

FDI Subsidies in a General Oligopolistic Equilibrium Model

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June 14, 2023

Abstract

We employ a general oligopolistic equilibrium model to analyze the welfare effect of FDI subsidies. Specifically, firms in the exporting industry produce under oligopolistic competition while a firm in the FDI industry produces under monopoly. We consider the welfare impact of the subsidies under different financing sources such as a labor income tax and a consumption tax. The results indicate that a small subsidy financed by consumption taxes may improve welfare. The reason is that small subsidies financed by labor income taxes do not affect the wage, and thus do not alter any other economic variables. On the other hand, small subsidies financed by consumption taxes influence the demand and supply condition, which subsequently decreases the wage. This reduction in the wage can improve welfare.

Keywords: FDI; subsidy; welfare analysis; general oligopolistic equilibrium

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1 Introduction

According to a report by UNCTAD (2022), the amount of FDI in 2021 was approximately 1.6 trillion dollars, which indicates a 64% increase compared to the previous year. FDI, which decreased during the COVID-19 pandemic, is now showing a tendency to increase again. Inducing multinational enterprises (MNEs) can generally bring direct benefits to host countries by lowering the prices of goods they supply through the transfer of production, which saves transportation costs across borders, and labor costs in the host country (when the host country has low wages). Moreover, foreign capital and job creation brought about by MNEs are evaluated as benefits for the host country's interests. The policymakers have thus been open to the foreign affiliates of MNEs. Countries that hold positive views towards FDI are attempting to attract FDI through incentive measures, such as tax breaks, employment promotion subsidies, and construction of industrial facilities. In fact, these measures affect the MNE's behavior.

A concrete example can be seen in the provision of subsidies to the semiconductor industry. In Japan, the "5G Promotion Act," which includes subsidies for the semiconductor industry, was implemented in 2022. As a result, Taiwan Semiconductor Manufacturing Company (TSMC) began constructing a plant in Kumamoto, subsidized with 476 billion yen, while Micron Technology announced the construction of a plant in Hiroshima in 2022. In 2023, Samsung Electronics announced its plan to establish a factory in Yokohama, with an estimated subsidy amount ranging between 10 and 15 billion yen. In the United States, the "CHIPS Act," which incorporates subsidies for the semiconductor industry, was proposed in 2020 and passed in 2022. In response to this expectation, TSMC announced its expansion into Arizona in 2020, and Samsung Electronics revealed its plan to build a plant in Texas in 2021. (The amount of subsidies for these companies is currently under adjustment.)

Therefore, government subsidies for semiconductor manufacturers are regarded as an important factor in investment decision-making.¹ However, it cannot be immediately asserted that policies aimed at attracting FDI necessarily enhance the welfare of the host country.² In the end, it is

¹Host countries' policies on FDI by overseas firms are debatable. For instance, Wells *et al.* (2001) demonstrate that a elimination of tax incentives for foreign firms does not have a correlation with the inflow of FDI into host countries. On the other hand, Lim (2008) reveals that the establishment of a investment promotion agency (IPA) in a host country leads to an increase in FDI inflows.

²The positive effect of FDI on the host country's economy is not clear, and further discussion is necessary. For example, Alfaro *et al.* (2004) demonstrate that FDI contributes to the host country's economic growth when the financial market in the host country is developed. On the other hand, Borensztein *et al.* (1998) and Carkovic and Levine (2005) reveal that FDI does not have an impact on the host country's economic growth.

necessary to compare the benefits brought by the presence of MNEs attracted by subsidies with the fiscal costs incurred to provide such subsidies.

In developed countries, taxes used for economic policies such as subsidies for FDI are often financed through labor income taxes. This is because governments in developed countries can collect the tax income easily. Tanzi and Zee (2000) point out that labor income taxes are generally less distortionary than other taxes. However, even in developed countries, there are cases where governments struggle to collect income taxes. According to OECD Revenue Statistics, income taxes account for a very small percentage of the total tax revenue in Chile and Colombia (approximately 10.8% for Chile and 6.7% for Colombia) in 2021. The main source of tax revenue in these two countries is consumption tax, accounting for about 50% of total tax revenue. Regarding less developed countries such as China, Indonesia, Thailand, and Vietnam, the proportion of income tax to total tax revenue is low, at 5.6%, 10.8%, 11.3%, and 8.0% respectively. On the other hand, the proportion of consumption tax to total tax revenue in these countries is high, with figures of 41.6%, 42.6%, 57.1%, and 42.6% respectively. Thus, the consumption tax can be used for economic policies such as FDI subsidies.

The above discussion raises a question of how the different financing sources of subsidies towards FDI affect welfare. More specifically, the question arises as to how the welfare effects of providing FDI subsidies for "fixed costs" to attract the foreign monopoly firm such as TSMC would vary depending on the financing source of the FDI subsidies.

To answer this question, we utilize a general oligopolistic equilibrium (GOLE) model developed by a series of papers by J. Peter Neary.³ The GOLE model aims to incorporate general equilibrium into oligopoly models. In the construction process of the model, it assumes that firms have significant market power within the industry or sector they operate in but are small economic players in the overall economy. Therefore, the GOLE model enables the analysis of the crucially important effects of market power in a global context. This aspect describes the real economy. Over the past four decades, there has been a significant increase in the proportion of pure profits in gross value added, accompanied by a substantial decline in the share of labor. The results of Autor *et al.* (2017), Autor *et al.* (2020), and De Loecker *et al.* (2020) suggest that this trend may be driven by a rise in industry concentration. Consequently, the modeling of strategic interactions among large firms has become increasingly important.⁴

³See Neary (2003a), Neary (2003b), Neary (2007), Eckel and Neary (2010), Neary (2010), and Neary (2016).

⁴The literature using a GOLE model has been expanding. See Bastos and Kreickemeier (2009), Egger and Etzel

We construct a model assuming two symmetric countries (Home and Foreign) with the presence of an export industry, a Home FDI industry, and a Foreign FDI industry using the fundamental GOLE model developed by Neary (2016). In the export industry, Home and Foreign firms produce under oligopolistic competition. In the Home FDI industry, only the Home monopolistic firm produces, and in the Foreign FDI industry, only the Foreign monopolistic firm produces. To produce goods, we assume the labor coefficients of the export industry and the FDI industries are different. Furthermore, we assume the labor coefficients of the Home and Foreign FDI industries are same. We consider the situation where the Home government provides small subsidies for fixed costs for the Foreign monopolistic FDI firm. In addition, the Foreign government provides those for the Home monopolistic FDI firm due to the symmetric assumption. The results show that the small subsidies financed by consumption taxes can improve welfare.

As for the welfare impact of FDI subsidies financed by labor income taxes, the result indicates that such subsidies do not affect welfare because labor income taxes do not create distortions in consumption, and subsidies do not affect the production level of firms. Thus, the wage and prices of goods remain unchanged, and subsidies have no effect on welfare.

