for maximization is:

$$\frac{dW}{ds^d} = n^d \frac{d\pi^d}{ds^d} + n^h \frac{d\pi^h}{ds^d} - Y^d - \hat{s}^d \frac{dY^d}{ds^d} = 0. \tag{11}$$

Using (11) and (A.30)(equations numbered (A.) are all in Appendix), we have the general formula for the optimal export subsidy $\hat{s}^d$:

$$\hat{s}^d = Y^d p' \left[\left(1 - \frac{dr}{ds^d}\right) \frac{\partial Y^f/\partial s^d}{dY^d/ds^d} + \frac{n^d - 1}{n^d} + \frac{\partial Y^f/\partial w^F}{dY^d/ds^d} \left(\frac{dr}{ds^d}\right) \right] + \frac{Y^d \Omega}{dY^d/ds^d}, \tag{12}$$

where $\Omega \equiv \left\{ n^h (d\pi^h/ds^d) - Y^d (dr/ds^d) \right\} / Y^d$. Equation (12), which expresses the optimal level of export subsidy, is an expression similar to equation (20) in Ishikawa and Spencer (1999). The first two terms of (12) represent the standard 'strategic effect' and 'terms of trade effect', respectively, which can be derived without trade in intermediate goods.[6] The last two terms represent the 'cost-raising effect' and the 'leakage effect', respectively, which capture the rent shifts owing to the intermediate-good market.

The 'strategic effect' is caused by the change in the foreign output depending on whether firm f views its output as a strategic substitute or a complement. From (4), an export subsidy reduces the output of firm f and raises the final-good price when y^f is a strategic substitute. The second 'terms of trade effect' appears only when there is more than one domestic downstream firm. Under Cournot competition, each firm produces more output than the optimal level, jointly maximizing the industrial profit. Ω in the fourth term, which we call the 'leakage effect', is derived in Ishikawa and Spencer (1999) under the segmented input markets.[7] An export subsidy creates a rent-shift flow from the domestic downstream firms to the foreign upstream firms when the subsidy raises the domestic input price. The second term of Ω, $-dr/ds^d$

[6] See also Krishna and Thurby (1991).

[7] Ishikawa and Spencer (1999) call this effect the 'intermediate market effect'.

expresses this rent flow from the domestic downstream firms to the upstream firms, and the first term of Ω captures the flow to the domestic upstream producers. If the domestic country depends heavily on imports of the intermediate good, making the second term of Ω small, then the leakage of the subsidy to the foreign country reduces the incentives for an export subsidy.[8]

The remaining third term of (12) is specific to our integrated market model. This term captures another rent shift from firm f to firm d, and we refer to it as the 'cost-raising effect' after the 'cost-raising strategy' of Salop and Scheffman (1983, 1987). Under an integrated input market, when the input demand function is not too convex, an increase in the domestic export subsidy raises the world input price (Proposition 1), which implies a rise in the marginal costs of foreign final-good producers. From (5), such an increase in the marginal cost of firm f reduces the foreign output and raises the final-good price and the profits of firm d. The 'cost-raising effect' and the 'strategic effect' both capture the rent shift from firm f to firm d. However, these effects should be distinguished, as the former is independent of whether firm f's output is a strategic substitute or a complement.

5 A Comparison with the Different Market Circumstances

Under an integrated input market, export subsidies cause two effects with trade in intermediate goods: the 'leakage effect' and the 'cost-raising effect'. These two effects have opposing implications for the welfare-enhancing role of export subsidies. In this section, we examine their net effect, comparing the general formula for the optimal export policy (12) with those obtained under the different circumstances of the intermediate-good market.

5.1 The Three Models

We consider the following three models. The first model, referred to as model N, is the benchmark case under which each firm is vertically integrated and there are no transactions of the inputs. This is well known as the 'third-market model' of Brander and Spencer (1985). In

[8] However, if domestic final-good producers use only the domestic inputs, export subsidies will ease the double marginalization in the domestic input markets and Ω becomes positive. See Ishikawa and Spencer (1999, Proposition 3).

the second model S, we allow trade in intermediate goods, but the input market is segmented internationally and the input price in the foreign market is fixed.[9] This is the 'basic model' of Ishikawa and Spencer (1999). Finally, in the model I, which we have discussed, we consider the world integrated market of the intermediate good. Comparing these three models, we can distinguish between the effects caused by trade in intermediate goods and those caused by the integration of intermediate-good markets so that we obtain what determines the net effects of export subsidies.

