DISCUSSION PAPER SERIES

Discussion paper No. 201

Strategic Production Subsidy/Tax under Mutual Endogenous Entry of Foreign Firms

Keisaku Higashida
(School of Economics, Kwansei Gakuin University)

Hiroaki Ino
(School of Economics, Kwansei Gakuin University)

December 2019

SCHOOL OF ECONOMICS

KWANSEI GAKUIN UNIVERSITY

1-155 Uegahara Ichiban-cho
Nishinomiya 662-8501, Japan

Strategic Production Subsidy/Tax under Mutual Endogenous Entry of Foreign Firms*

Keisaku Higashida†
Hiroaki Ino‡

Version: December 12, 2019

Abstract

Considering a subsidy/tax on domestic production, this study examines the tax competition between two symmetric countries in the presence of the mutual endogenous entry of foreign firms into each country's market through exports and foreign direct investment (FDI). In the absence of FDI, we find that whether the equilibrium tax rate is positive or negative is determined by the export intensity of domestic firms and thus the tax rate is always negative (i.e., a subsidy) in the symmetric interior case. However, in the presence of FDI, the necessary and sufficient condition for the sign of the equilibrium tax rate is weighted toward FDI (but still characterized by an observable indicator); hence, the tax rate can plausibly be positive (i.e., a tax). We also show that from the perspective of global welfare, the equilibrium tax rate is excessively low (high) if and only if it is a subsidy (tax).

Keywords: Cournot competition, strategic trade policy, free trade agreement, rapid foreign penetration, protectionism, countervailing duty, emission tax

JEL Code:F12, F13, F15.

*Acknowledgments The authors are grateful to kind and useful comments by Hiroshi Mukunoki, Yigit Saglam, and the participants of the workshop in Victoria University of Wellington and 2018 Japanese Economic Association Autumn Meeting. We would like to thank Editage (www.editage.com) for English language editing. The usual disclaimer applies. This work was supported by JSPS KAKENHI (19H01494 and 19K21693).

†Corresponding author. School of Economics, Kwansei Gakuin University. Address: 1-155 Uegahara Ichiban-cho, Nishinomiya, Hyogo 662-8501, Japan. E-mail:keisaku@kwansei.ac.jp

‡School of Economics, Kwansei Gakuin University. Address: 1-155 Uegahara Ichiban-cho, Nishinomiya, Hyogo 662-8501, Japan. E-mail:hiroakiino@04.alumni.u-tokyo.ac.jp

1 Introduction

With the worldwide trend toward free trade, countries have agreed to open their domestic markets and allow the free entry of foreign firms. However, even under such an agreement, they have an incentive to strategically arrange domestic policy[1] to promote their own welfare. In particular, when a country opens its market, prices change because of rapid foreign penetration, resulting in the possible decline in domestic production. Hence, one country's policy can affect trading partners' market prices. However, such strategic interdependence caused by mutual endogenous entry remains an under-researched topic.

This study theoretically analyzes a subsidy/tax on domestic production as a domestic policy and investigates a new aspect of tax competition between two countries under strategic interdependence through the mutual endogenous entry of foreign firms. Furthermore, as the options to enter the other country's market, we consider both exports and foreign direct investment (FDI) and derive implications for the presence of FDI. For example, Brander and Spencer (1985), the seminal work on competition through strategic trade policy, consider a production subsidy in a third country model and Smith (1987) investigates import tariffs but considers foreign firms' choice between imports and FDI in a home country model. However, these studies do not incorporate free entry as we do.[2] Does the competition of subsidizing domestic production also occur under the mutual endogenous entry of foreign firms? If so, does the presence of FDI alleviate such subsidy competition to protect domestic firms?

Similar to our study, Venables (1985) considers mutual entry between two countries under Cournot competition. He investigates the long-run situation in which both domestic and foreign firms endogenously enter markets.[3] An incentive to protect the profits of domestic firms cannot appear in such a pure long-run situation because no firms can earn a positive profit in this case. However, because we are interested in rapid foreign penetration after opening a market, the entry decision of existing foreign firms can be made immediately, whereas that of potential domestic firms is considered to be more inflexible. Therefore, we suppose that the number of domestic firms (incumbents) is exogenous and only the number of foreign firms (new entrants) is endogenous.[4] In other words, we consider the term in which only the firms that

[1] Keen and Ligthart (2005) provide an interesting implication about the coordination of domestic (consumption) tax after the promotion of free trade (tariff reduction).

[2] For a literature review of optimal trade policy in imperfectly competitive markets, see Etro (2014).

[3] For recent studies of international trade with endogenous market structures, see Stähler and Upmann (2008) and Markusen and Stähler (2011), among others.

[4] Furthermore, we rank the flexibility of the entry/exit decision through exports and FDI, as that through exports is more flexible than that through FDI. See the model setting and footnote 1 for more details.

already operate in their own countries can be players in the markets. In this situation, because the free entry of foreign firms determines the market price and eliminates the price effect of the production tax/subsidy, the government never cares about consumers. Nevertheless, governments have an incentive to provide a production subsidy to protect firms' profits in the domestic market. Recently, such a medium-term model has been adopted in studies of international economics (Lahiri and Ono, 1998a; Kayalica and Lahiri, 2007; Etro, 2011, 2014; Ino and Miyaoka, 2016). Among others, Etro (2011) investigates a production subsidy in this context by extending Brander and Spencer's (1985) third country model and Ino and Miyaoka (2016) investigate the political production control, which is equivalent to a production subsidy under the endogenous entry of foreign firms in a home country model. However, all these works consider other market structures or policies than our study does.[5] Ours is a two-country model in the presence of FDI that considers a domestic production subsidy/tax under mutual foreign entry.

This study investigates the tax rates resulting from the above-mentioned non-cooperative optimal tax competition and shows the following results. If we focus only on exporting as the entry method, the production tax causes a trade-off between the effects on the profits of domestic firms in the home market and on the tax revenue obtained from exports to the foreign market. Thus, whether the equilibrium tax rate is positive or negative is determined by the export intensity of domestic firms. Consequently, in the absence of FDI, the equilibrium tax rate is always negative (i.e., a subsidy) in the symmetric interior case. However, if we take FDI into account, the production tax additionally affects the tax revenue obtained from foreign FDI firms in the home market and the profits of home FDI firms operating in the foreign market. Both these two effects increase the production tax rate. Thus, the necessary and sufficient condition for the sign of the equilibrium tax rate is weighted toward FDI. Accordingly, in the presence of FDI, the equilibrium tax rate can plausibly be positive (i.e., a tax). We characterize the welfare effects presented here using observable quantities as well as show that in terms of global welfare, the equilibrium tax rate is excessively low (high) when it is a subsidy (tax).

These results imply that the country's incentive to levy taxation on domestic production crucially depends on the presence of FDI. Under mutual entry, we have the market force that FDI increases the domestic tax rate. This force is more substantial than the conventional wisdom that FDI lowers the excessive subsidy rate and makes the subsidy competition between countries milder. The presence of FDI can thus alter the phase of competition to tax competition, which

[5]Neither Etro (2011) nor Ino and Miyaoka (2016) incorporates FDI. Without considering FDI, Etro (2014) mainly investigates import tariffs under unilateral trade in a domestic market. Lahiri and Ono (1998a) consider FDI in a domestic market without international trade and Kayalica and Lahiri (2007) focus on lobbying activities related to FDI.

makes such tax competition excessively severe.

The rest of the paper is organized as follows. The next section formulates the model. Sections 3 and 4 investigate the strategic tax rates in the absence and presence of FDI, respectively. In Section 5, we evaluate these equilibrium tax rates from the perspective of global welfare. In Section 6, we further discuss a countervailing duty (CVD)[6] and an application to an emission tax. Interestingly, under mutual entry, we show that CVDs can make subsidy competition severer and that the non-cooperative emission tax rate can be higher than the marginal environmental damage. Section 7 concludes.