Regarding the welfare effect of FDI subsidies financed by consumption taxes, the result suggests that such subsidies can improve welfare. Similar to the labor income tax case, subsidies do not affect the production level of firms directly, but through consumption taxes, it distorts demand and supply. This negative shock affects the labor market, resulting in a decrease in the wage when the government provides a small subsidy. The wage reduction leads to lower producer prices. On the other hand, consumer prices (producer prices plus consumption taxes) of exporting industries increase, while those of domestic and foreign FDI industries decrease. Assuming the labor coefficient of the exporting industry is larger than that of FDI industries, welfare tends to improve when the difference between the former and the latter is positive. Specifically, welfare tends to increase when trade costs are high, fixed costs of FDI are large, and the FDI industry's labor coefficient is high enough. When trade costs are high, producer prices of exporting industries increase while those of FDI industries decrease. When fixed costs of FDI become large, the wage level becomes higher, resulting in a larger negative shock on production in the exporting industry than in FDI industries due to the labor coefficient relationship of both industries. When the FDI labor coefficient is large enough, the response to wage changes becomes larger, resulting in a

(2012), Fujiwara (2017), and Beladi and Chakrabarti (2019).

negative shock induced by wage reduction on producer prices of FDI that is significant. Thus, the difference tends to become positive in these cases.

This paper contributes to a vast literature on the welfare effects of FDI subsidies, providing the first attempt (to the best of my knowledge) at applying a framework with GOLE to this policy issue. The model has the advantage of allowing for a precise description of monopolistic FDI firms behavior with subsidies. Comparing welfare effects of fixed cost subsidies financed by labor income taxes with consumption taxes is a natural question to investigate with this model, yet it is an under-explored issue.

This paper is closely related to Fujiwara (2017), Chor (2009), and Han *et al.* (2023). Fujiwara (2017) analyzes the welfare effects of trade liberalization and FDI liberalization in an economy where both export and FDI industries coexist, using the GOLE model. The result shows that FDI liberalization always improves welfare. Different from this paper, he assumes firms in both industries produce under oligopolistic competition. In addition, he does not analyze the effects of subsidies. Chor (2009) constructs the model with heterogeneous firms based on Helpman *et al.* (2004) to assess the welfare effects of FDI subsidies for both fixed and variable costs financed by lump-sum labor income taxes. He shows that a small FDI subsidy always improves welfare because when the amount of subsidy is small, the benefits derived from the selection effect (moving from export to FDI) outweigh the fiscal costs. Han *et al.* (2023) extends the model presented by Chor (2009). They compare the welfare effects of variable costs subsidies for FDI financed by labor income taxes with consumption taxes and corporate income taxes. They reveal that subsidies financed by labor income taxes has always better impacts on welfare than both consumption and corporate income taxes. This result stems from the existence of distortion by both taxes because the distortion has the additional negative effects on demand and supply. In contrast to their papers, we assume monopolistic FDI firms and compare the welfare effects of fixed costs FDI subsidies financed by labor income taxes and consumption taxes. In addition, we analyze the welfare effects under general equilibrium model.⁵

The remaining parts of the paper are as follows. Section 2 describes the basic model. Section 3 examines the welfare effect of subsidies for fixed costs financed by labor income taxes. Section 4 analyzes the welfare effect of subsidies for fixed costs financed by consumption taxes. Section 5 concludes.

⁵See Haaland and Wooton (1999), Fumagalli (2003), Skaksen (2005), and Pennings (2005) for other literature on the welfare effect of FDI subsidies.

2 Basic Model

2.1 Demand

Our model is based on Neary (2016). There are two identical countries (Home and Foreign) that consist of duopolistic and monopoly industries in a unit interval $[0, 1]$. The representative consumer in Home has a following continuum-quadratic preference:

$$U[q^H(z)] = \int_0^1 \left\{ aq^H(z) - \frac{[q^H(z)]^2}{2} \right\} dz. \quad (1)$$

The representative consumer maximizes the utility subject to the budget constraint:

$$\int_0^1 p^H(z)q^H(z)dz \leq Y \quad (2)$$

where Y is consumer income. Solving the utility maximization problem gives the first order condition as follow:

$$a - q^H(z) = \lambda p^H(z)$$

where λ is the Lagrangean multiplier and the marginal utility of income. Following Neary (2016), firms are assumed to have market power in their product markets, but they have little influence on the whole economy. Thus, we set $\lambda = 1$. The demand function becomes:

$$q^H(z) = a - p^H(z) \quad (3)$$

Substituting the demand function in (3) into the utility function in (1) yields the indirect utility function:

$$V^H = \frac{a - \sigma_2^H}{2} \quad \text{where} \quad \sigma_2^H = \int_0^1 [p^H(z)]^2 dz. \quad (4)$$

This expression is the convenient way to evaluate consumer welfare because the indirect utility only depends on the second moment of prices.

2.2 Supply

The producers maximize their profits. There is a set of exporting industry $X \in [2z^*, 1]$ in the economy. Firms in exporting industries compete under oligopoly. In addition, the economy consists of a set of Home FDI industry $I \in [0, z^*]$ and a set of Foreign FDI industry $I \in [z^*, 2z^*]$. In these FDI industries, the firms compete under monopoly. In each industry, firms produce homogeneous goods. With assumptions of market segmentation and the oligopoly in the exporting industry, the inverse demand functions for exporting goods in Home and Foreign are:

$$p_X^H = a - q_X^{HH} - q_X^{FH} \quad (5)$$

$$p_X^F = a - q_X^{FF} - q_X^{HF} \quad (6)$$

where q^{HH} is Home firm's good for Home, q^{FH} is Foreign firm's good for Home, q^{FF} is Foreign firm's good for Foreign, and q^{HF} is Home firm's good for Foreign.

In FDI industries, Home and Foreign firms produce for both their own countries and the other countries under monopoly in each country. The inverse demand functions in Home become:

$$p_I^{HH} = a - q_I^{HH}, \quad p_I^{FH} = a - q_I^{FH}. \quad (7)$$

The inverse demand functions in Foreign become:

$$p_I^{FF} = a - q_I^{FF}, \quad p_I^{HF} = a - q_I^{HF}. \quad (8)$$

Regarding the production technology, constant marginal labor input for the exporting industry is α_X and it for Home and Foreign FDI industries is α_I . Firms in the exporting industry incur specific trade costs, τ , to serve the other countries. Firms in the FDI industries have to pay the fixed unit of labor, f , for constructing an additional plant. We further assume that fixed costs of FDI have to be payed by labor in a host country. Taking these assumptions into account, profit functions of Home exporting and FDI firms become:

$$\pi_X^H = p_X^H q_X^{HH} + p_X^F q_X^{HF} - w\alpha_X(q_X^{HH} + q_X^{HF}) - \tau q_X^{HF} \quad (9)$$

$$\pi_I^H = p_I^{HH} q_I^{HH} + p_I^{HF} q_I^{HF} - w\alpha_I(q_I^{HH} + q_I^{HF}) - wf, \quad (10)$$

where w is the wage in Home, which is same level as in Foreign due to symmetric assumption. Naturally, the foreign firms' profit is determined analogously. In the exporting industry, the firms produce goods under a Cournot competition. Using (5) and (6), first order conditions of Home exporting firm become:

$$a - w\alpha_X - 2q_X^{HH} - q_X^{FH} = 0, \quad a - w\alpha_X - 2q_X^{HF} - q_X^{FF} - \tau = 0.$$

The symmetric assumption for two countries leads relationships, $q_X^{HH} = q_X^{FF}$ and $q_X^{HF} = q_X^{FH}$. Solving these equations, the Cournot equilibrium outputs become:

$$q_X^{HH} = \frac{a - w\alpha_X + \tau}{3}, \quad q_X^{HF} = \frac{a - w\alpha_X - 2\tau}{3}. \quad (11)$$

A firms in the Home FDI industry produces goods under monopoly in each market, thus the monopoly equilibrium outputs from first order conditions become:

$$q_I^{HH} = \frac{a - w\alpha_I}{2}, \quad q_I^{HF} = \frac{a - w\alpha_I}{2}. \quad (12)$$

Again, due to the assumption of the identical countries, the outputs of the Foreign FDI firm become: $q_I^{HH} = q_I^{FF}$ and $q_I^{HF} = q_I^{FH}$.