Now we compare the formulas of the three models in general demand functions. With regard to models S and N, we obtained the formulas from equation (21) in Ishikawa and Spencer (1999) with a little manipulation.[10] In model N, the optimal level of subsidy $\hat{s}_N^d$ is expressed as:

$$\hat{s}_N^d = \frac{Y^d \beta}{dY^d/ds^d}, \ \beta \equiv \frac{\gamma^f - n^d}{\psi}. \tag{13}$$

The necessary and sufficient condition for the optimality of a small export subsidy is $\beta > 0$. We interpret β as the net effect of the 'strategic' and 'terms of trade' effects.

In model S, the optimal subsidy $\hat{s}_S^d$ is expressed as:

$$\hat{s}_S^d = \frac{Y^d}{dY^d/ds^d}\left[\frac{N^u}{\psi^u}\beta - \frac{1-E^u}{\psi^u} + \frac{X^h}{Y^d}\left(\frac{2-E^u+n^m\delta^u E^u/X^D}{\psi^u}\right)\right], \tag{14}$$

where X^D is the total output in the domestic intermediate-good market.

The optimal level $\hat{s}_I^d$ in model I turns to be:

$$\hat{s}_I^d = \frac{Y^d}{dY^d/ds^d}\left[\frac{N^u}{\psi^u}\beta - \frac{(n^d-n^f)}{N}\frac{(1-E^u)}{\psi^u} + \frac{n^d}{N}\frac{X^h}{Y^d}\left(\frac{2-E^u+n^m\delta^u E^u/X}{\psi^u}\right)\right]. \tag{15}$$

The derivation of (15) is given in Appendix.

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[9] Although the assumption of a fixed price for the foreign intermediate good may seem restrictive, Ishikawa and Spencer (1999) shows that, under a linear demand function, the domestic export subsidies do not change the foreign input price. In addition, the model S can be regarded as capturing the international differences in vertical structure, where foreign downstream firms are fully vertically integrated.

[10] Equation (13) in this paper is found by substituting $\Omega = 0$ into equation (21) in Ishikawa and Spencer (1999). To obtain (14) in this paper, we substitute the effect of the subsidy on the input price and the profits of the domestic input producers into Ishikawa and Spencer's equation (21).

5.2 The Number of Final-good Producers

First, we show that the net scale of the 'leakage' and 'cost-raising' effects is determined by the number of the final-good producers. Comparing (14) and (15), we find the difference in the coefficient of the second term $(1 - E^u)/\psi^u$. In model S, the second term of (14) represents the change of an input price owing to the export subsidy and the leakage of the subsidy to the input market, which depresses the optimal level of the subsidy (or raises the tax level). In model I, by contrast, the sign of the second term of (15) depends on the number of the final-good producers $(n^d - n^f)$. Then, we obtain the following result from (14) and (15):[11]

Proposition 4 *Suppose* $1 > E^u$ *(i.e.,* $dr/ds^d > 0$*) and* $n^h = 0$ *(i.e.,* $X^h = 0$*) in models* S *and* I*, then: (i) in model* S*,* $\beta > 0$ *is necessary but not sufficient for* $\hat{s}_S^d > 0$*; (ii) in model* I*, if* $n^d < n^f$*, then* $\beta > 0$ *is sufficient but not necessary for* $\hat{s}_I^d > 0$*; and (iii) in model* I*, if* $n^d > n^f$*, then* $\beta > 0$ *is necessary but not sufficient for* $\hat{s}_I^d > 0$*.*

Because $\beta > 0$ is necessary and sufficient for a small export subsidy to raise domestic welfare in model N, Proposition 4 shows whether imports of the intermediate goods enhance or reduce the welfare-enhancing effect of the export subsidy in models S and I. Because $\beta > 0$ tends to hold when the number of domestic downstream firms is small, case (ii) in Proposition 4 ($n^d < n^f$) is more likely when considering the optimal use of the export subsidy. In this case, importing the intermediate good decreases the optimal level of export subsidies under segmented markets, whereas, under the integrated market, it raises the optimal level of the export subsidy unless the input demand is too convex.

