# Essays on International Trade and Foreign Direct Investment

*by*

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# Preface

The three key topics of international trade and foreign direct investment (FDI) after the development of information and communication technologies (ICTs) are as follows. *i*) Reducing communication costs adds complexity to FDI strategies. Nevertheless, communication costs remain significant and understanding the impact of reduced communication costs on home welfare is crucial. *ii*) Owing to the higher demand for semiconductors, FDI subsidies are increasing globally, prompting an inquiry into whether these subsidies are beneficial for home welfare. *iii*) The emergence of e-commerce, particularly online marketplaces, has led to increased exports for small- and medium-sized enterprises (SMEs). However, the potential future elimination of tariff exemptions for SMEs imports raises questions about its economic implications of such tariff removal. We aim to examine the topics from new perspectives in the disertation.

The dissertation consists of five chapters, including three essays. Chapter 1 introduces the economic background of international trade and FDI after the development of ICTs and outlines the basic structure of this dissertation.

In Chapter 2, we consider the welfare effect of the reduction in communication costs in a three-country model of firm heterogeneity in which export-platform FDI and horizontal FDI coexist. We demonstrate a non-monotonic size relationship in the welfare impact assessment by reducing communication costs between developed countries and between developed and less developed countries when both investment strategies coexist. This dependence is influenced by transportation costs and the proportion of firms using export-platform FDI versus horizontal FDI.

In Chapter 3, we investigate whether FDI subsidies improve home welfare by considering the different financing sources of subsidies, such as labor income taxes and consumption taxes. We find that the subsidies financed by labor income taxes do not affect welfare. On the other hand, the subsidies financed by consumption taxes may improves welfare. This result indicates that trade costs, fixed costs of FDI, and technological difference between the exporting and FDI industries have a significant role for enhancing welfare through subsidies.

Chapter 4 examines the effect of a tariff on an economy with an online marketplace operated by an online platform operator. We explore the following cases: $(O)$, where a foreign monopolist exports its product using the online marketplace; $(OO)$, where two oligopolistic foreign firms export their goods via the online marketplace; and $(OX)$, where one foreign firm uses the online marketplace while the other firm exports directly. We find that introducing a tariff reduces the profits of firms that uses the online marketplace. In addition, when sales fees are sufficiently high (low), a tariff increases (decreases) the profits of the direct exporting firm, decreases (increases) the profits of the online platform operator, and potentially decreases (increases) home welfare. Chapter 5 concludes.

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# Contents

# List of Figures

# Chapter 1

# General Introduction

## 1.1 Research Background

In the 1990s, Internet-based web browsing became widespread and extended to the public with the development of information and communication technologies (ICTs). Subsequently, ICTs underwent rapid expansion and began to exert a substantial influence on various domains, including information exchange, communication, and business. Baldwin (2016) refers to the contemporary era, characterized by the reduction in communication costs due to the advancement of ICTs, as the "Second Unbundling" world.

Owing to the rapid growth of ICTs, the foreign direct investment (FDI) strategies have become more complicated in the modern economy (Feinberg and Keane, 2006; Baldwin and Okubo, 2014). This is because plants in foreign countries can acquire the necessary knowledge and information about their production activities from their headquarters (HQs), which are geographically separated due to the ICTs revolution (Markusen, 2002; Helpman, 2006). One complex form of FDI is the export-platform FDI, which is particularly prevalent in the European union (EU) (Head and Mayer, 2017). However, communication costs have not vanished entirely and still exert a significant influence on FDI activities (Tintelnot, 2017; Head and Mayer, 2019). Furthermore, there are variations in the magnitude of communication costs among countries (Tintelnot, 2017).

Many studies have examined the taxonomy of firms' FDI strategies, including export-platform FDI [1], investigate the effects of transportation and communication costs on the location choices of MNEs (Gokan *et al.*, 2019) and welfare (Head and Mayer, 2019). However, few studies have

[1] See Yeaple (2003), Grossman *et al.* (2006), and Ekholm *et al.* (2007).

focused on how communication costs between source and host counties affect welfare. Chapter 2 investigates the effects of each type of communication cost on welfare when various FDI strategies coexist.