2 The model

2.1 Basic setting

Consider a two-country model in which both home and foreign countries are symmetric. In the home (foreign) country, m home (n foreign) firms produce goods X and supply them to the domestic market. These firms also choose exports or FDI when entering the other country's market; the numbers of home (foreign) firms that choose exports and FDI are denoted by m_E and m_I (n_E and n_I), respectively. The numbers of existing firms, m and n, are exogenous; however, as explained later, the numbers of firms that enter the other market through exports and FDI are endogenously determined. We focus on the symmetric case in which $m = n$ and the interior case in which $0 < m_E + m_I < m$ and $0 < n_E + n_I < n$.

The firms do not pay any fixed costs to supply goods X to the domestic market because they are already operating in their own country's market and such a cost is therefore sunk. By contrast, they incur a fixed entry cost when they enter the other country's market.[7] The entry cost when a firm chooses exports is $f > 0$, which is common to all firms. On the contrary, the entry cost of the home (foreign) market when foreign firm j (home firm j) chooses FDI is $F_j > 0$, which differs among firms. For example, it is easier for the first entrant through FDI than for the second entrant to find workers with skills and suitable production sites in the host country because the endowment of human resources and land is limited. In such a case, the speed of decision-making is a source of the difference in the fixed cost.[8] Without loss of generality, we assume that $F_1 < F_2 < F_3 \cdots$, where the subscript is the index j. We ignore the

[6] CVDs are duties that governments can impose under World Trade Organization (WTO) rules to offset the damage caused by subsidizing trading partners.

[7] When firms enter the markets of other countries, they usually pay an entry cost. They may have to conduct market research and/or create a new distribution channel by agreeing contracts with local distributors.

[8] Another way of interpreting the difference is as follows. There are the difference in fixed costs when the costs for the acquisition of human resources and fundraising differ among firms. However, in this case, the possibility of equilibria in which firms with higher fixed costs execute FDI sooner should be carefully examined.

integer problem and assume that the entry cost of the jth firm through FDI is the function of j, which is differentiable:

$$F_j = F(j), \quad F' > 0.^9 \tag{1}$$

The marginal cost of producing one unit of goods X is $c \geq 0$, which is common to all firms. When the firms export their products to the other country, they have to pay transportation costs. The per unit transportation cost is $c_{EX} \geq 0$. Define $C = c + c_{EX}$.

Inverse demand for goods X in each country is given by

$$P = A - aX, \qquad A > 0, \quad a > 0, \tag{2}$$

where P and X denote the price and the amount of demand, respectively.

The home (foreign) government may levy a tax on domestic production, which is denoted by $t \in \mathbb{R}$ ($t^* \in \mathbb{R}$). We do not exclude a production subsidy. Hence, t and t^* can be negative. In the home market, the profit of home firm i is

$$\pi_i \equiv (A - aX)x_i - (c + t)x_i, \tag{3}$$

and the profit of foreign firm j that enters the home market through FDI is

$$\pi_j \equiv (A - aX)x_j - (c + t)x_j - F_j. \tag{4}$$

Moreover, the profit of foreign firm k that enters the home market through exports is

$$\pi_k \equiv (A - aX)y_k - (C + t^*)y_k - f. \tag{5}$$

In these expressions of the profits, x_i, x_j, and y_k represent each firm's quantities produced by each option. In the foreign market, the profits of foreign firm i, home firm j that enters the foreign market through FDI, and home firm k that enters the foreign market through exports are analogously defined by π_i^*, π_j^*, and π_k^*. We represent the variables in the foreign market by attaching the superscript $*$.[10]

The welfare of the home country is the sum of the home consumer surplus, profits of home firms, and home tax revenue, which is given by

$$W \equiv CS(X) + \sum_{i=1}^{m} \pi_i + \sum_{j=1}^{m_I} \pi_j^* + \sum_{k=1}^{m_E} \pi_k^* + tY, \tag{6}$$

[9] In other words, according to the fixed costs that are set in this paragraph, our model assumes the flexibility to enter/exit the market: that for the exporting foreign firm is the most flexible, for the domestic firms is the most inflexible, and for the FDI firms is intermediate.

[10] More precisely, the indexes of the firms in the foreign market should also be denoted as i^*, j^*, and k^*. Firm j^* or k^* (j or k) corresponds to some home firm i (foreign firm i^*). However, to avoid complex expressions and explanations, we somewhat abuse these indexes. Because the home and foreign markets are independent in our model, readers will easily see what they represent from the context.

where $CS(X) \equiv aX^2/2$ represents the consumer surplus and

$$Y \equiv \sum_{i=1}^{m} x_i + \sum_{j=1}^{n_I} x_j + \sum_{k=1}^{m_E} y_k^* = X + \left(\sum_{k=1}^{m_E} y_k^* - \sum_{k=1}^{n_E} y_k \right) \tag{7}$$

represents total domestic production (total demand plus net exports) in the home country. The welfare of the foreign country is given by W^* analogously.

The structure of the game is as follows. In the first stage, each government determines the tax rate to maximize its own welfare. In the second stage, each firm determines whether it enters the other country's market. In addition, each firm selects whether it enters through exports or FDI when doing so. For simplicity, we assume that each firm chooses one of the two alternatives. In the third stage, both the home and the foreign firms choose their outputs in each country's market and compete in a Cournot fashion. We solve the game using backward induction.

2.2 Market competition and entry decision

Consider the market competition and entry in the home country. In the third stage, by focusing on the interior solution, the first-order conditions (FOCs) for firms i, j, and k are given by[11]

$$\frac{\partial \pi_i}{\partial x_i} = A - aX - ax_i - c - t = 0, \tag{8}$$

$$\frac{\partial \pi_j}{\partial x_j} = A - aX - ax_j - c - t = 0, \tag{9}$$

$$\frac{\partial \pi_k}{\partial y_k} = A - aX - ay_k - C - t^* = 0. \tag{10}$$

By symmetry, $x_i = x_j = x$ and $y_k = y$ in the third stage's equilibrium. Taking these equilibrium outputs that satisfy (8)–(10) into account, in the second stage, the numbers of foreign firms that enter the home market, n_I and n_E, are determined by the following zero-profit conditions (ZPCs):[12]

$$\pi_j = (A - aX)x - (c + t)x - F(n_I) = 0, \tag{11}$$

$$\pi_k = (A - aX)y - (C + t^*)y - f = 0, \tag{12}$$

where $X = mx + n_I x + n_E y$. Thus, summarizing all the conditions, the second stage's equilibrium outcomes must satisfy (8)–(12), and thus they can be denoted as $\tilde{x}_i(m, \mathbf{t}) = \tilde{x}_j(m, \mathbf{t}) = \tilde{x}(m, \mathbf{t})$, $\tilde{y}(m, \mathbf{t})$, $\tilde{n}_I(m, \mathbf{t})$, $\tilde{n}_E(m, \mathbf{t})$, where $\mathbf{t} = (t, t^*)$. In addition, for the other variables, $\tilde{}$ denotes the equilibrium value in the second stage. For example, equilibrium total home demand is denoted as $\tilde{X}(m, \mathbf{t}) = m\tilde{x} + \tilde{n}_I\tilde{x} + \tilde{n}_E\tilde{y}$.

[11] We can easily show that the second-order conditions (SOCs) and stability conditions are satisfied.

[12] The stability conditions for the second-stage equilibrium can be easily verified.

Similarly, in the foreign market, the second stage's equilibrium outcomes are also defined by the three FOCs and two ZPCs for this market:

$$\frac{\partial \pi_i^*}{\partial x_i^*} = A - aX^* - ax^* - c - t^* = 0, \tag{13}$$

$$\frac{\partial \pi_j^*}{\partial x_j^*} = A - aX^* - ax^* - c - t^* = 0, \tag{14}$$

$$\frac{\partial \pi_k^*}{\partial y_k^*} = A - aX^* - ay^* - C - t = 0. \tag{15}$$

$$\pi_j^* = (A - aX^*)x^* - (c + t^*)x^* - F(m_I) = 0, \tag{16}$$

$$\pi_k^* = (A - aX^*)y^* - (C + t)y^* - f = 0, \tag{17}$$

where $X^* = nx^* + m_I x^* + m_E y^*$, and the equilibrium outcomes can be denoted as $\tilde{x}_i^*(n, \mathbf{t}) = \tilde{x}_j^*(n, \mathbf{t}) = \tilde{x}^*(n, \mathbf{t})$, $\tilde{y}^*(n, \mathbf{t})$, $\tilde{m}_I(n, \mathbf{t})$, $\tilde{m}_E(n, \mathbf{t})$ analogously.