The intuition of Proposition 4 can be found in the following expression derived from (15):

$$\hat{s}_I^d = \frac{Y^d}{dY^d/ds^d}\left\{\frac{N^u}{\psi^u}\beta + (1 - r_s)\frac{(1 - E^u)}{\psi^u} + r_s\left[-\frac{1 - E^u}{\psi^u} + \frac{X^h}{Y^d}\left(\frac{2 - E^u + n^m \delta^u E^u / X}{\psi^u}\right)\right]\right\}. \quad (16)$$

The terms in square brackets in (16) are the same expressions as the second and the last terms in brackets of (14), which shows the 'leakage effect' of the subsidy. While one unit increase in the export subsidy to firm d shifts the input demand function upward by one unit in model S,

[11] Proposition 4 (i) is also proved in Ishikawa and Spencer (1999, Proposition 5).

the input demand shifts by $r_s = n^d/N < 1$ in model I (see (7)). A rise in the domestic input price is mitigated in model I, as domestic firms can purchase inputs from the foreign market. Therefore, the integration of the intermediate-good markets weakens the 'leakage effect' of the export subsidy. The second term in curly braces in (16) represents the 'cost-raising effect', which promotes the rent shifting from firm f to firm d if and only if the subsidy raises the input price ($1 > E^u$).

As seen in (15), which of these two effects dominates depends on the number of the final producers. When the subsidy raises the input price, the 'cost-raising effect' increases with the relative number of the foreign firms, $1 - r_s = n^f/N$, whose outputs are decreased by the subsidy, whereas the 'leakage effect' increases with the relative number of the domestic firms, r_s, whose demand for the input is increased by the subsidy. If the number of domestic firms is smaller than that of foreign firms ($n^d < n^f$), the rent shifting owing to the cost-raising effect dominates the leakage of the subsidy to the intermediate-good market.

Let us consider the case where the number of domestic firms d is half of the total number of the final-good producers ($n^d = n^f$) and there is no domestic input producer ($n^h = 0$). In this case, except for the first term, all terms of (15) are canceled out and the criterion for the optimal export policy becomes the same as that in model N. In Bernhofen (1997), where $n^d = n^f = 1$ is assumed, the criterion turns out to be the same condition as that in Brander and Spencer (1985); the export subsidies raise domestic welfare if and only if firm f views its output as a strategic substitute.

5.3 The Total Number of Firms in Both Stages

We have examined how the two opposing effects caused by trade in intermediate goods depend on the difference in the number of final-good producers. However, as seen in (14) and (15), there are other factors that affect the optimal level of the export subsidy, such as the scale of domestic imports of the intermediate good and the total number of firms in both stages. To examine the effect of these factors, we graphically illustrate the optimal policy decisions in each model, assuming the case of linear demand.[12]

From (13), (14) and (15), the necessary and sufficient conditions for the export subsidy to improve domestic welfare are:

$$\hat{s}_N^d \geq 0 \text{ if and only if } n^d \leq \frac{N+1}{2}, \tag{17}$$

$$\hat{s}_S^d \geq 0 \text{ if and only if } n^d \leq \frac{N+1}{2}\left(\frac{N^u+1}{N^u}\right) - \frac{N+1}{N^u}\theta, \tag{18}$$

$$\hat{s}_I^d \geq 0 \text{ if and only if } n^d \leq \frac{N+1}{2}\left(\frac{N(N^u+1)}{(N+1)\theta + NN^u}\right), \tag{19}$$

where $\theta \equiv (Y^d - X^h)/Y^d$ is the share of the imported intermediate good to the domestic exports of the final good.[13] By definition, $0 \leq \theta \leq 1$ holds in model S, whereas $\theta \leq 1$ holds in model I and a negative θ means domestic exports of the intermediate good.

The conditions (17), (18) and (19) are described in Figure 2. The NN line is the locus of (θ, n^d) satisfying (17) with equality, given the total number of firms (N, N^u). A small export subsidy improves the domestic welfare in model N when (θ, n^d) lies below the NN line, whereas a small export tax improves the welfare when (θ, n^d) is above the NN line. Similarly, the export subsidy increases domestic welfare in models S and I if and only if (θ, n^d) is placed above the SS line and the II line, respectively.