In conjunction with the development of ICTs, the semiconductor industry has gained significance owing to intensified international competition. Many countries and regions now provide subsidies and grants (e.g., In Japan, the "5G Promotion Act," in the US, the "CHIPS Act," and in the EU, the "European CHIPS Act,") to acquire inward FDI from semiconductor firms, emphasizing self-sufficiency in manufacturing and national security concerns. These subsidies contribute to various aspects of semiconductor firms, including research and development, production facility upgrades, and workforce development.

Several authors have conducted studies on FDI subsidies, including Chor (2009) and Han *et al.* (2023). Both papers based on the monopolistic competition and firm heterogeneity à la Helpman *et al.* (2004). Chor (2009) analyzes the welfare effects of the FDI subsidies financed by labor income taxes for variable and fixed costs. On the other hand, Han *et al.* (2023) analyze the welfare effects of FDI subsidies financed by labor income taxes, corporate taxes, and consumption taxes for variable costs. In the recent empirical studies (Autor *et al.*, 2017, 2020; De Loecker *et al.*, 2020), a notable surge in the proportion of unadulterated profits within gross-value added, concomitant with a marked reduction in the labor proportion, could potentially be attributed to an escalation in industry concentration. The natural extension analyzes the welfare effect of FDI subsidies financed by labor income and consumption taxes for fixed costs under oligopolistic competition. This will be shown in Chapter 3.

Finally, ICT advancements have broadened small and medium-sized enterprises' (SMEs) access to international markets, resulting in increased export opportunities. By utilizing online platforms and e-commerce, SMEs can efficiently expand their products and services to international markets, reach a global customer base, and create new sales opportunities (Lendle and Olarreaga, 2017; Lanz *et al.*, 2018). Regarding SMEs' trade, the European Commission announced a reform proposal for the customs system, aiming for further integration of the EU Customs Union on May 17, 2023. This announcement abolished the duty-free exemption for goods valued at less than 150 euros.

Many studies focus on identifying which firms export their goods using online platforms, such as Amazon.com and Rakuten Ichiba, and show the differences between firms using the online platforms and direct exporting firms, including Sun (2021) and Carballo *et al.* (2022). These studies reveal that SMEs can start exporting their goods using online platforms, and that the productivity level of SMEs is lower than that of direct exporting firms. However, no study has analyzed the effects of a tariff on the economies with firms using online platforms. Chapter 4 will explore this issue.

## 1.2 Preview of Chapters

In Chapter 2, we assume that plants require specific production knowledge that belongs to their HQs, and communication costs arise when HQs and their plants are located in different countries. In this situation, MNEs based in developed countries that invest in less developed countries typically establish plants as export-platforms for FDI and incur communication costs between developed and less developed countries. By contrast, MNEs investing in other developed countries employ plants for horizontal FDI and face communication costs between developed countries. We construct a model in which firms engaging in export-platform and horizontal FDI coexist in an economy by considering firm-level heterogeneity in productivity levels á la Helpman *et al.* (2004). We demonstrate that a comparison of the welfare impact of reducing each communication cost exhibits a non-monotonic relationship when both investment strategies coexist. This relationship is contingent on the magnitude of transportation costs and the relative proportion of firms utilizing export-platform FDI compared to those employing horizontal FDI.

In Chapter 3, we employ a general oligopolistic equilibrium model as in Neary (2016) to analyze the welfare effect of subsidies for fixed costs of FDI. Specifically, we construct a model in which exporting and FDI industries coexist in an economy. In addition, firms in the exporting industries produce goods under oligopolistic competition, whereas firms in the FDI industry produce goods under a monopoly. In this situation, we consider the welfare impact of subsidies under different financing sources such as labor income taxes and consumption taxes. The results indicate that small subsidies financed by consumption taxes may improve welfare. This is because small subsidies financed by labor income taxes do not affect wages and thus do not alter any other economic variables. However, small subsidies financed by consumption taxes influence demand and supply conditions, which subsequently decreases wages. This reduction in the wage can improve welfare.