3 Strategic tax rates in the absence of FDI

To discuss the effect of FDI on tax competition, in this section, we first consider the case in which the firms operate without FDI by exogenously presuming $m_I = n_I = 0$ and $x_j = x_j^* = 0$. Then, the remaining three equilibrium outcomes in the home market $(\tilde{x}, \tilde{y}, \tilde{n}_E)$ are determined from (8), (10), and (12) by dropping the conditions for the FDI firms (9) and (11). Similarly, the equilibrium outcomes in the foreign market $(\tilde{x}^*, \tilde{y}^*, \tilde{m}_E)$ are given by (13), (15), and (17).

3.1 The effects of a production tax in the markets

First, we examine the effect of a change in the tax rate on the outputs and number of entrants. Observing the equilibrium conditions, we find that (10) and (12) can be independently solved with respect to two endogenous variables, $\tilde{X}$ and $\tilde{y}$. In addition, the home production tax rate t is not included in these two equations. Thus, we immediately obtain the following result. The structure is similar in the foreign market as mentioned in the parentheses.[13]

Proposition 1 *In the home (foreign) market, total consumption $\tilde{X}$ ($\tilde{X}^*$) and the output of each exporting firm $\tilde{y}$ ($\tilde{y}^*$) are not influenced by the home tax rate t (foreign tax rate t^*).*

[13]The basic mechanism of this result is the same as Proposition 1 of Bayindir-Upmann (2003). Recently, the similar neutral property in free entry markets has been widely used in studies of industrial organization. See, for example, Etro (2007) and Ino and Matsumura (2012).

Proposition 1 implies that the price in the home market and thus the home consumer surplus are not influenced by a change in the home tax rate. As for the remaining effects of t in the home market, differentiating (8) with respect to t, we obtain

$$\frac{\partial \tilde{x}}{\partial t} = -\frac{\partial \tilde{X}}{\partial t} - \frac{1}{a} = -\frac{1}{a} < 0, \tag{18}$$

and from $\tilde{X} = m\tilde{x} + \tilde{n}_E\tilde{y}$, we obtain

$$\frac{\partial \tilde{n}_E}{\partial t} = \frac{\partial}{\partial t}\frac{\tilde{X} - m\tilde{x}}{\tilde{y}} = \frac{m}{a\tilde{y}} > 0, \tag{19}$$

Where, in both calculations, the second equalities use Proposition 1. According to Proposition 1, an increase in imports perfectly cancels out a decrease in production in the home country.[14]

As for the effects of t in the foreign market, differentiating (15) and (17) with respect to t yields[15]

$$\begin{pmatrix} -a & -a \\ -ay^* & \tilde{P} - C - t \end{pmatrix} \begin{pmatrix} \frac{\partial \tilde{X}^*}{\partial t} \\ \frac{\partial \tilde{y}^*}{\partial t} \end{pmatrix} = \begin{pmatrix} 1 \\ \tilde{y}^* \end{pmatrix},$$

where $\tilde{P} - (C + t) = a\tilde{y}^*$ by (15). Thus, solving these equations yields

$$\frac{\partial \tilde{X}^*}{\partial t} = -\frac{1}{a} < 0, \tag{20}$$

$$\frac{\partial \tilde{y}^*}{\partial t} = 0. \tag{21}$$

In contrast to Proposition 1, the home tax influences foreign consumption and raises the price in the foreign market. Further, differentiating (13), we obtain

$$\frac{\partial \tilde{x}^*}{\partial t} = -\frac{\partial \tilde{X}^*}{\partial t} = \frac{1}{a} > 0. \tag{22}$$

Finally, from $\tilde{X}^* = n\tilde{x}^* + \tilde{m}_E\tilde{y}^*$, we obtain

$$\frac{\partial \tilde{m}_E}{\partial t} = \frac{\partial}{\partial t}\frac{\tilde{X}^* - n\tilde{x}^*}{\tilde{y}^*} = -\frac{n+1}{a\tilde{y}^*} < 0. \tag{23}$$

An increase in production tax in one country decelerates the foreign penetration in the other country. Then, it increases the production of each domestic firm in the other country, whereas it makes this country's market less competitive and its price then increases as a result.

[14] $\partial(m\tilde{x})/\partial t = \partial(\tilde{n}_E\tilde{y})/\partial t$.

[15] Note that $\tilde{P}$ is independent of t from Proposition 1.

3.2 Tax competition

In the first stage, the home government maximizes home social welfare, and its FOC is[16]

$$0 = \frac{\partial \tilde{W}}{\partial t} = \frac{\partial (m\tilde{\pi}_i)}{\partial t} + \frac{\partial (t\tilde{Y})}{\partial t} \tag{24}$$

$$= -m\tilde{x} + \tilde{m}_E \tilde{y}^* + t\frac{\partial \tilde{Y}}{\partial t}, \tag{25}$$

where $\tilde{Y} = m\tilde{x} + \tilde{m}_E \tilde{y}^*$. The first equality is obtained because $\partial CS(\tilde{X})/\partial t = 0$ and $\partial(\tilde{m}_E \tilde{\pi}_k^*)/\partial t = 0$ hold from Proposition 1 and the ZPC (17), respectively. The second equality stems from $\partial \tilde{\pi}_i/\partial t = -2\tilde{x}$ from (18) and the FOC (8). Thus, the home tax rate in the equilibrium $\tilde{t}$ must satisfy

$$\tilde{t} = \frac{m\tilde{x} - \tilde{m}_E \tilde{y}^*}{\partial \tilde{Y}/\partial t}, \tag{26}$$

where total home production decreases in t, that is,

$$\frac{\partial \tilde{Y}}{\partial t} = m\frac{\partial \tilde{x}}{\partial t} + \tilde{m}_E \frac{\partial \tilde{y}^*}{\partial t} + \frac{\partial \tilde{m}_E}{\partial t}\tilde{y}^* < 0 \tag{27}$$

from (18), (21), and (23). Therefore, $\tilde{t}$ is positive if and only if $m\tilde{x} - \tilde{m}_E \tilde{y}^* < 0$. To interpret this condition, let us denote the ratio of exports to the home supply of the home firms in the equilibrium by

$$EI \equiv \frac{\tilde{m}_E \tilde{y}^*}{m\tilde{x}}, \tag{28}$$

which represents how intensively the home industry engages in exporting. Then, the equilibrium production tax satisfies the following proposition. The situation is the same for the foreign country's equilibrium tax rate $\tilde{t}^*$, where the export intensity of the domestic firm is $EI^* \equiv (\tilde{n}_E \tilde{y})/(n\tilde{x}^*)$.

Proposition 2 *In tax competition (first stage) in the absence of FDI, $\tilde{t} > 0$ ($\tilde{t}^* > 0$) holds if and only if $EI > 1$ ($EI^* > 1$) in the equilibrium. Thus, in the symmetric interior equilibrium, both the countries' tax rates must be negative (i.e., a subsidy).*

The latter half of the proposition is because $\tilde{m}_E < m$ in the interior equilibrium and $\tilde{y}^* = \tilde{y} \leq \tilde{x}$ in the symmetric equilibrium with $t = t^*$, where the last inequality is obvious from $C + t^* \geq c + t$ and the FOCs (8) and (10).

In considering the optimal tax rate, Proposition 1 implies that there is no *effect arising from the inefficiency of imperfect competition* in the home market because the domestic tax does not affect total consumption in the country. On the contrary, the *profit-capturing effect* necessarily

[16] We assume that the SOCs and stability conditions are satisfied.

exists, which is represented by the first term of (24), and this lowers the tax rate. The *tax revenue effect* also influences the optimal tax rate, which is represented by the second term of (24). This effect can be decomposed into $\tilde{Y} + t(\partial \tilde{Y}/\partial t)$. The former direct effect works to raise the tax rate, whereas the latter indirect effect through a decrease in domestic production works against it. Thus, the source of the positive effect is only in the tax revenue effect.