The differences in the slopes of these three lines are due to the structure of the intermediate-good markets. No transaction of input in model N makes the NN line horizontal, whereas the SS line and the NN line are downward sloping because of the 'leakage effect.' When the domestic country imports the intermediate good ($\theta > 0$), the SS line lies below the II line and they intersect at point A.[14] This shows that the 'cost-raising effect' caused by the integration

[12] We use a linear demand function for two reasons. First, as stated in footnote 9, under a linear demand function, the formula for the optimal export policy in model S is still valid even when we allow a change of a foreign input price. Second, without the linearity, it seems too difficult to compare (14) and (15) because the elasticity of the inverse demand for the intermediate good E^u includes the third-order derivative of a demand function for the final good.

[13] Hummels, Ishii and Yi (2001) refer to the imported input share θ as *vertical specialization* (VS) and calculate it for 10 OECD countries and four emerging markets, using the input-output tables for 1970–1990. They report that the world VS share of merchandise trade grew about 30% and achieved significant growth in the chemical and machinery sectors.

[14] This is because $\theta = 0$ and $\theta = (N^u - 1)/2 \geq 0$ satisfy (18) and (19) with equality.

of input markets mitigates the 'leakage effect' at a given import share.

Now using Figure 2, we examine how concentration in both markets changes the optimal export policy decision. First, when the number of the final-good producers increases, the three lines all shift upward. The distances between point B and C and between point D and E expand so that the area ABC is enlarged where the sign of the optimal tax-cum-subsidy differs in models S and I.

Proposition 5 *Under a linear demand function, an increase in the total number of downstream producers makes the optimal choice between the tax and subsidy on final-good exports more sensitive to whether the intermediate-good markets are segmented or integrated.*

When the total number of the upstream producers decreases, the vertical intersects B and C move downward, whereas point A moves upward, making the SS line and the II line steeper. The steeper slopes of the SS and NN lines imply that a small change of the import share can change the sign of the optimal tax-cum-subsidy.

Proposition 6 *Under a linear demand function, a decrease in the total number of upstream producers makes the optimal choice between the tax and subsidy on final-good exports more sensitive to the share of the imported intermediate good.*

The monopoly case in the input market gives a clear example of Proposition 5 and 6. When $N^u = 1$, the SS line corresponds to the $S'S'$ line in the figure, where C corresponds to the origin and point A to A'. If the monopolist is the domestic firm, which implies $\theta \leq 0$, then the optimal policy is a subsidy, regardless of the number of the final-good producers. In the case of a foreign monopoly ($\theta = 1$), in contrast, a small export tax always raises domestic welfare.[15] Although the II line rotates around point E in the clockwise direction and point A corresponds to A', the vertical intersect B does not correspond to the origin. In model I, a small export tax does not always raise welfare, even in the case of a foreign monopoly, because an export tax causes an *inverse* 'cost-raising effect' as rent shifts from firm d to firm f.

Finally, it should be noted that θ could be negative in model I. From Figure 2, the optimal policy always becomes a subsidy if θ is sufficiently small. When the domestic country exports

[15] Proposition 6 in Ishikawa and Spencer (1999).

the input ($\theta < 0$), a rise in the world input price produces a rent shift from the foreign downstream firms to the domestic upstream firms, which is an improvement in terms of trade. Calculating the explicit condition, we find that a small export subsidy always raises welfare if $\theta < (3/2)[1 - N^u(N-1)/(N+1)]$.

6 Concluding Remarks

In this paper, we examine how trade in intermediate goods affects the rent extraction role of export subsidies under an integrated market for the intermediate good. In contrast to Ishikawa and Spencer (1999), imports of intermediate goods typically favor the welfare-enhancing effect of the export subsidy under an integrated input market unless the number of domestic downstream producers exceeds that of the foreign producers. It is well known that an export subsidy tends to raise one country's welfare when the number of domestic producers is smaller than that of foreign producers. This criterion is still valid with trade in intermediate goods under the integrated intermediate-good market. Our analysis suggests that the trade in intermediate goods and the integration of world input markets may lead to an additional beggar-thy-neighbor aspect to export subsides, forcing foreign producers to suffer high input prices.