2.3 Labor market equilibrium

In GOLE model, the wage is endogenously determined. To close the model, we need the one further condition. In each country, labor supplies L units of inelastic labor supply. This labor supply must be equal to labor demand. The labor market clearing condition of Home is:

$$\begin{aligned} L &= \int_0^{z^*} \alpha_I q_I^{HH} dI + \int_{z^*}^{2z^*} (\alpha_I q_I^{FH} + f) dI + \int_{2z^*}^1 \alpha_X (q_X^{HH} + q_X^{HF}) dX \\ &= \frac{2z^* a \alpha_I - 2z^* \alpha_I^2 w + 2z^* f}{2} + \frac{2(1 - 2z^*) a \alpha_X - (1 - 2z^*) \tau \alpha_X - 2(1 - 2z^*) \alpha_X^2 w}{3} \end{aligned} \quad (13)$$

Solving the above labor market clearing condition gives the endogenous wage as follow:

$$w = \frac{[2(1 - 2z^*) \alpha_X + 3z^* \alpha_I] a - (1 - 2z^*) \alpha_X \tau - 3(L - z^* f)}{2(1 - 2z^*) \alpha_X^2 + 3z^* \alpha_I^2}. \quad (14)$$

From the equilibrium wage, we can establish the following lemma:

Lemma 1. *Trade costs negatively affect the wage and fixed costs positively affect it.*

Proof. See Appendix. □

The intuition of this lemma is as follows. If the trade costs decline, the total outputs of the Home exporting firms, $q_X^{HH} + q_X^{HF}$, increase. This increase in the outputs results in the more labor demand and the higher wage in Home. Thus, the trade costs negatively affect the wage. On the other hand, if the fixed costs decrease, the outputs of Home and Foreign FDI firms for the Home consumer, q_I^{HH} and q_I^{FH} , do not change. However, the reduction in fixed costs decreases the labor demand directly and the wage declines in Home. Therefore, the fixed costs positively affect the wage.

2.4 General equilibrium

Here, we derive the general equilibrium outputs and prices explicitly. Substituting (14) into (11), We can yield the general equilibrium outputs of a Home firm in the exporting industry as follows:

$$q_X^{HH} = \frac{-z^* \alpha_I (\alpha_X - \alpha_I) a + [(1 - 2z^*) \alpha_X^2 + z^* \alpha_I^2] \tau + \alpha_X (L - z^* f)}{2(1 - 2z^*) \alpha_X^2 + 3z^* \alpha_I^2} \quad (15)$$

$$q_X^{HF} = \frac{-z^* \alpha_I (\alpha_X - \alpha_I) a - [(1 - 2z^*) \alpha_X^2 + 2z^* \alpha_I^2] \tau + \alpha_X (L - z^* f)}{2(1 - 2z^*) \alpha_X^2 + 3z^* \alpha_I^2}. \quad (16)$$

Using (15) and (16), a general equilibrium price of the Home exporting industry becomes:

$$p_X^H = \frac{[2(1 - 2z^*) \alpha_X^2 + 2z^* \alpha_X \alpha_I + z^* \alpha_I^2] a + z^* \alpha_I^2 \tau - 2\alpha_X [L - z^* f]}{2(1 - 2z^*) \alpha_X^2 + 3z^* \alpha_I^2}. \quad (17)$$

We obtain the following lemma immediately.

Lemma 2. *Both trade costs and fixed costs of FDI positively affect the general equilibrium price of the Home exporting industry.*

Proof. See Appendix. □

The intuition of this lemma can be interpreted as follows. When there is a reduction in trade costs, the marginal costs of the Home exporting firm, denoted as $w\alpha_X + \tau$ in (9), decrease. Additionally, Lemma 1 suggests an additional effect resulting from the wage reduction caused by

the reduction in trade costs. This effect contributes positively to the marginal costs. There are conflicting effects on the price, but the former effect (the decrease in marginal costs) outweighs the latter effect. Consequently, the reduction in trade costs leads to a decline in both the marginal costs and the exporting price. On the other hand, the decrease in fixed costs of FDI only affects the marginal costs negatively, due to the wage reduction explained in Lemma 1. Therefore, as the fixed costs of FDI decrease, the price of the exporting industry also decreases.

Substituting (14) into (12), we get the general equilibrium outputs of a Home FDI firms as follow:

$$q_I^{HH} = q_I^{HF} = \frac{2(1 - 2z^*)\alpha_X(\alpha_X - \alpha_I)a + (1 - 2z^*)\alpha_X\alpha_I\tau + 3\alpha_I[L - z^*f]}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \quad (18)$$

Using (18) and the symmetric assumption, general equilibrium prices of goods supplied by the Home and Foreign FDI firms in Home become:

$$p_I^{HH} = p_I^{FH} = \frac{[2(1 - 2z^*)\alpha_X^2 + 2(1 - 2z^*)\alpha_X\alpha_I + 6z^*\alpha_I^2]a - (1 - 2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^*f]}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \quad (19)$$

From the general equilibrium FDI prices, we yield the following lemma:

Lemma 3. *Trade costs negatively affect the general equilibrium prices of the Home and Foreign FDI firms in Home but fixed costs of the FDI firm positively affect them.*

Proof. See Appendix. □

The intuition of this lemma can be summarized as follows. When trade costs decrease, the marginal costs of the FDI firm, denoted as $w\alpha_I$, increase. This is because trade costs have a negative impact on the wage, as shown in Lemma 1. As a result, the equilibrium prices of the FDI firms in Home increase due to the reduction in trade costs. On the other hand, it is already established that a reduction in fixed costs has a positive effect on the wage. Therefore, when the fixed costs of FDI decrease, the equilibrium prices of the FDI firms become lower.

3 Subsidies financed by labor income taxes

In this section, we show how small FDI subsidies financed by labor income taxes affect welfare in Home. Labor income taxes change the budget constraint in (2) as follow:

$$\int_0^1 p^H(z)q^H(z)dz \leq (1-t)Y$$

This new budget constraint has no effect on the consumer behavior. Thus, the demand function under labor income taxes is same as (3).

Subsidies for fixed costs of FDI change the profit function of a Home FDI firms in (10) as follows:

$$\hat{\pi}_I^H = p_I^{HH}q_I^{HH} + p_I^{HF}q_I^{HF} - w\alpha_I(q_I^{HH} + q_I^{HF}) - w(1 - s_{lit})f, \quad (20)$$

where s_{lit} is subsidies financed by labor income taxes. Profit functions of the Home FDI firm with the fixed costs subsidies do not change the firm behavior. Therefore, the outputs of the Home FDI firm is same as (12). With these conditions, we next consider a Home government's budget condition.