Therefore, the intuition behind Proposition 2 is the following trade-off, which is represented by observable indicator EI.

On the one hand, in the home market (represented in the denominator), the profits of the home firms are protected by a reduction in production tax t. This tax reduction improves the strategic position of the home firms in the home market and the resulting promotion of their production (increase in $m\tilde{x}$) cancels out the foreign penetration (decrease in $\tilde{n}_E\tilde{y}$).[17] Thus, this strategic profit-capturing effect on domestic firm protection, which lowers the tax, exactly relates to $m\tilde{x}$, which is represented by the denominator of EI.

On the other hand, in the foreign market (represented in the numerator), the home government has an incentive to increase t to obtain tax revenue from the home exporting firms. This opposite positive effect is included in the direct tax revenue effect ($\tilde{Y} = m\tilde{x} + \tilde{m}_E\tilde{y}^*$), as mentioned earlier. Because tax revenue from operating in the home market ($m\tilde{x}$) is just the transfer, it is canceled out by a part of the profit-capturing effect ($\partial m\tilde{\pi}_i/\partial t = -2m\tilde{x}$) other than the strategic profit-capturing effect ($m\tilde{x}$). Therefore, tax revenue from operating in the foreign market ($\tilde{m}_E\tilde{y}^*$) remains.[18] Thus, this effect on the tax revenue from the foreign business, which raises the tax, exactly relates to $\tilde{m}_E\tilde{y}^*$, as represented by the numerator of EI.

Because these two effects work oppositely, export intensity EI, which represents their relative size, is the key condition. However, this never exceeds 1 in the two symmetric country case and $\tilde{t}$ becomes negative (i.e., a production subsidy). In other words, in this case, the government's incentive to protect domestic firms always dominates its incentive to earn from the foreign market.

[17] Recall the explanation just after (19). This is because t does not influence the consumer surplus under the endogenous entry of foreign firms.

[18] Note the exporting firm always earns the zero-profit *including* the tax payment under the endogenous entry. Recall the explanation just after (23). An increase in t induces the exits of the home exporting firms. However, it makes the foreign market less competitive and the business in the foreign market more profitable even for the remaining home firms ($\tilde{m}_E\tilde{y}^*$). This rent-shift from the foreign to the home surplus obtained as the home country's tax revenue.

4 Strategic tax rates in the presence of FDI

In this section, we introduce FDI into our analysis. Then, the five equilibrium outcomes in the home market $(\tilde{x}_i, \tilde{x}_j, \tilde{y}, \tilde{n}_I, \tilde{n}_E)$ are determined from (8)–(12). Because (8) and (9) are the same condition, $\tilde{x}_i = \tilde{x}_j = \tilde{x}$ holds. Thus, compared with in the previous section, the additional equilibrium outcome is only $\tilde{n}_I$ and the condition to induce it is (11). Similarly, the equilibrium outcomes in the foreign market $(\tilde{x}^*, \tilde{y}^*, \tilde{m}_I, \tilde{m}_E)$ are given by (13)–(17).

4.1 The effects of a production tax in the markets

With regard to the effect of t in the home market, recall that Proposition 1 stems only from (10) and (12). Hence, Proposition 1 is also valid in this section. As analyzed in the previous section, an increase in the home (foreign) tax rate does not influence home (foreign) consumption and prices. Moreover, similarly to in the previous section, we also obtain (18) from (8). Differentiating (11) with respect to t,[19] we obtain

$$(\tilde{P} - c - t)\frac{\partial \tilde{x}}{\partial t} - \tilde{x} - F'\frac{\partial \tilde{n}_I}{\partial t} = 0 \qquad \therefore \frac{\partial \tilde{n}_I}{\partial t} = -\frac{2\tilde{x}}{F'} < 0, \tag{29}$$

where $\tilde{P} - (c + t) = a\tilde{x}$ from (9). Finally, from $\tilde{X} = m\tilde{x} + \tilde{n}_I\tilde{x} + \tilde{n}_E\tilde{y}$, we obtain

$$\frac{\partial \tilde{n}_E}{\partial t} = \frac{\partial}{\partial t}\frac{\tilde{X} - m\tilde{x} - \tilde{n}_I\tilde{x}}{\tilde{y}} = \frac{(m + \tilde{n}_I)F' + 2a\tilde{x}^2}{a\tilde{y}F'} > 0, \tag{30}$$

where the second equality uses Proposition 1. Because an increase in t decreases not only the home firm's production but also the foreign firm's entries through FDI, according to Proposition 1, an increase in imports offsets the sum of these production reductions.[20]

Next, we consider the effects of t in the foreign market. We can obtain (20), (21), and (22) in a similar way to in the previous section. Then, differentiating (16) with respect to t, we obtain

$$\tilde{x}^*\frac{\partial \tilde{P}^*}{\partial t} + (\tilde{P}^* - c - t^*)\frac{\partial \tilde{x}^*}{\partial t} - F'\frac{\partial \tilde{m}_I}{\partial t} = 0 \qquad \therefore \frac{\partial \tilde{m}_I}{\partial t} = \frac{2\tilde{x}^*}{F'} > 0, \tag{31}$$

where $\partial \tilde{P}^*/\partial t = -a(\partial \tilde{X}^*/\partial t)$ by definition and $\tilde{P}^* - (c + t^*) = a\tilde{x}^*$ from (14). Finally, from $\tilde{X}^* = n\tilde{x}^* + \tilde{m}_I\tilde{x}^* + \tilde{m}_E\tilde{y}^*$, we obtain

$$\frac{\partial \tilde{m}_E}{\partial t} = \frac{\partial}{\partial t}\frac{\tilde{X}^* - n\tilde{x}^* - \tilde{m}_I\tilde{x}^*}{\tilde{y}^*} = -\frac{(n + 1 + \tilde{m}_I)F' + 2a\tilde{x}^{*2}}{a\tilde{y}^*F'} < 0. \tag{32}$$

In the presence of FDI, an increase in t, which discourages the home firms from exporting, encourages them to enter the other country through FDI. As a result, in the foreign market, a decrease in imports is shifted by an increase in production through FDI. Thus, the price change in t, namely $\partial \tilde{P}^*/\partial t = 1$ from (20), is the same as in the previous section.

[19] Note that $\tilde{P}$ is independent of t from Proposition 1.

[20] From $\partial \tilde{X}/\partial t = 0$, $-\partial(m\tilde{x} + \tilde{n}_I\tilde{x})/\partial t = \partial(\tilde{n}_E\tilde{y})/\partial t$ holds.

4.2 Tax competition

Now, let us turn to the analysis in the first stage, where the home and foreign governments maximize each country's social surplus.[21]

Because the profit of the last home entrant into the foreign market through FDI is zero, the total profit of the home firms that enter the foreign market through FDI, namely $\sum_j \tilde{\pi}_j^*$, is given by

$$\int_0^{\tilde{m}_I} \{F(\tilde{m}_I) - F(z)\}dz. \tag{33}$$

In addition, total domestic production in the home country is $\tilde{Y} = m\tilde{x} + \tilde{n}_I\tilde{x} + \tilde{m}_E\tilde{y}^*$. Thus, the FOC for the home government is

$$0 = \frac{\partial \tilde{W}}{\partial t} = F'(\tilde{m}_I)\tilde{m}_I\frac{\partial \tilde{m}_I}{\partial t} + \frac{\partial(m\tilde{\pi}_i)}{\partial t} + \frac{\partial(t\tilde{Y})}{\partial t} \tag{34}$$

$$= 2\tilde{m}_I\tilde{x}^* - m\tilde{x} + \tilde{n}_I\tilde{x} + \tilde{m}_E\tilde{y}^* + t\frac{\partial \tilde{Y}}{\partial t}, \tag{35}$$

where the first term in the first line can be rewritten as $2\tilde{m}_I\tilde{x}^*$ from (31) and thus the second equality is obtained. In contrast to the FOC (25) in the absence of FDI, we have two additional factors in (35). One is the first term representing the effect on the total profits of home firms that enter the foreign market through FDI.[22] The other is the term that represents the effect of FDI on tax revenue.