Chapter 4 examines the impact of a tariff on an economy with an online marketplace operated by an online platform operator. Specifically, our model focuses on the case in which only foreign manufacturing firms serve their products to the home market through exports. In this setup, firms utilizing the online marketplace pay sales fees to the online platform operator. We explore the following cases: $(O)$ where a foreign monopolist exports its product using the online marketplace, $(OO)$ where two oligopolistic foreign firms export their goods via the online marketplace, and $(OX)$ where one foreign firm uses the online marketplace while the other firm exports directly. The introduction of a tariff reduces profits of firms utilizing the online marketplace. In addition, a tariff may increase the profits of firms engaged in direct exports and potentially decrease home welfare, particularly when sales fees are sufficiently high. Conversely, online platform operator's profits may increase when the sales fees are sufficiently low.

# Chapter 2

# Communication Costs and FDI: Welfare Implications with Firm Heterogeneity

## 2.1 Introduction

The field of international trade has extensively debated the significance of transportation costs, while the importance of communication costs has received less attention. However, according to Helpman (2006), the rapid advancements in information and communication technologies (ICTs) have enabled firms to geographically separate their production activities. Markusen (2002) argues that plants rely on their headquarters (HQs) to acquire knowledge and information necessary for their production activities. Typically, HQs engage in activities such as management, research and development (R&D), and finance, while their associated plants focus on production. Baldwin (2016) refers to this separation of production stages as the second unbundling. Despite the substantial decrease in communication costs over the past two decades, they still exert an influence on firms' production processes primarily because the transmission of information remains imperfect, necessitating face-to-face communication.[1]

[1] Giroud (2013) shows that the establishment of a new airline connecting HQs and plants, which reduces travel time and face-to-face communication costs, leads to a 7% increase in plant productivity compared to the pre-airline period. Dischinger *et al.* (2014) uncover the tendency of European firms to achieve higher profits in their domestic plants than in their foreign plants. Charnoz *et al.* (2018) provide evidence that the introduction of a high-speed railway, resulting in reduced travel time between HQs and plants, leads to a higher share of management activities being conducted at the HQs. Furthermore, Kalnins and Lafontaine (2013) show that an increase in the distance between HQs and plants is associated with a decrease in the longevity of the plants. Additionally, Battiston *et al.* (2017) find that face-to-face communication plays a crucial role in facilitating collaboration among workers specializing in different activities across geographically separated HQs and plants.

Generally, it is considered that communication costs arise between where geographically distant places. In contrast to the assumption that communication costs are solely determined by distance, it is crucial to acknowledge the significant role played by communication costs that are independent of physical proximity. Stein and Daude (2007) shows that time differences have a negative and significant impact on the location of FDI, and the effect of time zone differences has increased over time. From these facts, it is suggested that the likelihood of it disappearing with the introduction of new information technologies is low, and communication costs do not rely solely on geographical distance. In addition, Rydzek *et al.* (2015) uncover that elevated communication costs, encompassing expenses associated with creating, transferring, and accessing intangible assets, are influenced by the cultural differences between countries. These differences include factors such as language disparities, work ethics, and moral values, which are not directly contingent on the geographical distance between locations. Consequently, when plants and HQs are located in different countries, communication costs become a significant factor to consider.