3.1 Budget Neutral under labor income taxes

We assume that the Home government uses all revenues from labor income taxes for subsidies for the Foreign FDI firm. Using (9) and (20), the Home government's revenue from the labor income taxes in Home is given as:

$$tY = t\left(\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI + wL\right).$$

The Home government's spending for the Foreign FDI becomes:

$$\bar{s} \int_0^{z^*} wf dI = z^* s_{lit} wf.$$

Budget neutral conditions leads the relationship of t and s_{lit} as follow:

$$\begin{aligned} t &= \frac{z^* s_{lit} w f}{\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI + wL} \\ &= \frac{z^* s_{lit} w f}{\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \pi_I^H dI + wL + z^* s_{lit} w f}. \end{aligned} \quad (21)$$

Differentiating (21) with respect to s_{lit} around $s_{lit} = 0$, we have:

$$\left. \frac{\partial t}{\partial s_{lit}} \right|_{s_{lit}=0} = \frac{z^* w f \left(\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \pi_I^H dI + wL \right)}{\left(\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \pi_I^H dI + wL \right)^2} = \frac{z^* w f}{\int_{2z^*}^1 \pi_X^H dX + \int_0^{z^*} \pi_I^H dI + wL} > 0.$$

Naturally, this relationship means that the government has to impose heavy taxes if the government spending increases. In the next subsection, we consider welfare effects of subsidies in the Home country.

3.2 Welfare analysis with labor income taxes

An indirect utility function in (4) can be explicitly rewritten as:

$$V^H = \frac{a - \int_0^{z^*} [p_I^{HH}(z)]^2 dI - \int_{z^*}^{2z^*} [p_I^{FH}(z)]^2 dI - \int_{2z^*}^1 [p_X^H(z)]^2 dX}{2}. \quad (22)$$

As we discussed, the demand and supply are same as the case where subsidies do not exist. Thus, the indirect utility function does not consist of either subsidies or labor income taxes. If we differentiate the indirect utility function with respect to subsidies financed by labor income taxes around $s_{lit} = 0$, we have:

$$\left. \frac{\partial V^H}{\partial s_{lit}} \right|_{s_{lit}=0} = 0. \quad (23)$$

We immediately establish the following proposition.

Proposition 1. *Small subsidies financed by labor income taxes have no effects on welfare.*

The intuition of this result is straightforward. In the GOLE model, the welfare change occurs through the wage change. Under small subsidies financed by the labor income taxes, both factors do not affect the demand and supply. In the end, these stable factors which do not affect the labor

market have the same wage rate whether subsidies exist or not. Therefore, small subsidies do not have any effect on welfare.

4 Subsidies financed by consumption taxes

In this section, we analyse how small subsidies financed by consumption taxes affect Home welfare. To facilitate the welfare analysis, we assume that consumption taxes are the specific form.⁶ In addition, we give the upper bar any economic variables with subsidies which are different from the basic model.

4.1 Demand under consumption taxes

The utility maximization problem of the Home representative consumer with consumption taxes becomes:

$$U[\bar{q}^H(z)] = \int_0^1 \left\{ a\bar{q}^H(z) - \frac{[\bar{q}^H(z)]^2}{2} \right\} dz \quad \text{s.t.} \quad \int_0^1 [\bar{p}^H(z) + t]\bar{q}^H(z) dz \leq \bar{Y}.$$

With this budget constraint, the demand function becomes:

$$\bar{q}^H(z) = a - t - \bar{p}^H(z). \tag{24}$$

Naturally, the demand decreases in consumption taxes. Substituting (24) into utility function, we have:

$$\bar{V}^H = \frac{a - \bar{\sigma}_H^2}{2} \quad \text{where} \quad \bar{\sigma}_H^2 = \int_0^1 [\bar{p}^H(z) + t]^2 dz \tag{25}$$

With consumption taxes, the indirect utility depends on the second moment of consumer prices (producer prices plus consumption taxes).

⁶Consumption taxes are the normally a value-added way. However, we cannot solve the model with value-added consumption taxes. Thus, we apply specific consumption taxes.

4.2 Supply under consumption taxes

From (24), the producers face the inverse demand function under consumption taxes as follow:

$$\bar{p}^H(z) = a - t - \bar{q}^H(z). \quad (26)$$

As we discussed in the previous section, subsidies for FDI fixed costs change the profit function of the Home FDI firm but do not affect the profit function of the Home exporting firms. The profit functions of each mode with subsidies financed by consumption taxes become:

$$\bar{\pi}_X^H = \bar{p}_X^H \bar{q}_X^{HH} + \bar{p}_X^F \bar{q}_X^{HF} - \bar{w} \alpha_X [\bar{q}_X^{HH} + \bar{q}_X^{HF}] - \tau \bar{q}_X^{HF}, \quad (27)$$

$$\bar{\pi}_I^H = \bar{p}_I^{HH} \bar{q}_I^{HH} + \bar{p}_I^{HF} \bar{q}_I^{HF} - \bar{w} \alpha_I [\bar{q}_I^{HH} + \bar{q}_I^{HF}] - (1 - s_{ct}) \bar{w} f, \quad (28)$$

where s_{ct} is subsidies financed by consumption taxes. In the same procedure as in Section 2, the Cournot equilibrium outputs of the Home exporting firm become:

$$\bar{q}_X^{HH} = \frac{a - t - \bar{w} \alpha_X + \tau}{3}, \quad \bar{q}_X^{HF} = \frac{a - t - \bar{w} \alpha_X - 2\tau}{3}, \quad (29)$$

and the monopoly equilibrium outputs of the Home FDI firm become:

$$\bar{q}_I^{HH} = \frac{a - t - \bar{w} \alpha_I}{2}, \quad \bar{q}_I^{HF} = \frac{a - t - \bar{w} \alpha_I}{2} \quad (30)$$

The difference from the basic model is that consumption taxes distort the optimal outputs while the subsidies do not affect them directly.

4.3 Labor market equilibrium under consumption taxes

In this subsection, we endogenize the wage with subsidies financed consumption taxes. The labor market clearing condition in (13) can be rewritten as:

$$\begin{aligned} L &= \int_0^{z^*} \alpha_I \bar{q}_I^{HH} dI + \int_{z^*}^{2z^*} (\alpha_I \bar{q}_I^{FH} + f) dI + \int_{2z^*}^1 \alpha_X (\bar{q}_X^{HH} + \bar{q}_X^{HF}) dX \\ &= \frac{2z^*(a-t)\alpha_I - 2z^*\alpha_I^2\bar{w} + 2z^*f}{2} + \frac{2(1-2z^*)(a-t)\alpha_X - (1-2z^*)\tau\alpha_X - 2(1-2z^*)\alpha_X^2\bar{w}}{3}. \end{aligned}$$

Solving this equation yields the endogenous wage with the subsidies as follow:

$$\bar{w} = \frac{[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I](a - t) - (1 - 2z^*)\alpha_X\tau - 3(L - z^*f)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \quad (31)$$

The subsidies do not affect the equilibrium wage directly but they affect the wage through consumption taxes. To ensure the positive wage, the term, $L - z^*f$, is not so large.⁷

4.4 General equilibrium under consumption taxes

Substituting (31) into (29), we have the general equilibrium outputs of the Home exporting firm. They are explicitly given as:

$$\bar{q}_X^{HH} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)(a - t) + [(1 - 2z^*)\alpha_X^2 + z^*\alpha_I^2]\tau + \alpha_X(L - z^*f)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \quad (32)$$

$$\bar{q}_X^{HF} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)(a - t) - [(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau + \alpha_X(L - z^*f)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \quad (33)$$

Using (32) and (33), a general equilibrium price of the Home exporting industry becomes:

$$\bar{p}_X^H = \frac{[2(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2](a - t) + z^*\alpha_I^2\tau - 2\alpha_X[L - z^*f]}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \quad (34)$$

With subsidies financed by consumption taxes, lemma 2 still hold.