From (35), the home tax rate in the equilibrium ($\tilde{t}$) must satisfy

$$\tilde{t} = \frac{(m\tilde{x} - \tilde{n}_I\tilde{x}) - (\tilde{m}_E\tilde{y}^* + 2\tilde{m}_I\tilde{x}^*)}{\partial \tilde{Y}/\partial t}, \tag{36}$$

where total home production decreases in t, that is,

$$\frac{\partial \tilde{Y}}{\partial t} = (m + \tilde{n}_I)\frac{\partial \tilde{x}}{\partial t} + \frac{\partial \tilde{n}_I}{\partial t}\tilde{x} + \tilde{m}_E\frac{\partial \tilde{y}^*}{dt} + \frac{\partial \tilde{m}_E}{\partial t}\tilde{y}^* < 0 \tag{37}$$

from (18), (21), (29), and (32). Therefore, $\tilde{t}$ is positive if and only if the numerator of (36) is negative. To interpret this condition, we define

$$FI \equiv \frac{\tilde{m}_E\tilde{y}^* + 2\tilde{m}_I\tilde{x}^*}{m\tilde{x} - \tilde{n}_I\tilde{x}}, \tag{38}$$

for the home government. Then, we obtain the following proposition. We can describe the decision-making of the foreign government analogously by defining $FI^* \equiv (\tilde{n}_E\tilde{y} + 2\tilde{n}_I\tilde{x})/(n\tilde{x}^* - \tilde{m}_I\tilde{x}^*)$.

[21] We assume that the SOCs and stability conditions are satisfied.

[22] In this term, the effect on a new marginal entrant is zero because its profits must satisfy the ZPC. Thus, the presented effect is for the FDI firms that have already been operating in the market before a marginal increase in t. This effect is twice as large as their production ($2\tilde{m}_I\tilde{x}^*$). To obtain the intuition of our result later, it is worth noting why this is double. The expression $2\tilde{x}^*$ is derived from the first and second terms of (31). Therefore, one is an increase in an FDI firm's profit caused by a change in the price ($\partial\tilde{P}^*/\partial t > 0$) and the other is that caused by a change in the output of the FDI firm ($\partial\tilde{x}^*/\partial t > 0$).

Proposition 3 *In tax competition (first stage) in the presence of FDI, $\tilde{t} > 0$ ($\tilde{t}^* > 0$) holds if and only if $FI > 1$ ($FI^* > 1$) in the equilibrium. Thus, even in the symmetric interior equilibrium, both the countries' tax rates can be positive (i.e., a tax).*

If we simply extend the export (foreign supply) intensity defined in (28) by taking the production of FDI firms into account, a straightforward definition would be $FI' \equiv (\tilde{m}_E\tilde{y}^* + \tilde{m}_I\tilde{x}^*)/m\tilde{x}$, which is namely the ratio of the home firms' total foreign supply through exports and FDI to the home firm's domestic supply. Under the symmetric interior equilibrium, where $m_E + m_I < m$ and $\tilde{y}^* = \tilde{y} \leq \tilde{x}$ holds, this ratio never exceeds 1 because $\tilde{m}_E\tilde{y} + \tilde{m}_I\tilde{x} < m\tilde{x}$. However, our indicator FI is further modified in two aspects: the denominator (related to the home market) is reduced by the FDI of foreign firms ($-\tilde{n}_I\tilde{x}$) and the numerator (related to the foreign market) is amplified by the FDI of home firms ($2\tilde{m}_I\tilde{x}^*$). Because of these weights toward FDI, we have $FI > FI'$. As a result, even in the symmetric interior case, $FI > 1$ can be satisfied plausibly.[23]

Intuitively, the modified condition in Proposition 3 is weighted toward FDI because being related to FDI, the following additional two effects arise. Consequently, these effects can alter the phase of the competition from subsidy competition to tax competition.

First, in the home market, as mentioned in the previous section, an incentive to protect domestic firms works against the foreign firm's imports. However, if the government reduces t for that, it also reduces the tax revenue from the foreign FDI firms producing in the home country ($\tilde{n}_I\tilde{x}$). Thus, in this negative effect on the tax rate (the denominator), $\tilde{n}_I\tilde{x}$ must be subtracted.

Second, in the foreign market, as mentioned in the previous section, the incentive to obtain tax revenue from exporting firms ($\tilde{m}_E\tilde{y}^*$) raises the tax rate. However, for FDI firms, differently from the tax revenue effect, the effect of an increase in t works on their profits through two channels as follows.[24] The home FDI firms already producing in the foreign market are influenced by t just as foreign domestic firms are. First, the higher t makes the market less competitive and raises the price. This benefit is captured by the profits of the home FDI firms producing in the market ($\tilde{m}_I\tilde{x}^*$) as well as foreign domestic firms. The impact per unit production through this channel is the same as that through tax revenue from exporting firms ($\tilde{m}_E\tilde{y}^*$) because they both relate to the same price change. Second, the higher t also improves the strategic position of the firms producing in the foreign country, including both FDI and foreign domestic firms, and this encourages their production ($\partial\tilde{x}^*/\partial t = -1/P' > 0$). Since the profits of the firms

[23] By symmetry, this condition simplifies to $\tilde{m}_E\tilde{y} + 3\tilde{m}_I\tilde{x} > m\tilde{x}$. In the next section (see the last paragraph), we provide a numerical example that concretely shows the cases in which $FI > 1$.

[24] See footnote 22 to check the corresponding mathematical expressions.

	Domestic production and Exports	FDI
Home market	− Profits of home firms ($m\tilde{x}$)	+ Tax revenue from foreign firms ($\tilde{n}_I\tilde{x}$)
Foreign market	+ Tax revenue from home firms ($\tilde{m}_E\tilde{y}^*$)	+ Profits of home firms ($2\tilde{m}_I\tilde{x}^*$)

Table 1: Channels of welfare effects in increasing the production tax. The symbols + and − represent the positive and negative effects, respectively. The mathematical expressions in parentheses are the related quantities used to measure the relative impacts of the welfare effects.

already producing in the foreign market are positive (under imperfect competition, the markup is $-P'x^* > 0$), this benefit ($-1/P' \times -P'x^* = \tilde{x}^*$) is also captured by the profits of $\tilde{m}_I$ home FDI firms ($\tilde{m}_I\tilde{x}^*$).[25] Thus, in the positive effect on the tax rate (the numerator), the unit benefit through the profits of FDI is double ($2\tilde{m}_I\tilde{x}^*$) that for the tax revenue effect related to exports ($\tilde{m}_E\tilde{y}^*$).

Table 1 summarizes how the effects of t influence the welfare of home country W. All the welfare effects presented here can be characterized by observable quantities (inside the parentheses). When we restrict our attention to supply through *domestic production and exports* other than FDI (second column), the government can protect the *profits* of home firms in the *home market* by decreasing t (second row) but earn the *tax revenue* from the home firms exporting to the *foreign market* by increasing t (third row). Thus, in the absence of FDI, the key trade-off is between these two welfare effects, as seen in the previous section. When we pay attention to supply through *FDI* (third column), by contrast, two effects exist: one is on the *tax revenue* in the *home market* (second row) and the other is on the *profits* of home firms in the *foreign market* (third row). In the home market, by increasing home tax t, tax revenue is also earned from foreign FDI firms. In the foreign market, by increasing t, the profit of home FDI firms receives the double benefit of an increase in prices and an increase in production, as mentioned earlier.[26]

[25] While such an increase in the production of the FDI firm decreases exports, the profits of exporting home firms are always zero under endogenous entry.

[26] This benefit is obtained because heterogeneous fixed costs ensure FDI firms earn positive profits. If the fixed costs of FDI firms are homogeneous, the model exhibits a bang-bang solution in which all firms select exports or FDI in the second stage. When all firms select exports, in the absence of FDI, the welfare effects are the two effects in the second column. Thus, the optimal tax rates are negative in the symmetric equilibrium. If all firms select FDI, without exports, no tax revenue can be obtained from the foreign market. Moreover, the profits of FDI firms are zero because of the homogeneous fixed costs. Thus, the welfare effects are the two effects in the second row, which appear in the home market. Since all n firms select FDI ($\tilde{n}_I = n$), the optimal tax rates are zero in the symmetric equilibrium ($m\tilde{x} = \tilde{n}_I\tilde{x}$).