Our comparative analysis in section 5 provides some insights into the relationship between a strategic export subsidy and the evolution of the world intermediate-good market. The recent development of the international outsourcing or fragmentation is explained by a decline of trade costs (Jones and Kierzkowski (1990), Jones (2000)). Successive reductions in trade costs from a prohibitive level to a sufficiently low level might cause the regime shifts shown in the transitions from model N to model S, and then model S to model I. The rent-extraction effects of an export subsidy are weakened by the outsourcing of inputs under an international price discrepancy. With a sufficient decrease in trade costs allowing arbitrage, however, the effectiveness of export subsidies is recovered.

In this paper, we have omitted the domestic final-good market to focus on the interaction between the final and intermediate-good markets. Even if the domestic market is included in the analysis, the distinction between market segmentation and integration will lead to significant differences in the effect of trade policy, especially in terms of the income distribution. For example, let us consider the situation where the domestic final-good market is the same as the third market with the assumption of linear demand and segmented final-good markets. In the segmented-markets case, a rise in the domestic input price caused by an export subsidy reduces the outputs of the domestic downstream firms in the domestic market and raises the price of the domestic final good. This results in a decrease in the domestic consumer surplus and causes another rent shift from firm d to firm f in the domestic market. These two effects reduce the optimal level of the subsidy as well as the leakage effect. In the integrated-market case, because the price of the foreign input also rises, no rent shift effect occurs between firms d and f in the domestic final-good market. However, total supply for the domestic final-good market is depressed even more than in the segmented market case. Therefore, the integration of the input market will make export subsidies more favorable to domestic producers and more harmful to domestic consumers.

References

Bernhofen, Daniel M. (1997) 'Strategic trade policy in a vertically related industry.' *Review of International Economics* 5(3), 429–433

Brander, James A., and Barbara J. Spencer (1985) 'Export subsidies and international market share rivalry.' *Journal of International Economics* 18, 83–100

Chang, Winston W., and Fang-Yueh Chen (1994) 'Vertically related markets: Export rivalry between DC and LDC firms.' *Review of International Economics* 2(2), 131–142

Chen, Yongmin, Jota Ishikawa, and Zhihao Yu (2003) 'Trade liberalization and strategic outsourcing.' *Journal of International Economics.* forthcoming

Feenstra, Robert C. (1998) 'Integration of trade and disintegration of production in the global economy.' *Journal of Economic Perspectives* 12, 31–50

Hummels, David, Jun Ishii, and Kei-Mu Yi (2001) 'The nature and growth of vertical specialization in world trade.' *Journal of International Economics* 54, 75–96

Ishikawa, Jota, and Barbara J. Spencer (1999) 'Rent-shifting export subsidies with an imported intermediate product.' *Journal of International Economics* 48, 199–232

Ishikawa, Jota, and Ki-Dong Lee (1997) 'Backfiring tariffs in vertically related markets.' *Journal of International Economics* 42, 395–423

Jones (2000) *Globalozation and the Theory of Input Trade* (Cambridge, MA: MIT Press)

Jones, Ronald W., and Henryk Kierzkowski (1990) 'The role of services in production and international trade: A theoretical framework.' In *The Political Economy of International Trade,* ed. Ronald W. Jones and Anne O. Krueger (Oxford: Basil Blackwell) pp. 31–48

Krishna, Kala, and John Morgan (1998) 'Implementing results-oriented trade policies: the case of the US-Japanese auto parts dispute.' *European Economic Review* 42, 1443–1467

Krishna, Kala, and Marie Thurby (1991) 'Optimal policies with strategic distortions.' *Journal of International Economics* 31, 291–308

Ordover, Janusz A., Garth Saloner, and Steven C. Salop (1990) 'Equilibrium vertical foreclosure.' *American Economic Review* 80(1), 127–142

Salinger, Michael A. (1988) 'Vertical mergers and market foreclosure.' *Quarterly Journal of Economics* 103(2), 345–356

Salop, Steven C., and David T. Scheffman (1983) 'Raising rival's cost.' *American Economic Review: Papers and Proceedings* 73(2), 267–271

— (1987) 'Cost raising strategy.' *Journal of Industrial Economics* 36(1), 19–34

Seade, Jesus K. (1980) 'The stability of Cournot revisited.' *Journal of Economic Theory* 15, 15–27

Spencer, Barbara J., and Ronald W. Jones (1991) 'Vertical foreclosure and internatinal trade policy.' *Review of Economic Studies* 58, 153–170

— (1992) 'Trade and protection in vertically related markets.' *Journal of International Economics* 32, 31–55