Also, substituting (31) into (30), the general equilibrium outputs of the Home FDI firm are given as:

$$\bar{q}_I^{HH} = \bar{q}_I^{HF} = \frac{2(1 - 2z^*)\alpha_X(\alpha_X - \alpha_I)(a - t) + (1 - 2z^*)\alpha_X\alpha_I\tau + 3\alpha_I[L - z^*f]}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \quad (35)$$

Using (35) and symmetric assumption, general equilibrium prices of goods supplied by the Home and Foreign FDI firms in Home are given as:

$$\begin{aligned} \bar{p}_I^{HH} &= \bar{p}_I^{FH} \\ &= \frac{[2(1 - 2z^*)\alpha_X^2 + 2(1 - 2z^*)\alpha_X\alpha_I + 6z^*\alpha_I^2](a - t) - (1 - 2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^*f]}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \end{aligned} \quad (36)$$

⁷We impose further assumption, $L - 2z^*f > 0$ to solve the model. This is the same assumption as Fujiwara (2017).

4.5 Budget Neutral under consumption taxes

Same as the labor income tax case, the Home government uses all revenues from consumption taxes to subsidies for foreign FDI firms. The budget neutral condition of the Home government becomes:

$$t \int_0^1 \bar{q}^H(z) dz = s_{ct} \int_{z^*}^{2z^*} \bar{w} f dI$$

From the above equation, consumption taxes can be expressed as a function of subsidies as follow⁸:

$$t = \frac{B - \sqrt{B^2 - 4AC}}{2A}, \quad (37)$$

where

$$\begin{aligned} A &= 6z^*(1 - 2z^*)(\alpha_X - \alpha_I)^2, \\ B &= Aa + 3z^*(1 - 2z^*)\alpha_I(\alpha_X - \alpha_I)\tau + 3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I][L - (1 - s_{ct})z^*f], \\ C &= 3z^*s_{ct}f \{ [2(1 - 2z^*)\alpha_X + 3z^*\alpha_I]a - (1 - 2z^*)\alpha_X\tau - 3(L - z^*f) \}. \end{aligned}$$

Using (37), we investigate the effects of small subsidies on consumption taxes. Differentiating consumption taxes with respect to subsidies around $s_{ct} = 0$, we have:

$$\begin{aligned} \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} &= \frac{\left. \frac{\partial C}{\partial s_{ct}} \right|_{s_{ct}=0}}{B} \\ &= \frac{3z^*f \{ [2(1 - 2z^*)\alpha_X + 3z^*\alpha_I]a - (1 - 2z^*)\alpha_X\tau - 3(L - z^*f) \}}{B} > 0. \end{aligned} \quad (38)$$

This implies that the Home government has to impose the heavier taxes when it increases subsidies around $s_{ct} = 0$.

4.6 Effects of small subsidies on the wage and producer prices

Before proceeding the welfare analysis, we confirm the effects of small subsidies on the wage and the producer prices. First, we reveal the small subsidies effects on the wage. Differentiating (31)

⁸See the detail for Appendix

with respect to the subsidies around $s_{ct} = 0$, we have:

$$\left. \frac{\partial \bar{w}}{\partial s_{ct}} \right|_{s_{ct}=0} = \frac{-[2(1-2z^*)\alpha_X + 3z^*\alpha_I]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} < 0.$$

We immediately obtain the following lemma.

Lemma 4. *Small FDI subsidies for fixed cost financed by the consumption taxes negatively affect the wage.*

The intuition of this lemma is straightforward. The small subsidies decrease the demand and supply through the increase in consumption taxes explained in (38). This implies that the Home firms need the less labor force. Thus, the wage becomes smaller if the subsidies increase.

Second, we investigate the small subsidies effect on the producer price of the Home exporting industry. Differentiating (34) with respect to subsidies around $s_{ct} = 0$, we obtain:

$$\left. \frac{\partial \bar{p}_X^H}{\partial s_{ct}} \right|_{s_{ct}=0} = \frac{-[2(1-2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} < 0.$$

From this result, we can establish the following lemma.

Lemma 5. *Small FDI subsidies for fixed costs financed by consumption taxes negatively affect the producer price of the exporting industry in Home.*

The intuition of this lemma is as follows. When consumption taxes increase, the change in the outputs of the Home exporting firm, as shown in (32) and (33), depends on the size of the labor coefficients, α_X and α_I . However, according to (26), consumption taxes have a negative impact on the prices. Considering this direct effect of consumption taxes on the prices, subsidies have a negative impact on the price of the Home exporting industry due to the relationship in (38).

Third, we show the effect of small subsidies on the prices of Home and Foreign FDI industries. Differentiating (36) with respect to subsidies around $s_{ct} = 0$, we yield:

$$\left. \frac{\partial \bar{p}_I^{HH}}{\partial s_{ct}} \right|_{s_{ct}=0} = \left. \frac{\partial \bar{p}_I^{FH}}{\partial s_{ct}} \right|_{s_{ct}=0} = \frac{-[2(1-2z^*)\alpha_X^2 + 2(1-2z^*)\alpha_X\alpha_I + 6z^*\alpha_I^2]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} < 0.$$

From this result, we obtain the following lemma.

Lemma 6. *Small FDI subsidies for fixed costs financed by consumption taxes negatively affect the producer prices of the Home and Foreign FDI firms in Home.*

The intuition of this lemma is similar to Lemma 5. When subsidies increase, the change in the outputs of both the Home and Foreign FDI firms in the Home market, as shown in (35), relies on the difference between the labor coefficients. However, with the direct negative effect of consumption taxes on the prices, small subsidies have the negative impacts on the prices of both the Home and Foreign FDI goods in the Home market.

4.7 Welfare analysis with subsidies financed by consumption taxes

Finally, we analyze the effect of subsidies for FDI fixed costs financed by consumption taxes on welfare. The indirect utility function (25) can be rewritten as:

$$\bar{V}^H = \frac{a - \int_0^{z^*} (\bar{p}_I^{HH} + t)^2 dI - \int_{z^*}^{2z^*} (\bar{p}_I^{FH} + t)^2 dI - \int_{2z^*}^1 (\bar{p}_X^H + t)^2 dX}{2}, \quad (39)$$

where

$$\bar{p}_X^H + t = \frac{[2(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2]a - 2z^*\alpha_I(\alpha_X - \alpha_I)t + z^*\alpha_I^2\tau - 2\alpha_X[L - z^*f]}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2}, \quad (40)$$

$$\begin{aligned} \bar{p}_I^{HH} + t &= \bar{p}_I^{FH} + t \\ &= \frac{\left\{ \begin{aligned} &[2(1 - 2z^*)\alpha_X^2 + 2(1 - 2z^*)\alpha_X\alpha_I + 6z^*\alpha_I^2]a + 2(1 - 2z^*)\alpha_X(\alpha_X - \alpha_I)t \\ &-(1 - 2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^*f] \end{aligned} \right\}}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \end{aligned} \quad (41)$$

The welfare effects of subsidies on welfare around $s_{ct} = 0$ are given as:

$$\begin{aligned} \left. \frac{\partial \bar{V}^H}{\partial s_{ct}} \right|_{s_{ct}=0} &= -\frac{1}{2} \left[\frac{\partial \int_0^{z^*} (\bar{p}_I^{HH} + t)^2 dI}{\partial s_{ct}} + \frac{\partial \int_{z^*}^{2z^*} (\bar{p}_I^{FH} + t)^2 dI}{\partial s_{ct}} + \frac{\partial \int_{2z^*}^1 (\bar{p}_X^H + t)^2 dX}{\partial s_{ct}} \right] \Bigg|_{s_{ct}=0} \\ &= - \left[(\bar{p}_I^{HH} + t) \frac{\partial \int_0^{z^*} (\bar{p}_I^{HH} + t) dI}{\partial s_{ct}} + (\bar{p}_I^{FH} + t) \frac{\partial \int_{z^*}^{2z^*} (\bar{p}_I^{FH} + t) dI}{\partial s_{ct}} \right. \\ &\quad \left. + (\bar{p}_X^H + t) \frac{\partial \int_{2z^*}^1 (\bar{p}_X^H + t) dX}{\partial s_{ct}} \right] \Bigg|_{s_{ct}=0} \end{aligned} \quad (42)$$