5 Welfare analysis

In this section, we compare the non-cooperative tax rates analyzed thus far with the cooperative tax rates that maximize global welfare $W + W^*$, where

$$W^* = CS^*(X) + \sum_{i=1}^{n} \pi_i^* + \sum_{j=1}^{n_I} \pi_j + \sum_{k=1}^{n_E} \pi_k + t^* Y^*. \tag{39}$$

The FOC for maximizing global social welfare with respect to t is[27]

$$0 = \frac{\partial \tilde{W}}{\partial t} + \frac{\partial \tilde{W}^*}{\partial t}, \tag{40}$$

where $\partial \tilde{W}/\partial t$ is (35) and $\partial \tilde{W}^*/\partial t$ is obtained as follows. Differentiating the first term of (39) yields the effect on the foreign consumer surplus, which is given by

$$\frac{\partial CS^*}{\partial t} = \frac{\partial a(\tilde{X}^*)^2/2}{\partial t} = -\tilde{X}^* = -(n + \tilde{m}_I)\tilde{x}^* - \tilde{m}_E \tilde{y}^* < 0, \tag{41}$$

where we use (20). Because an increase in the home tax rate increases the price of goods X in the foreign market, this effect is negative. The second factor is the effect on the profits of foreign firms obtained from their domestic (foreign) market. Because the number of foreign firms that enter the foreign market is fixed, this effect is given by

$$n\frac{\partial \tilde{\pi}_i^*}{\partial t} = n\left\{ \frac{\partial \tilde{P}^*}{\partial t}\tilde{x}^* + (\tilde{P}^* - c - t^*)\frac{\partial \tilde{x}^*}{\partial t} \right\} = 2n\tilde{x}^* > 0, \tag{42}$$

which is positive. When inducing the last equality, we use (20), (22), and the FOC (8). Differentiating the third term of (39), the effect on the profits of foreign firms that enter the home market through FDI is given by

$$F'(\tilde{n}_I)\tilde{n}_I \frac{\partial \tilde{n}_I}{\partial t} = -2\tilde{n}_I \tilde{x} < 0, \tag{43}$$

which is negative. The equality is obtained from (29). In the absence of FDI, this factor does not appear. As for the fourth term of (39), the effect on the profits of foreign firms that enter the home market through exports is neutral because of the ZPC (12). The fifth factor is the effect on foreign tax revenue. Because an increase in the home tax rate raises production in the foreign country,[28] this effect is positive and given by

$$t^* \frac{\partial \tilde{Y}^*}{\partial t} > 0, \tag{44}$$

[27] We assume that the SOCs are satisfied in the relevant range.

[28] From (22), (30), (31), and Proposition 1 ($\partial \tilde{y}/dt = 0$), we have

$$\frac{\partial \tilde{Y}^*}{\partial t} = (n + \tilde{m}_I)\frac{\partial \tilde{x}^*}{\partial t} + \frac{\partial \tilde{m}_I}{\partial t}\tilde{x}^* + \tilde{n}_E \frac{\partial \tilde{y}}{dt} + \frac{\partial \tilde{n}_E}{\partial t}\tilde{y} > 0.$$

where $\tilde{Y}^* = (n + \tilde{m}_I)\tilde{x}^* + \tilde{n}_E\tilde{y}$ for the presence of FDI and $\tilde{Y}^* = n\tilde{x}^* + \tilde{n}_E\tilde{y}$ for the absence of FDI. Thus, the sum of these effects (41)–(44) yields

$$\frac{\partial \tilde{W}^*}{\partial t} = n\tilde{x}^* - \tilde{m}_I\tilde{x}^* - \tilde{m}_E\tilde{y}^* - 2\tilde{n}_I\tilde{x} + t^*\frac{\partial \tilde{Y}^*}{\partial t}, \tag{45}$$

where $\tilde{m}_I = \tilde{n}_I = 0$ in the absence of FDI.

Thus, in the symmetric equilibrium ($n\tilde{x}^* = m\tilde{x}$, $\tilde{m}_I\tilde{x}^* = \tilde{n}_I\tilde{x}$, and $\tilde{n}_I\tilde{x}^* = \tilde{m}_I\tilde{x}$), the condition (40) reduces to

$$0 = t\left(\frac{\partial \tilde{Y}}{\partial t} + \frac{\partial \tilde{Y}^*}{\partial t}\right).$$

This implies that the global optimal level of t must be zero.[29] By symmetry, we can describe the decision-making with respect to t^* analogously. Consequently, we obtain the following proposition in the models of both the absence and the presence of FDI.

Proposition 4 *In the symmetric interior market equilibrium, the global optimal (cooperative) tax rates are* $t = 0$ *and* $t^* = 0$.

The intuition for this result is as follows. The markets of goods X in both countries are imperfectly competitive. Thus, when considering global welfare, both tax rates should be negative (i.e., subsidies) because subsidies mitigate the distortion caused by imperfect competition by increasing total output. However, subsidies promote the entry of firms, which incurs fixed costs. The fixed cost payment results in a decline in global welfare. Proposition 4 reveals that the first tax-lowering effect and second tax-raising effect cancel out.

Combined with the results in Propositions 2 and 3, Proposition 4 implies that the tax rate of each country in the non-cooperative equilibrium is lower than the global optimal rate when FDI is not available, whereas it is higher than that if and only if $FI > 1$ when FDI is available. In other words, the equilibrium tax rate is excessively low (high) if and only if it is a subsidy (tax). Because the countries ignore the welfare effects on other countries, under strategic interdependence, the competition between them becomes excessively severe from the perspective of global welfare under both subsidy and tax competition.[30]

Numerical example To illustrate our results, we provide a numerical example for various values of m, as depicted in Figure **??**. The indicator FI at the symmetric equilibrium is over 1 when m is relatively small (i.e., relatively monopolistic before opening markets) and below

[29] $\partial\tilde{Y}/\partial t + \partial\tilde{Y}^*/\partial t$ is not zero even in the symmetric equilibrium because of (30) and (32).
[30] The tax rate is consistent with the optimal rate when $FI = 1$.

1 when m is relatively large (i.e., relatively competitive before opening markets). These cases correspond to the positive and negative equilibrium tax rates $\tilde{t}$, respectively. The less competitive the preceding domestic market is, the more foreign exporting firms can enter after the market is opened, and thus the price is more likely to be affected by the foreign tax rate. As a result, tax competition to capture FDI firms' profits and tax revenue from the foreign market becomes severe. The welfare loss compared with the global welfare-maximizing level is positive when $\tilde{t} > 0$ and $\tilde{t} < 0$ and is minimized and disappears when $FI = 1$. When $\tilde{t} > 0$, tax competition shrinks the market size and the price is higher than the global optimal level. On the contrary, when $\tilde{t} < 0$, subsidy competition enlarges the market size and the price falls below the global optimal level. This lower price deteriorates welfare because it is caused by the excess entries of subsidized exporting firms. Under global welfare, the subsidies given to exporting firms are canceled out by a portion of their entry costs because exporting firms enter the markets until their profits fall to zero. Therefore, the welfare loss caused by tax/subsidy competition is minimized when m is intermediate.

6 Further discussion and application

6.1 Countervailing Duty

The WTO prohibits export subsidies, but it does not prohibit the use of production subsidies. However, governments can impose a CVD that offsets the effects of trading partners' subsidies if (i) the production subsidy increases the exports of subsidized firms and (ii) the increased imports harm foreign firms. In our structure, (i) is satisfied since a decrease in t (an increase in the subsidy) increases $\tilde{m}_E \tilde{y}^*$ from (21) and (32). Further, (ii) is satisfied since it decreases $\sum_i \pi_i^*$ from (42). Thus, we next discuss how our welfare effects are modified under the CVD, finding that CVDs can make subsidy competition severer under mutual endogenous entry.