Owing to the rapid growth of ICTs, the FDI strategies have become more complicated in the modern economy (Feinberg and Keane, 2006; Baldwin and Okubo, 2014). An important complicated FDI strategy is export-platform FDI ($EP$ FDI). In this study, the terminology of $EP$ FDI means that a firm in a developed country builds a plant in a less developed country which exports their products back to a source country and exports to another developed country. $EP$ FDI occurs in a situation where all three countries within the free trade area, such as the European Union (EU), and has been growing rapidly (Head and Mayer, 2017). In addition, the motive for market acquiring FDI (horizontal FDI) in the EU has decreased (Head and Mayer, 2019; Sondermann and Vansteenkiste, 2019) while the motive for vertical FDI ($EP$ FDI in this study includes vertical motivation) has increased (Neary, 2009; Sondermann and Vansteenkiste, 2019).[2] The recent studies (Tintelnot, 2017; Head and Mayer, 2019) show communication costs have the significant effects for FDI including $EP$ FDI.

Despite the significant impact of communication costs, much of the literature on international economics has predominantly focused on traditional transportation costs. Furthermore, it is important to note that communication costs differ between developed and less developed countries.[3] To the best of our knowledge, there is currently no literature that addresses the issue that commu-

[2] Hanson *et al.* (2005) find that U.S. firms' average share of export sales in those plants remains about one third, but there has been a huge increase in Mexico and Canada after the formation of NAFTA.

[3] Tintelnot (2017) estimates that unit input costs (including communication costs) of German firms' plants in foreign countries and shows those costs are different in each country where the plants locate.

nication costs are at different levels in developed and less developed countries within an industry equilibrium where different types of FDI firms coexist. This raises the question of which communication cost factor has a greater impact on welfare within this specific industry equilibrium.

To answer the question, we construct a three-country model (two developed countries and a less developed country) with heterogeneous firm model à la Helpman *et al.* (2004). There are two goods, homogeneous and differentiated goods, and consumers in all countries consume the homogeneous goods. We assume that the consumers in the developed countries consume the differentiated goods, whereas those in the less developed country do not. Firms have the two facilities such as the HQs and plants. If the HQs and plants are in the different countries, the firms incur communication costs. We assume that communication costs between the developed countries and between the developed and less developed countries are different. If firms export their products to the other countries, they incur transportation costs. We assume transportation costs are the same for all countries.

In the current study, we focus on the equilibrium where the following four different strategies of firms coexist. Domestic ($D$) firms have a single plant in the source country (one of developed countries) and only supply their products to the source country. Exporting ($X$) firms also have a single plant in the source country and supplies their products to both source and destination countries (the other developed country) from the plant. To supply their products to the destination country, they incur transportation costs. As we discussed, $EP$-FDI firms have a single plant in the less developed country, export their products back to the source country, and export it to the destination country from the plant. The $EP$-FDI firms incur both transportation and communication costs between the developed and less developed countries. Horizontal FDI ($I$-FDI) firms have a single plant in both source and destination countries and supply their products to both countries from each plant. The firms incur communication costs between the developed countries to supply their products to the destination country.

As for firms' productivity sorting, the relationships of $D$, $X$, and $I$-FDI firms are described in Helpman *et al.* (2004). In the equilibrium, heterogeneous firms arrange $D$, $X$, $EP$-FDI, and $I$-FDI strategies in ascending order of their productivity levels. This sorting order is consistent with empirical facts. Bernard *et al.* (2003) describe the relationship between $D$ and $X$ firms. Aw and Lee (2008) find that the productivity of firms investing in less developed countries is higher than that of $X$ firms. This induces the relationship between $X$ and $EP$-FDI. Finally, Wakasugi and Natsuhara (2012) and Marti (2020) reveal that firms invest in developed countries have higher productivity levels than those invest in less developed countries. This implies that $I$-FDI firms are more productive than $EP$-FDI firms.

Under the equilibrium, the results of welfare analysis of the reduction in communication costs can be divided into three cases. First, when transportation costs are low, the reduction in communication costs between the developed and less developed countries consistently has a larger impact on welfare than that between the developed countries. Second, when transportation costs are at an intermediate level, a welfare impact of the reduction in communication costs depend on the relative mass of $EP$-FDI firms to $I$-FDI firms. Third, when transportation costs are high, the decrease in communication costs between the developed countries consistently has a larger impact on welfare than that between the developed and less developed countries.