From (42), the welfare effects depend on the effects of subsidies on the consumer prices, $\bar{p}_X^H + t$, $\bar{p}_I^{HH} + t$, and $\bar{p}_I^{FH} + t$. Moreover, the effects of subsidies on welfare depend on the difference between

the labor coefficients, $\alpha_X - \alpha_I$. In this paper, we focus on the case that $\alpha_X - \alpha_I > 0$ holds.⁹ With the condition, $\alpha_X - \alpha_I > 0$, we obtain the following proposition of the effects of subsidies on the consumer prices of exporting and FDI prices.

Proposition 2. *The consumer price of exporting goods becomes lower while the that of FDI goods becomes higher with the small FDI subsidies financed by consumption taxes.*

Proof. Differentiating (40) and (41) with respect to s_{ct} around $s_{ct} = 0$ with $\alpha_X - \alpha_I > 0$, we have:

$$\begin{aligned} \left. \frac{\partial(\bar{p}_X^H + t)}{\partial s_{ct}} \right|_{s_{ct}=0} &= \frac{-2z^*\alpha_I(\alpha_X - \alpha_I)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} < 0, \\ \left. \frac{\partial(\bar{p}_I^{HH} + t)}{\partial s_{ct}} \right|_{s_{ct}=0} &= \left. \frac{\partial(\bar{p}_I^{FH} + t)}{\partial s_{ct}} \right|_{s_{ct}=0} = \frac{2(1 - 2z^*)\alpha_X(\alpha_X - \alpha_I)}{2[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0} > 0. \end{aligned}$$

□

The intuition of this lemma is as follows. Subsidies provide greater advantages for exporting firms compared to FDI firms, given the condition $\alpha_X - \alpha_I > 0$. This is due to the reduction in variable costs resulting from wage reductions. Lemma 5 and Lemma 6 show that the producer price of both exporting and FDI goods decreases, which has a downward effect on consumer prices. However, consumption taxes have upward effects on consumer prices, which has an upward effect. Regarding consumer prices of goods in the exporting industry in the Home market, the downward effect is larger than the upward effect. Conversely, for goods supplied by Home and Foreign FDI firms in the Home market, the downward effect is smaller than the upward effect.

From the above discussion, under the condition, $\alpha_X - \alpha_I > 0$, the welfare improvement stems from the reduction in the consumer prices of exporting industry's goods. We can rewrite (42) as:

$$\begin{aligned} \left. \frac{\partial \bar{V}^H}{\partial s_{ct}} \right|_{s_{ct}=0} &= \frac{z^*(1 - 2z^*)(\alpha_X - \alpha_I)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \\ &\quad \cdot \left\{ 2\alpha_I(\bar{p}_X^H + t)|_{s_{ct}=0} - \alpha_X[(\bar{p}_I^{HH} + t)|_{s_{ct}=0} + (\bar{p}_I^{FH} + t)|_{s_{ct}=0}] \right\} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0}, \quad (43) \\ &= \frac{z^*(1 - 2z^*)(\alpha_X - \alpha_I)}{[2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2]^2} \cdot \Omega_{ct} \cdot \left. \frac{\partial t}{\partial s_{ct}} \right|_{s_{ct}=0}, \end{aligned}$$

⁹With $\alpha_X - \alpha_I < 0$, the result is opposite to the case with $\alpha_X - \alpha_I > 0$. With $\alpha_X - \alpha_I = 0$, the result is same as in the case that subsidies are financed by labor income taxes.

where

$$\Omega_{ct} = -2(\alpha_X - \alpha_I)[(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_I^2]a + \alpha_I[(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau - \alpha_X\alpha_I(L - z^*f).$$

With the condition, $\alpha_X - \alpha_I > 0$, and (38), equation (43) indicates that welfare improves when the consumer prices of the exporting industry is high and those of the Home and Foreign FDI industries are low. In specific, the welfare improvement occurs when the term, Ω_{ct} , is positive. From (43), we obtain the following proposition.

Proposition 3. *With $\alpha_X - \alpha_I > 0$, small FDI subsidies for fixed costs tend to enhance the welfare when trade costs are large, fixed costs of FDI are large, and the labor coefficients of FDI are large enough.*

Proof. See Appendix. □

Around $s_{ct} = 0$, (40) and (41) become nearly equal to (17) and (19). When trade costs are large, we can observe that the consumer prices of goods in exporting industries increase, while those in FDI industries decrease, as shown in Lemma 2 and Lemma 3. When the fixed costs of FDI are large, all consumer prices becomes larger. However, the rise in the consumer prices in exporting industries is larger than that in Home and Foreign FDI industries. These are also same results as in Lemma 2 and Lemma 3. Thus, the difference between consumer prices of goods supplied by exporting firms and those supplied by Home and Foreign FDI firms becomes large when trade costs and fixed costs of FDI are large. On the other hand, the labor coefficient of FDI industries has different effects on welfare compared to the above two variables. When the labor coefficient of FDI is sufficiently large, the producer price of FDI firms, denoted as $\bar{p}_I^{HH} = \bar{p}_I^{FH} = (a - t + \bar{w}\alpha_I)/2$, decreases significantly due to the wage reduction as shown in Lemma 4. This implies that the increase in consumer prices of both FDI firms become significantly smaller. The relatively small increase in consumer prices leads to only minor negative effects on welfare.¹⁰

5 Conclusion

We use the GOLE model developed by Neary (2016) to evaluate the welfare impact of host country small FDI subsidies aimed at attracting a monopolistic foreign firm. Specifically, we examine the

¹⁰See Appendix for the detail.

welfare implications of small subsidies for fixed cost of FDI, while considering the differences in financing sources for these subsidies.

In our analysis, we show the small FDI subsidies that are financed through labor income taxes had no impact on welfare. As labor income taxes do not cause distortions in consumption and subsidies do not affect the production level of firms. As a result, the wage and prices of goods remain constant, and subsidies do not affect welfare. This finding is in contrast to the result of Chor (2009) that the small subsidies always improve welfare in the host country. On the other hand, consumption taxes have negative effects on both demand and supply. This negative shock leads to a decrease in the wage, even when the government provides small subsidies. As a result, consumer prices for exporting industries decrease while those for FDI industries increase. Welfare improves when the difference between consumer prices of exporting and FDI industries is positive. Assuming that the labor coefficient of the exporting industry is higher than that of FDI industries, welfare tends to improve when trade costs are high, fixed costs of FDI are large, and the FDI industry's labor coefficient is high enough. When trade costs are high, producer prices of exporting industries become high while those of FDI industries become low. When fixed costs of FDI become large, the wage level become high, resulting in a larger negative shock on production in the exporting industry than in FDI industries due to the labor coefficient relationship of both industries. When the FDI labor coefficient is large enough, the response to change in the wage becomes larger, resulting in a larger negative shock on producer prices of FDI. Thus, the difference between consumer prices of exporting and FDI industries tends to become positive in these cases. This finding differs from the result of Han *et al.* (2023), suggesting that subsidies to FDI financed by consumption taxes have a greater potential to enhance welfare than those by labor income taxes do.