Let us consider the home country that imposes tax $-t^*$ on its imports y_k as a CVD when the foreign country provides subsidy $t^* \leq 0$. Tax revenue from this CVD, $-t^* \sum_{k=1}^{n_E} y_k$, should be additionally included in home country's welfare W. The foreign country also imposes tax $-t$ as a CVD in the same manner. Then, because the subsidies on imports are offset by the CVDs, the equilibrium outcomes in the home and foreign markets correspond to the case in which $t^* = 0$ and $t = 0$, respectively (e.g., $\tilde{x}(m, t, 0)$ and $\tilde{x}^*(m, 0, t^*)$ for a domestic firm's output). Thus, the

FOC for the home government is modified as

$$0 = \frac{\partial \tilde{W}}{\partial t} = F'(\tilde{m}_I)\tilde{m}_I \frac{\partial \tilde{m}_I}{\partial t} + \frac{\partial (m\tilde{\pi}_i)}{\partial t} + \frac{\partial (t\tilde{Y})}{\partial t} - t^* \frac{\partial (\tilde{n}_E \tilde{y})}{\partial t} \tag{46}$$

$$= -m\tilde{x} + \tilde{n}_I \tilde{x} + \tilde{m}_E \tilde{y}^* + t\frac{\partial \tilde{Y}}{\partial t} - t^* \tilde{y} \frac{\partial \tilde{n}_E}{\partial t}. \tag{47}$$

Under the CVDs, the equilibrium tax rate $\tilde{t}_C \leq 0$ must satisfy this.

Therefore, the welfare effects of t are modified by two channels. First, the positive effect through the profits of home FDI firms (the first term in the first line) vanishes because $\partial \tilde{m}_I(m, 0, t^*)/\partial t = 0$ under the foreign country's CVD. Second, the positive effect through the tax revenue gained by the home country's CVD appears because $\partial \tilde{n}_E(m, t, 0)/\partial t > 0$ from (30). Since these channels conflict, the imposition of CVDs does not always alleviate production subsidy competition.[31]

Proposition 5 *Under subsidy competition with CVDs, $\tilde{t}_C < \tilde{t}$ and $\tilde{t}^*_C < \tilde{t}^*$ can hold (i.e., both countries' equilibrium subsidy rates under CVDs can be higher than the equilibrium subsidy rates without CVDs).*

6.2 Emission tax

As an interesting application of our strategic production subsidy/tax, we can consider emission tax competition in the presence of exports and FDI. Let us consider that one unit of goods X emits one unit of pollution during production. We reinterpret t and t^* as the emission tax rates imposed by the home and foreign governments, respectively. Home and foreign environmental damage is given by $E = E(Y)$ and $E^* = E(Y^*)$, where $E' \geq 0, E'' \geq 0$. All the other setups are the same as in the previous sections.

Under this reinterpretation, all the analyses under market competition (see the second and third stages) are the same. However, under tax competition (first stage), because environmental damage is included in W, the FOC for the home government (35) is modified as

$$0 = \partial \tilde{W}/\partial t = 2\tilde{m}_I \tilde{x}^* - m\tilde{x} + \tilde{n}_I \tilde{x} + \tilde{m}_E \tilde{y}^* + (t - E'(\tilde{Y}))\frac{\partial \tilde{Y}}{\partial t}.$$

[31] For example, consider the case in which $\tilde{t} = \tilde{t}^* = 0$ without CVDs. Then, (35) implies that the expression (47) equals $-2\tilde{m}_I \tilde{x}^* < 0$ for $t = t^* = 0$; in other words, a marginal decrease in t (a marginal increase in the production subsidy) increases their own welfare when CVDs are imposed. Thus, if the SOCs are globally met, the symmetric interior equilibrium tax rate $\tilde{t}_C = \tilde{t}^*_C$ must be subject to CVDs, and solving (47) with respect to $t = t^*$, this satisfies

$$\tilde{t}_C = \frac{(m\tilde{x} - \tilde{n}_I \tilde{x}) - \tilde{m}_E \tilde{y}^*}{\partial \tilde{Y}/\partial t - \tilde{y}\partial \tilde{n}_E/\partial t} < 0,$$

which is smaller than $\tilde{t} = 0$ (i.e., the CVDs yield the production subsidy).

The additional term $-E'(\partial\tilde{Y}/\partial t) \geq 0$ represents the effect of environmental damage. Accordingly, the condition (36) is modified as

$$\tilde{t} - E'(\tilde{Y}) = \frac{(m\tilde{x} - \tilde{n}_I\tilde{x}) - (\tilde{m}_E\tilde{y}^* + 2\tilde{m}_I\tilde{x}^*)}{\partial\tilde{Y}/\partial t},$$

where $\tilde{m}_I = \tilde{n}_I = 0$ in the absence of FDI. Thus, as analogs of Propositions 2 and 3, we obtain the following propositions on the equilibrium (first-stage) emission tax rate $(\tilde{t}, \tilde{t}^*)$.

Proposition 6 *Under emission tax competition in the absence/presence of FDI, $\tilde{t} > E'$ ($\tilde{t}^* > E'$) holds if and only if $EI > 1$ ($EI^* > 1$)/$FI > 1$ ($FI^* > 1$) in the equilibrium. Thus, in the symmetric interior equilibrium, both countries' emission tax rates must be lower/can be higher than the marginal environmental damage.*

Regarding the welfare analysis, since $\partial\tilde{W}^*/\partial t$ also includes the additional factor $-E'(\partial\tilde{Y}^*/\partial t) \leq 0$ related to foreign environmental damage, we obtain the following analog of Proposition 4.

Proposition 7 *In the symmetric interior market equilibrium, the global optimal (cooperative) tax rates are $t = E'$ and $t^* = E'$.*

The cooperative tax rates should be the marginal environmental damage, and the cases in which the non-cooperative tax rates are lower or higher than this respectively correspond to the subsidy and tax cases in the previous sections, which are analyzed without introducing environmental damage ($E = 0$). In particular, the non-cooperative emission tax rate may necessarily be higher than the marginal environmental damage in the presence of FDI. Studies have shown that when applying strategic trade policy to environmental issues, non-cooperative environmental policies are likely to be laxer than the optimum.[32] Thus, our results here contribute to this field by clarifying the conditions under which the opposite relationship holds under mutual endogenous entry.

7 Concluding remarks

Considering rapid foreign penetration after opening markets, this study investigated tax competition by imposing a subsidy/tax on domestic production between two symmetric countries.

[32]For a model with fixed numbers of firms, Kennedy (1994) assumes a two-country model as we do and shows that a government's incentive to lower the emission tax (rent-capturing effect) basically dominates the opposite effect (pollution-shifting effect). For a model with endogenous numbers of firms, Bayindir-Upmann (2003) assumes a third-market model and examines a situation under free entry in one of two countries, showing that non-cooperative emission tax rates are lower than cooperative emission tax rates. Kayalica and Lahiri (2005) also examine environmental standards under a third-market model. In their model, one of two exporting countries is a host country of FDI from outside these two countries. Then, they demonstrate that when the number of FDI firms is endogenously determined, the host country's environmental standards are laxer than those in the other country.

When domestic incumbents face the free entry of the other country's firms in each country's market, the strategic interdependence under tax competition caused by this mutual endogenous entry works in a clear-cut way: the production subsidy/tax in the domestic market does not influence the domestic market price, whereas it does affect the other country's market price. Governments thus have an incentive to subsidize the production of domestic firms to protect their profits—even under the endogenous entry of foreign firms. They also have several incentives to tax domestic production related to the profit through FDI and tax revenue from home and foreign markets.

We showed that in the absence of FDI, the equilibrium tax rate is always negative (i.e., a subsidy) in the symmetric interior case. By contrast, in the presence of FDI, the tax rate is positive (i.e., a tax) if and only if $FI > 1$. From the perspective of global welfare, the equilibrium tax rate is excessively low when the equilibrium tax rate is negative (i.e., a subsidy) and excessively high when it is positive (i.e., a tax). Therefore, the presence of FDI does not always alleviate subsidy competition; rather, it accelerates tax competition when $FI > 1$. For the past several decades, trade volumes and FDI have been increasing constantly globally. In this respect, it can be said that the possibility that $FI > 1$ holds has been increasing.