These results can be explained by the following reasons. When transportation costs are low (or high), the price of the differentiated goods supplied by $EP$-FDI firms becomes small (or large). This implies that the mass of the differentiated goods produced by $EP$-FDI becomes large (or small) and the effect of the lower price is enlarged greatly (or slightly). In other wards, low (or high) transportation costs increase welfare substantially (or minimally) resulting from the reduction in communication costs between the developed and less developed countries. Therefore, irrespective of the relative mass of $EP$-FDI firms to $I$-FDI firms, welfare effects of reducing communication costs between the developed and less developed countries are larger (or smaller) than those of reducing communication costs between the developed countries when transportation costs are low (or high). On the other hand, when transportation costs are at an intermediate level, the price of the differentiated goods supplied by $EP$-FDI firms are also at an intermediate level. This indicates that the effect of the lower price is enlarged at an intermediate level. In this case, the relative mass of $EP$-FDI and $I$-FDI firms becomes crucial in determining the magnitude of welfare improvement resulting from the reduction in each communication cost.

## Related literature

Several studies analyze relations among export-platform FDI and other foreign activities. This study is closely related to Grossman *et al.* (2006), Gokan *et al.* (2019), and Head and Mayer (2019).

Grossman *et al.* (2006) examine FDI with export-platform motives and firm heterogeneity. Their study builds upon Yeaple (2003) and develops a model that incorporates heterogeneous firms similar to Melitz (2003). They utilize a three-country model, consisting of two similar developed countries and a less developed country, within a framework of monopolistic competition. Each firm can establish plants for intermediate input production and assembly in all three countries. The authors assume that firms face fixed communication costs when two types of plants locate in different countries. Their main purpose is to demonstrate the existence of multiple equilibria that differ in terms of productivity levels, fixed costs of foreign plants, and the cost of transporting intermediate and final goods. In contrast to their work, our study introduces communication costs as variable costs incurred by firms during the production of final goods. Moreover, our main focus is to analyze welfare effects of communication costs.

Gokan *et al.* (2019) analyze the differential effects of communication and transportation costs on firm location choices using a two-country model. They consider communication costs as variable costs associated with the production of final goods. Their main finding is that a reduction in communication costs increases the number of firms engaging in FDI, while a reduction in transportation costs decreases the number of firms involved in exporting. In contrast, our study adopts a three-country model that allows us to analyze $EP$-FDI and examines which communication cost has a larger impact on welfare.

Head and Mayer (2019) are based on Tintelnot (2017). They employ a general equilibrium model to analyze the location choice of multinational enterprises and its impact on welfare when there are changes in communication costs and transportation costs. Communication costs are assumed to be variable costs. The analysis reveals that communication costs have a greater impact on welfare compared to transportation costs. Instead of focusing on the location choice of MNEs, we analyze the changes in welfare when communication costs are different between developed countries and developed and less developed countries within a specific equilibrium in the industry.

The rest of this paper is organized as follows. Section 2.2 describes the basic model. Section 2.3 analyzes the market equilibrium under the situation where all five organizational forms that heterogeneous firms have. In Section 2.4, we analyze the impact of reduction in both communication and transportation costs, under the scenario where all organizational types exist. Section 2.5 provides concluding remarks.

## 2.2 Model set up

### 2.2.1 The economy

There exist three countries: two symmetric developed countries (Home and Foreign) and a less developed country. For consumption, consumers in the developed countries consume two goods, differentiated and homogeneous goods, while consumers in the less developed country consume only homogeneous goods. For production, firms in the developed countries can produce both differentiated and homogeneous goods while firms in the less developed country can produce only the homogeneous goods. All countries have one type of labor and require only a labor force to produce the differentiated and homogeneous goods. In addition, firms in the developed countries are heterogeneous with respect to productivity levels to produce the differentiated goods and have two production facilities, headquarters (HQs) and plants.