These new results which are different from previous literature are important for economic policy by the government. For example, if we focus on transportation costs, it is considered that the transportation costs between Japan and Taiwan are low. Therefore, if Japan provides subsidies to TSMC, it would be more effective to use labor income taxes as a source of financing. On the other hand, it is considered that transportation costs between the United States and Taiwan are high. Therefore, if the United States provides subsidies to TSMC, using consumption taxes (sales taxes in the United States) as a better financing source could potentially lead to better welfare. However, the actual implementation and governance of any such schemes will have to be carried

out carefully, in order to determine what the appropriate financing source for FDI subsidy level should be. In addition, this paper does not consider the effect of subsidies on the supply form of firms. The phenomena that firms previously supplied overseas through exports but change their strategy using FDI due to subsidies happens in the real world. This is an important issue for future work to investigate within a GOLE model setting.

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Appendix

A.1 Proof for lemma 1

Differentiating (14) with respect to τ and f , we have:

$$\begin{aligned}\frac{\partial w}{\partial \tau} &= \frac{-(1-2z^*)\alpha_X}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} < 0, \\ \frac{\partial w}{\partial f} &= \frac{3z^*}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} > 0.\end{aligned}$$

A.2 Proof for lemma 2

Differentiating (17) with respect to τ and f , we obtain:

$$\begin{aligned}\frac{\partial p_X^H}{\partial \tau} &= \frac{z^*\alpha_I^2}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} > 0, \\ \frac{\partial p_X^H}{\partial f} &= \frac{2z^*\alpha_X}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} > 0.\end{aligned}$$

A.3 Proof for lemma 3

Differentiating (19) with respect to τ and f , we yield:

$$\begin{aligned}\frac{\partial p_I^{HH}}{\partial \tau} &= \frac{\partial p_I^{FH}}{\partial \tau} = \frac{-(1-2z^*)\alpha_X\alpha_I}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]} < 0, \\ \frac{\partial p_I^{HH}}{\partial f} &= \frac{\partial p_I^{FH}}{\partial f} = \frac{3z^*\alpha_I}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]} > 0.\end{aligned}$$

A.4 Detail for the budget neutral condition

Using (29) and (30), the government's revenue is

$$\begin{aligned}t \int_0^1 \bar{q}^H(z) dz &= t \left\{ \int_0^{z^*} \bar{q}_I^{HH} dI + \int_{z^*}^{2z^*} \bar{q}_I^{FH} dI + \int_{2z^*}^1 (\bar{q}_X^{HH} + \bar{q}_X^{FH}) dX \right\} \\ &= \frac{t[(2-z^*)(a-t) - (1-2z^*)\tau - \{2(1-2z^*)\alpha_X + 3z^*\alpha_I\}\bar{w}]}{3}.\end{aligned}\tag{A.1}$$

The government's spending is

$$s_{ct} \int_{z^*}^{2z^*} \bar{w} f dI = z^* s_{ct} \bar{w} f. \quad (\text{A.2})$$

Equating (A.1) to (A.2) gives:

$$\begin{aligned} t \int_0^1 \bar{q}^H(z) dz &= s_{ct} \int_{z^*}^{2z^*} \bar{w} f dI \\ \Leftrightarrow (2 - z^*)at - (2 - z^*)t^2 - (1 - 2z^*)\tau t - \{2(1 - 2z^*)\alpha_X + 3z^*\alpha_I\} \bar{w} t - 3z^* s_{ct} \bar{w} f &= 0. \end{aligned} \quad (\text{A.3})$$

Define \bar{w} as follow:

$$\begin{aligned} \bar{w} &= \frac{[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I](a - t) - (1 - 2z^*)\alpha_X \tau - 3(L - z^*f)}{2(1 - 2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \\ &= \frac{w_N}{w_D} = \frac{w_{N1}(a - t) - w_{N2} - w_{N3}}{w_D}. \end{aligned}$$

Using this notation, (A.3) can be rewritten as:

$$\begin{aligned} (2 - z^*)w_D at - (2 - z^*)w_D t^2 - (1 - 2z^*)\tau w_D t - w_N w_{N1} t - 3z^* s_{ct} f w_N &= 0 \\ \Leftrightarrow (2 - z^*)w_D at - (2 - z^*)w_D t^2 - (1 - 2z^*)\tau w_D t - w_{N1}(w_{N1}a - w_{N2} - w_{N3})t + w_{N1}^2 t^2 \\ - 3z^* s_{ct} f (w_{N1}a - w_{N2} - w_{N3}) + 3z^* s_{ct} f w_{N1} t &= 0 \\ \Leftrightarrow [(2 - z^*)w_D - w_{N1}^2] t^2 \\ - \{(2 - z^*)w_D a - (1 - 2z^*)\tau w_D - w_{N1}(w_{N1}a - w_{N2} - w_{N3}) + 3z^* s_{ct} f w_{N1}\} t \\ + 3z^* s_{ct} f (w_{N1}a - w_{N2} - w_{N3}) &= 0 \\ \Leftrightarrow At^2 - Bt + C &= 0. \end{aligned} \quad (\text{A.4})$$

The term A , B , and C are explicitly given as:

$$\begin{aligned} A &= 6z^*(1 - 2z^*)(\alpha_X - \alpha_I)^2, \\ B &= Aa + 3z^*(1 - 2z^*)\alpha_I(\alpha_X - \alpha_I)\tau + 3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I][L - (1 - s_{ct})z^*f], \\ C &= 3z^* s_{ct} f \{[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I]a - (1 - 2z^*)\alpha_X \tau - 3(L - z^*f)\}. \end{aligned}$$

First, we show A , B , and C are positive. A is positive obviously. As for C , we assume that

the wage in (31) is positive. Thus C is also positive. Regarding B , we can rewrite B as:

$$B = 3z^*(1 - 2z^*)(\alpha_X - \alpha_I)[2(\alpha_X - \alpha_I)a + \alpha_I\tau] + 3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I][L - (1 - s_{ct})z^*f] \quad (\text{A.5})$$

The sign of (A.5) depends on the difference between the labor coefficients, $\alpha_X - \alpha_I$. However, B is always positive. If the difference is positive, $\alpha_X - \alpha_I > 0$, we can easily confirm B is positive. If the difference is negative, $\alpha_X - \alpha_I < 0$, the proof that $B > 0$ is bit complex. Suppose $B \leq 0$. We can rewrite (A.5) as:

$$2(\alpha_I - \alpha_X)a \leq \alpha_I\tau - \frac{3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I](L - z^*f + s_{ct}z^*f)}{z^*(1 - z^*)(\alpha_I - \alpha_X)}. \quad (\text{A.6})$$

From (15) and (16), the condition of the positive outputs of the exporting industry can be expressed as:

$$\begin{aligned} \bar{q}_X^{HH} + \bar{q}_X^{HF} > 0 &\Leftrightarrow 2z^*\alpha_I(\alpha_I - \alpha_X)a - z^*\alpha_I^2\tau + 2\alpha_X(L - z^*f) > 0. \\ &\Leftrightarrow 2(\alpha_I - \alpha_X)a > \alpha_I\tau - \frac{2\alpha_X(L - z^*f)}{z^*\alpha_I} + 2(\alpha_I - \alpha_X)t. \end{aligned} \quad (\text{A.7})$$