In this study, we assumed that the production cost (c) does not contribute to welfare. However, for example, Kayalica and Lahiri (2005) assume unemployment and that production costs are input costs. Accordingly, those input costs are included in welfare as income. This assumption is important when considering that many countries encourage inward direct investment partly because of job creation in the real world. However, even if we assume that a proportion of the production cost in our model is included in welfare as income, the results do not change.

Moreover, with regard to the flexibility of entry/exit decision-making, we made the extreme assumptions that the number of home firms is exogenous (i.e., the difference in their fixed entry costs between incumbents and potential entrants is infinity) and that the difference of that among exporting firms is zero. In future work, it would be important to generalize the flexibility of entry/exit decisions by introducing non-extreme differences in the fixed costs for home firms and exporting foreign firms as well as FDI firms. If the difference among home (exporting) firms is higher (lower) than that in the case of FDI, the results will remain robust.

References

[1] Bayindir-Upmann, T. Strategic environmental policy under free entry of firms. *Review of International Economics*, 11(2):379-396, 2003.

[2] Brander, J.A. and Spencer, B. Export Subsidies and Market Share Rivalry. *Journal of International Economics*, 18(1):83–100, 1985.

[3] Cheng, L. K. Assisting domestic industries under international oligopoly: The relevance of the nature of competition to optimal policies. *The American economic review*, 78(4):746–758, 1988.

[4] F. Etro. *Competition, innovation, and antitrust: a theory of market leaders and its policy implications*. Springer, New York, 2007.

[5] F. Etro. Endogenous market structures and strategic trade policy. *International Economic Review*, 52(1):63–84, 2011.

[6] F. Etro. Optimal trade policy under endogenous foreign entry. *Economic Record*, 90(290):282–300, 2014.

[7] H. Ino and T. Matsumura. How many firms should be leaders? Beneficial concentration revisited. *International Economic Review*, 53(4):1323–1340, 2012.

[8] H. Ino and A. Miyaoka. Government-induced Production Commitment in the Open Economy. *DISCUSSION PAPER SERIES*, Kwansei Gakuin University, No.142, 2016.

[9] Keen, M. and Ligthart, J. E. Coordinating tariff reduction and domestic tax reform under imperfect competition. *Review of International Economics*, 13:385–390, 2005.

[10] Kennedy, P. W. Equilibrium pollution taxes in open economies with imperfect competition. *Journal of Environmental Economics and Management* 27, 49-63, 1994.

[11] M.Ö. Kayalica and S. Lahiri. Strategic environmental policies in the presence of foreign direct investment. *Environmental and Resource Economics*, 30: 1–21, 2005.

[12] M.Ö. Kayalica and S. Lahiri. Domestic lobbying and foreign direct investment. The role of policy instruments. *Journal of International Trade & Economic Development*, 16(3):299–323, 2007.

[13] S. Lahiri and Y. Ono. Foreign direct investment, local content requirement, and profit taxation. *Economic Journal*, 108(447):444–457, 1998.

[14] J. Markusen and F. Stähler. Endogenous market structure and foreign market entry. *Review of World Economics*, 147(2):195–215, 2011.

[15] Smith, A. Strategic investment, multinational corporations and trade policy. *European Economic Review*, 31:89–96, 1987.

[16] F. Stähler and T. Upmann. Market entry regulation and international competition. *Review of International Economics*, 16(4):611–626, 2008.

[17] A.J. Venables. Trade and trade policy with imperfect competition: the case of identical products and free entry. *Journal of International Economics*, 19(1):1–19, 1985.

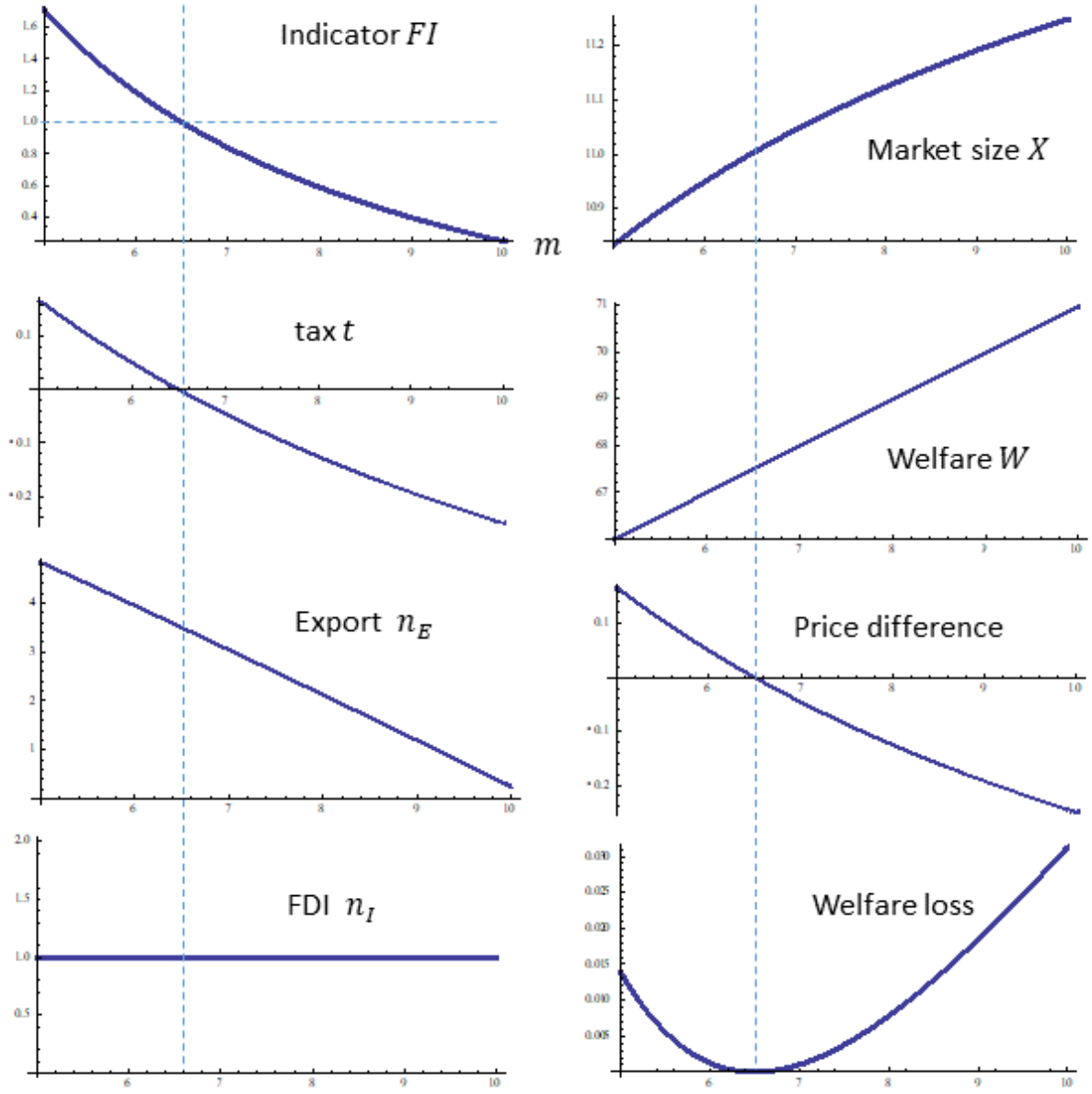

Figure 1: Equilibrium outcomes that is simulated in the case where $A = 12, a = 1, f = 1, F(j) = j, C = c = 0$ for various m (horizontal axis). The 1st graph depicts the indicator FI at the symmetric equilibrium. Then, in order, the graphs depict $\tilde{t}$, $\tilde{n}_E(m, \tilde{\mathbf{t}})$, $\tilde{n}_I(m, \tilde{\mathbf{t}})$, $\tilde{X}(m, \tilde{\mathbf{t}})$, and $\tilde{W}(m, \tilde{\mathbf{t}})$. The 2nd last and the last graphs depicts the difference between the equilibrium (incorporate) and the global welfare-maximizing (corporate) levels of price and welfare, respectively.