Spencer, Barbara J., and Ruth S. Raubitschek (1996) 'High-cost domestic joint ventures and international competition: Do domestic firms gain?' *International Economic Review* 37(2), 315–340

Appendix

A.1 Proof of Proposition 1

We totally differentiate (8):

$$[(n^h+1)r_x + r_{xx}n^h x^h]dx^h + n^m(r_x + r_{xx}x^h)dx^m = -r_s ds^d, \text{ and} \tag{A.20}$$

$$n^h(r_x + r_{xx}x^m)dx^h + [(n^m+1)r_x + r_{xx}n^m x^m]dx^m = -r_s ds^d. \tag{A.21}$$

Using (9), (A.20) and (A.21) gives the effect of s^d on the production of intermediate goods:

$$\frac{dx^h}{ds^d} = -r_s\left[\frac{1+n^m\delta^u E^u/X}{r_x\psi^u}\right], \quad \frac{dx^m}{ds^d} = -r_s\left[\frac{1-n^h\delta^u E^u/X}{r_x\psi^u}\right], \text{ and} \tag{A.22}$$

$$\frac{dX}{ds^d} = -r_s\frac{N^u}{r_x\psi^u} > 0. \tag{A.23}$$

From (7) and (A.23), the changes of the marginal cost of firm d and the input price are found:

$$\frac{d(r-s^d)}{ds^d} = \frac{dr}{ds^d} - 1 = -\frac{n^f\psi^u + n^d N^u}{N\psi^u} < 0 \text{ and } \frac{dr}{ds^d} = r_s + r_x\frac{dX}{ds^d} = r_s\frac{(1-E^u)}{\psi^u}. \tag{A.24}$$

Next using (A.22), the effect on the profits of input producers is:

$$\frac{d\pi^h}{ds^d} = r_s\frac{x^h}{\psi^u}[2-E^u+n^m\delta^u E^u/X] \text{ and } \frac{d\pi^m}{ds^d} = r_s\frac{x^m}{\psi^u}[2-E^u-n^h\delta^u E^u/X]. \tag{A.25}$$

Note that, when the firms h and m have the same cost function or when a demand function is linear, $\delta^u = 0$ holds. Equations (A.22), (A.23), (A.24) and (A.25) correspond to equations (10), (11), (12) and (13) in Ishikawa and Spencer (1999), respectively, by multiplying r_s.

A.2 Proof of Proposition 2 and 3

The partial derivatives of y^i (4) to (6) and (A.24) give the total effects of s^d on the production of the final good.

$$\frac{dy^d}{ds^d} = y_r^d \frac{dr}{ds^d} + y_{s^d}^d = \frac{-1}{p' n^d N \psi \psi^u} \left[n^d n^f \psi^u \psi + N^u (1 + n^f \delta E/Y) \right] \tag{A.26}$$

$$= \frac{-1}{p' N \psi \psi^u} [n^f \psi (1 - E^u) + N N^u \gamma^f]. \tag{A.27}$$

From (A.26) and (A.27), dy^d/ds^d is positive when $1 + n^f \delta E/Y > 0$ or $1 - E^u > 0$ holds. From (6) , $1 + n^f \delta E/Y > 0$ holds if and only if y_r^d . From (A.24) , $1 - E^u > 0$ holds if and only if $dr/ds^d > 0$

Using $y_r^f = y_{w^F}^f - y_{s^d}^F$, we obtain the effect on the final-good output of firm f:

$$\frac{dy^f}{ds^d} = y_r^f \frac{dr}{ds^d} + y_{s^d}^f = \left(1 - \frac{dr}{ds^d}\right) y_{s^d}^F + y_{w^F}^f \frac{dr}{ds^d}. \tag{A.28}$$

From (5), (A.24) and (A.28), dy^f/ds^d becomes negative when $dr/ds^d > 0$ and firm f's output is a strategic substitute. dy^f/ds^d becomes positive if $dr/ds^d < 0$ and firm f's output is a strategic complement.