Workers in the developed countries know how to produce the differentiated and homogeneous goods. In other words, they have technology to produce both of them. However, workers in the less developed country know only how to produce the homogeneous goods. The number of workers is $L_H$ in Home and $L_F$ in Foreign. As the developed countries are symmetric, the number of labor in both countries is equal, $L_H = L_F \equiv L$. In the less developed country, the supply of workers is $L_S$. We assume $L$ and $L_S$ are large enough to produce both goods. In addition, workers in each country are spatially immobile. The differentiated goods are supplied with increasing returns to scale and monopolistic competition, as per the traditional practice, while the homogeneous goods are produced under constant returns to scale. The wage in the developed countries is normalized to $w_H = w_F = 1$ and the wage in the less developed country is $w_S < 1$. These restrictions remain as long as each heterogeneous firm in the developed countries produces the homogeneous goods; these goods are also produced in the less developed country and freely traded.

To produce a differentiated good, a plant needs some knowledge and information, which is possessed by its HQ. When a plant and its HQ are located in the same country, the plant would not incur costs for acquiring knowledge or information for producing a differentiated good from its HQ. However, if they are located in different countries, the transmission of knowledge or information from the HQ to the plant would be costly. We regard this costly information-transmission activity as communication costs. We assume communication costs are the same between the developed countries, $\gamma_{HF} = \gamma_{FH} \equiv \gamma_N > 1$, and those are the same between the developed and less developed countries, $\gamma_{HS} = \gamma_{FS} \equiv \gamma_S > 1$, which are of the iceberg type.[4]

If a plant in a developed country or less developed country exports a differentiated good, then a firm incurs transportation costs. We assume transportation costs are the same globally, that is, transportation costs between the developed countries, the developed and less developed countries, and the other developed and less developed countries are equal ($\tau_{HF} = \tau_{FH} = \tau_{HS} = \tau_{FS} \equiv \tau > 1$). Transportation costs are also of the iceberg type. This assumption means that the three countries exist in the same region.

### 2.2.2 Consumer

The representative consumer in country $i = H, F$ has a following Cobb-Douglas utility function:

$$U_i = (1 - \beta)\, ln\, Z_i + \beta\, ln\, X_i, \tag{2.1}$$

where $Z_i$ represents a homogeneous good and $X_i$ is Dixit-Stiglitz consumption aggregate over differentiated goods $x_i(a)$. The price of the homogeneous good is set to 1, thus $Z_i$ is the numareire. The aggregate consumption $X_i$ is given by: $X_i \equiv \left( \int_{\Upsilon_i} x_i(a)^\alpha d\, G_i(a) \right)^{\frac{1}{\alpha}}$, where $\Upsilon_i$ is the set of varieties from firms in countries $i$ and $j$ which are available to consumers in country $i$, and $\alpha \equiv \frac{\sigma - 1}{\sigma} < 1$. The term $a$ is a labor coefficient drown by the distribution $G_i(a)$.

The consumer budget constraint becomes:

$$\int_{\Upsilon_i} p_i(a) x_i(a) d\, G_i(a) = w_i - Z_i, \tag{2.2}$$

where $p_i(a)$ is the consumer price of $a$ variety. Solving the utility maximization problem, the demand function for one variety is given by:

$$x_i(a) = \frac{\beta w_i p_i(a)^{-\sigma}}{P_i^{1-\sigma}}, \tag{2.3}$$

where a price index is $P_i = (\int_{\Upsilon_i} p_i(a)^{1-\sigma} d\, G_i(a))^{\frac{1}{1-\sigma}}$. Substituting $P_i$ into the aggregate consump-

[4] Gokan *et al.* (2019) consider the following three reasons why communication costs are the iceberg type; First, using an iceberg costs implies that communication costs are proportional to the plant output. Garicano (2000) and Gumpert (2018) state that spending time of managers to solve practical jobs in distant plants is proportional to firms' output. Second, an iceberg communication costs consists of both unrelated (talks using ICTs) and related (travel costs of engineers and business people) to distance. Third, less productive firms tend to incur higher communication costs. Linking communication costs to marginal costs results in an inverse relationship between communication costs and firms' productivity level when HQs locate far from those plants.

tion, we obtain:

$$X_i = \beta w_i \left[ \int_{\Upsilon_i} p_i(a)^{1-\sigma} d\, G_i(a) \right]^{\frac{1}{\sigma-1}}. \tag{2.4}$$

Naturally, the consumption of differentiated goods decreases in a price of one variety.