Combining (A.6) and (A.7), we have:

$$\begin{aligned} \alpha_I\tau - \frac{3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I](L - z^*f + s_{ct}z^*f)}{z^*(1 - z^*)(\alpha_I - \alpha_X)} &> \alpha_I\tau - \frac{2\alpha_X(L - z^*f)}{z^*\alpha_I} + 2(\alpha_I - \alpha_X)t \\ \Rightarrow \alpha_I\tau - \frac{3[2(1 - 2z^*)\alpha_X + 3z^*\alpha_I](L - z^*f + s_{ct}z^*f)}{z^*(1 - z^*)(\alpha_I - \alpha_X)} &> \alpha_I\tau - \frac{2\alpha_X(L - z^*f)}{z^*\alpha_I} \\ \Leftrightarrow z^*[2(1 - 2z^*)\alpha_X^2 + 6(1 - 2z^*)\alpha_X\alpha_I + 9z^*\alpha_I^2](L - z^*f) \\ &+ 3z^*\alpha_I[3z^*\alpha_I^2 + 2(1 - 2z^*)\alpha_X^2]s_{ct}z^*f < 0. \end{aligned}$$

This is the contradiction. Thus, with the positive out put of the exporting industry, B is always positive regardless of the sign of the difference between the labor coefficients.

Second, we consider the condition that equation (A.4) has real solutions. To have real solutions, equation (A.4) needs to satisfy the following condition: $B^2 - 4AC > 0$. We can rewrite B and

$4AC$ as:

$$\begin{aligned} B &= Aa + B_1 + w_{N1}(w_{N3} + 3s_{ct}z^*f) \\ 4AC &= 12As_{ct}z^*f(w_{N1}a - w_{N2} - w_{N3}) \end{aligned}$$

Using the above two equations, the condition, $B^2 - 4AC > 0$, is explicitly given as:

$$\begin{aligned} B^2 - 4AC &> 0 \\ \Leftrightarrow A^2a^2 + 2Aw_{N1}(w_{N3} - 3s_{ct}z^*f)a + B_1^2 + w_{N1}^2(w_{N3} + 3s_{ct}z^*f)^2 \\ &+ 2B_1w_{N1}(w_{N3} + 3s_{ct}z^*f) + 12As_{ct}z^*f(w_{N2} + w_{N3}) > 0 \end{aligned} \quad (\text{A.8})$$

If the condition, $2Aw_{N1}(w_{N3} - 3s_{ct}z^*f)a > 0$, holds, (A.8) holds because other terms are positive. We can rewrite $2Aw_{N1}(w_{N3} - 3s_{ct}z^*f)a$ as $6Aw_{N1}(L - z^*f - s_{ct}f)$. Recall that we assume $L - 2z^*f > 0$. With this condition, $6Aw_{N1}(L - z^*f - s_{ct}f) > 0$ holds due to $s_{ct} \in [0, 1]$. Thus, $B^2 - 4AC > 0$ holds and t has real solutions as follow:

$$t = \frac{B \pm \sqrt{B^2 - 4AC}}{2A} \quad (\text{A.9})$$

Finally, we consider which real solution is appropriate. Assume the positive outputs of all industries, we need $a - t > 0$. Using $t = (B + \sqrt{B^2 - 4AC})/(2A)$ and $\sqrt{B^2 - 4AC} > Aa$ from (A.8), we can rewrite $a - t > 0$ as:

$$\begin{aligned} a - t &> 0 \\ \Leftrightarrow 2Aa - B - \sqrt{B^2 - 4AC} &> 0 \\ \Leftrightarrow Aa - [B_1 + w_{N1}(w_{N3} + 3s_{ct}z^*f)] - \sqrt{B^2 - 4AC} &> 0 \\ \Rightarrow -[B_1 + w_{N1}(w_{N3} + 3s_{ct}z^*f)] &> 0 \end{aligned}$$

This is contradiction. Therefore, if $t = (B + \sqrt{B^2 - 4AC})/(2A)$ holds, we have $a - t \leq 0$.

On the other hand, Using $t = (B - \sqrt{B^2 - 4AC})/(2A)$ and $\sqrt{B^2 - 4AC} > B_1 + w_{N1}(w_{N3} +$

$3s_{ct}z^*f$) from (A.8), we can rewrite $a - t > 0$ as:

$$\begin{aligned}
a - t &> 0 \\
&\Leftrightarrow 2Aa - B + \sqrt{B^2 - 4AC} > 0 \\
&\Leftrightarrow Aa - [B_1 + w_{N1}(w_{N3} + 3s_{ct}z^*f)] + \sqrt{B^2 - 4AC} > 0 \\
&\Rightarrow Aa > 0
\end{aligned}$$

This always holds. Thus, if $t = (B - \sqrt{B^2 - 4AC})/(2A)$ holds, we have $a - t > 0$.

From the above discussions, we have:

$$t = \frac{B - \sqrt{B^2 - 4AC}}{2A}.$$

This function is the same equation as (37).

A.5 Proof for Proposition 3.

First, we consider the effects of trade costs and fixed costs of FDI on Ω_{ct} . The derivatives are

$$\begin{aligned}
\frac{\partial \Omega_{ct}}{\partial \tau} &= \alpha_I [(1 - 2z^*)\alpha_X^2 + 2z^*\alpha_I^2] > 0 \\
\frac{\partial \Omega_{ct}}{\partial f} &= z^*\alpha_X\alpha_I > 0
\end{aligned}$$

Second, we consider the case that the α_I is small enough. Suppose $\alpha_I \approx 0$. Then, Ω_{ct} becomes:

$$\Omega_{ct} = -2\alpha_X(1 - 2z^*)\alpha_X^2 a < 0$$

This implies that Ω_{ct} is negative if α_I is small enough.

If α_I is large enough, $\alpha_I \approx \alpha_X$,

$$\Omega_{ct} = \alpha_I^2 [\alpha_I \tau - (L - z^*f)] \tag{A.10}$$

This implies that Ω_{ct} tends to be positive if α_I is large enough and τ is large and f is large.

Thus, the welfare improvement tends to occur with trade costs are large, fixed costs of FDI are large, and the labor coefficients of FDI are large enough.

A.9 Proof related to Proposition 3.

Differentiating (40) and (41) with respect to τ , we have:

$$\begin{aligned}\frac{\partial(\bar{p}_X^H + t)}{\partial\tau} &= \frac{z^*\alpha_I^2}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} > 0, \\ \frac{\partial(\bar{p}_I^{HH} + t)}{\partial\tau} &= \frac{\partial(\bar{p}_I^{FH} + t)}{\partial\tau} = \frac{-(1-2z^*)\alpha_X\alpha_I}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]} < 0.\end{aligned}$$

These effects imply that the difference between the consumer prices becomes large when trade costs are large.

Differentiating (40) and (41) with respect to f , we have:

$$\begin{aligned}\frac{\partial(\bar{p}_X^H + t)}{\partial f} &= \frac{2\alpha_X}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} > 0, \\ \frac{\partial(\bar{p}_I^{HH} + t)}{\partial f} &= \frac{\partial(\bar{p}_I^{FH} + t)}{\partial f} = \frac{3\alpha_I}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]} > 0.\end{aligned}$$

Comparing these two effects, $2\alpha_X > 3\alpha_I/2$ holds because of the condition, $\alpha_X > \alpha_I$. Thus, fixed costs of FDI have the more effects on the consumer prices of goods supplied by exporting firms than those by FDI firms.