From the assumption of Leontief technology, the subsidies always raise the total production of final goods.

$$\frac{dY}{ds^d} = \frac{dX}{ds^d} = -r_s \frac{N^u}{r_x \psi^u} > 0. \tag{A.29}$$

Using $\partial \pi^d / \partial s^d = (1 + \beta) y^d$, $\partial \pi^d / \partial s^d = (1 + \beta) y^d$ and the similar expressions of π^f, where $\beta \equiv (\gamma^f - n^d)/\psi$, the changes in the profits of firm d and f are found as:

$$\frac{d\pi^d}{ds^d} = \frac{\partial \pi^d}{\partial s^d} \frac{d(s^d - r)}{ds^d} + \frac{\partial \pi^d}{\partial w^f} \frac{dr}{ds^d} = y^d \left[(1 + \beta) \left(1 - \frac{dr}{ds^d}\right) + \frac{n^f}{n^d} (1 - \beta) \frac{dr}{ds^d} \right], \tag{A.30}$$

$$\frac{d\pi^f}{ds^d} = \frac{\partial \pi^f}{\partial s^d} \frac{d(s^d - r)}{ds^d} + \frac{\partial \pi^f}{\partial w^f} \frac{dr}{ds^d} = -\frac{n^d y^f}{N \psi \psi^u} \left[N N^u (2p' + p'' y^f)/p' + 2 n^f \psi (1 - E^u) \right]. \tag{A.31}$$

Note $1 - \beta = n^d (2p' + p'' y^d)/p' \psi > 0$ and $1 - dr/ds^d > 0$ from (A.24), then $d\pi^d/ds^d$ is positive when $dr/ds^d > 0$. $d\pi^d/ds^d$ is negative when $dr/ds^d > 0$.

A.3 Derivation of equation (15)

We substitute (A.24) into (A.30):

$$\frac{d\pi^d}{ds^d} = y^d \left[\beta \left(1 - \frac{dr}{ds^d} - \frac{n^f}{n^d}\frac{dr}{ds^d}\right) + 1 - \frac{dr}{ds^d} + \frac{n^f}{n^d}\frac{dr}{ds^d}\right] \tag{A.32}$$

$$= y^d \left[\beta \left(1 - \frac{N}{n^d}\frac{dr}{ds^d}\right) - \frac{(n^d - n^f)}{n^d}\frac{dr}{ds^d}\right] + y^d \tag{A.33}$$

$$= y^d \left[\frac{N^u}{\psi^u}\beta - \frac{(n^d - n^f)}{N}\frac{(1 - E^u)}{\psi}\right] + y^d. \tag{A.34}$$

Putting (A.25) and (A.34) into (11), we obtain (15).