### 2.2.3 Welfare

As a measure of welfare for the subsequent analysis, we derive the indirect utility function, $V_i$, for a representative consumer. The demand function for differentiated products (2.3) and the budget constraint (2.2) together imply a level of demand for the homogeneous good, $Z_i = (1-\beta)w_i$. Substituting back this expression for $Z_i$ into the utility function (2.1), we obtain:

$$V_i = (1-\beta)ln(1-\beta)w_i + \beta\, ln\, X_i. \tag{2.5}$$

Naturally, welfare is increasing in the consumption aggregates. The analysis focuses on the industry equilibrium for the Home differentiated goods sector, namely $i = H$. The model formally includes a Foreign heterogeneous firms sector (denoted by $i = F$). However, the Foreign differentiated goods sector shares the same structure as the Home sector due to the symmetric assumption. This implies that welfare change by reduction in communication costs is the same for both developed countries. We thus write $i = H$ for no ambiguity.

### 2.2.4 Production and Profits

In this subsection, we consider possible strategies for a firm in Home. A firm's nationality is the location of its HQ the location of which is fixed. A firm's HQ supplies some services, knowledge, or information to its plant(s). When the HQ transmits its intellectual matters to plants in other countries, it incurs communication costs ($\gamma_S > 1$ and $\gamma_N > 1$). If a plant exports a differentiated good, it must pay transportation costs ($\tau > 1$). To start producing a variety, first, a firm in Home pays entry costs, $f_e$, and draws a productivity level $1/a$ from a known distribution $G_H(a)$. After observing this productivity level, the firm decides where to invest and whether to produce a differentiated good at the same time. The wage level in developed countries and less developed is:

$$w_i = \begin{cases} 1 & if \;\; i = H \; or \; F, \\ w_S < 1 & if \;\; i = S. \end{cases}$$

Firms' organizational forms are divided into five types—domestic (denoted by $D$), export (denoted by $X$), platform-FDI (denoted by $EP$), horizontal FDI (denoted by $I$), and multi-production-local FDI (denoted by $M$)—under the assumption of fixed costs for each strategy: $f_D < f_X < f_{EP} < f_I < f_M$.[5] We next explain cost functions of each type of firm in Home.

A $D$ firm has a single plant and HQ in own country. It supplies a differentiated goods to Home only and incurs the marginal cost $a$ and fixed cost: $f_D$. Thus, the cost function of the $D$-firm is:

$$C_H^D = ax_H^D + f_D, \tag{2.6}$$

where $x_H$ is the domestic consumption.

An $X$ firm's plant and HQ are located in Home and the firm supplies a differentiated good to Home and Foreign. The marginal costs of serving Home is same as a $D$ firm. When the firm exports the differentiated good to Foreign, it incurs transportation cost ($\tau > 1$) while it does not incur any communication costs because the HQ and plant are located in the same country. The marginal costs of serving Foreign are $a\tau$. Fixed costs denote $f_X$. A cost function for the $X$-firm is:

$$C_H^X = ax_H^X + (a\tau)x_F^X + f_X, \tag{2.7}$$

where $x_F$ is the consumption of Foreign.