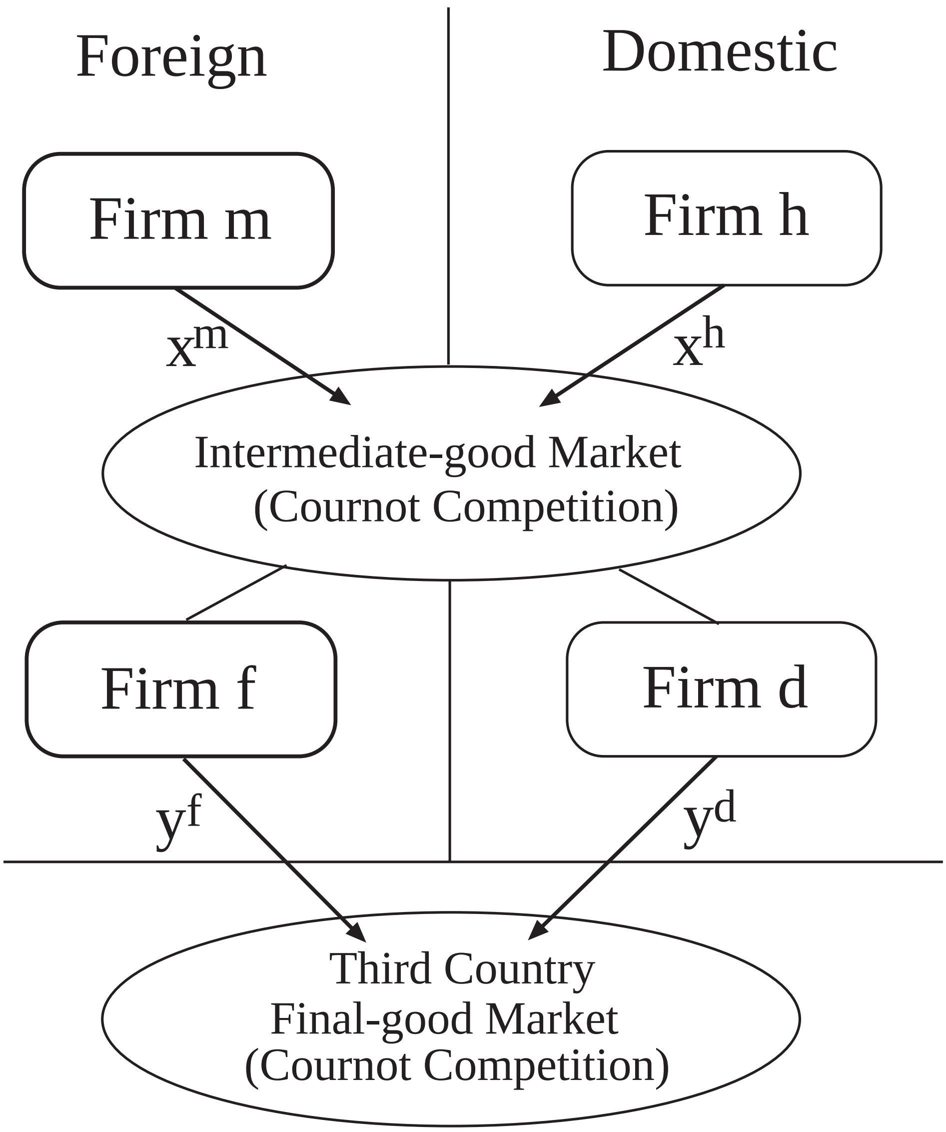

Figure 1: Market Structure

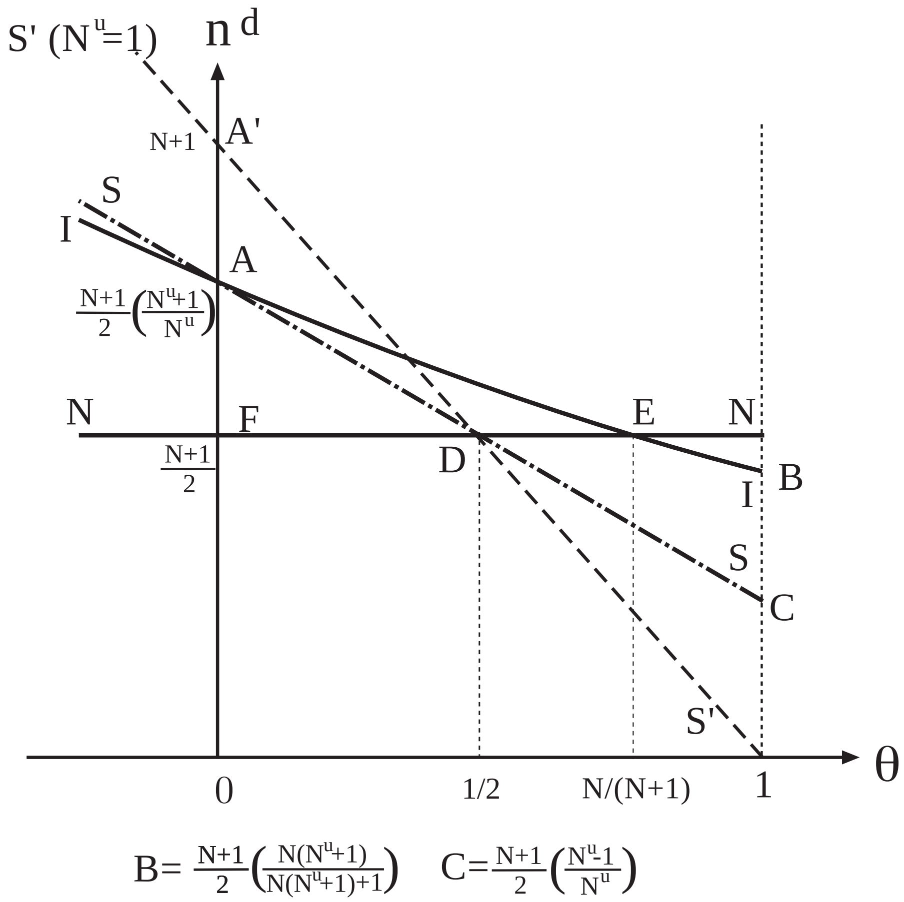

Figure 2: Optimal Policy Decisions