An $EP$-FDI firm has a single plant in less developed and supplies a differentiated good from there to both the developed countries. In this strategy, the firm incurs transportation costs for serving both markets. Furthermore, the firm incurs communication costs ($\gamma_S > 1$) because its HQ and the plant are spatially separated. This firm has to pay marginal costs, $a\tau\gamma_S w_S$, for both Home and Foreign-supplied goods. It must also to pay fixed costs: $f_{EP}$. Thus, a cost function for

[5]These five forms are possible strategies that the Home firm can choose. Calculating profit functions of other strategies, those are dominated by at least one of profit functions of the five strategies. The assumption of fixed costs is followed by Ekholm *et al.* (2007).

the $EP$-FDI firm becomes:

$$C_H^{EP} = (a\tau\gamma_S w_S)x_H^{EP} + (a\tau\gamma_S w_S)x_F^{EP} + f_{EP}. \tag{2.8}$$

An $I$-FDI firm has two plants. a single plant is located in Home with its HQ, but the other plant is located in Foreign. The plant in Home produces a differentiated good domestically and incurs a marginal cost $a$ same as a $D$ firm. The plant in Foreign supplies the differentiated good for Foreign consumers. In this case, the firm incurs only communication costs ($\gamma_N > 1$) to produce the differentiated good and the marginal costs becomes $a\gamma_N$. Concerning fixed costs, the firm pays $f_I$. The cost function of the $I$-FDI firm is:

$$C_H^I = ax_H^I + (a\gamma_N)x_F^I + f_I. \tag{2.9}$$

An $M$-FDI firm has two plants. A single plant supplying a differentiated good for Home market is located in the same country where its HQ is located. The other plant supplying it for Foreign market is located in less developed. In this case, marginal costs for Home is the same as a $D$ firm and those for Foreign is same as an $EP$ -FDI firm. Concerning fixed costs, the firm incurs $f_I$. A cost function of the $M$-FDI firm can be written as:

$$C_H^M = ax_H^M + (a\tau\gamma_S w_S)x_F^M + f_M. \tag{2.10}$$

Solving a profit maximization problem for each type of firms and and using (3) and (2.6)-(2.10), profit functions for each organizational form are obtained. Furthermore, applying the symmetricity of the total demand levels for one type of differentiated good between developed countries, the national demand levels are seen to be the same in both developed countries, $B_i = B_j \equiv B$, [6]

[6] $B_i = B_j \equiv B = \frac{1-\alpha}{\alpha^{1-\sigma}}\beta^\sigma L(X)^{1-\sigma}$.

Hence, the profit functions become as follows:

$$\pi_H^D = a^{1-\sigma} B - f_D, \tag{2.11}$$

$$\pi_H^X = a^{1-\sigma}\left(1 + \tau^{1-\sigma}\right) B - f_X, \tag{2.12}$$

$$\pi_H^{EP} = 2a^{1-\sigma}\left(\tau\gamma_S w_S\right)^{1-\sigma} B - f_{EP}, \tag{2.13}$$

$$\pi_H^I = a^{1-\sigma}\left(1 + {\gamma_N}^{1-\sigma}\right) B - f_I, \tag{2.14}$$

$$\pi_H^M = a^{1-\sigma}\left[1 + \left(\tau\gamma_S w_S\right)^{1-\sigma}\right] B - f_M. \tag{2.15}$$

### 2.2.5 Productivity sorting

In this study, we assume transportation costs are the same globally, This implies that the three countries have regional trade agreements (RTAs). If the three countries are located within RTAs, $EP$-FDI and $I$-FDI are major FDI forms (Head and Mayer, 2017, 2019). Thus, we focus on the equilibrium where the strategies $D$, $X$, $EP$, and $I$ coexist.[7] If Home firms begin production, their profits have to be positive. Solving $\pi_H^D(a) = 0$, we have the productivity cutoff, ${a_D}^{1-\sigma}$, which is the lowest productivity level of the market to have the firms earn positive profits. If the firms have the profits, $\pi_H^D(a) \leq \pi_H^X(a)$, they only serve to Home. If we put (2.11) = (2.12), the productivity cutoff, ${a_X}^{1-\sigma}$ can be yield. This cutoff means the highest level of $D$ firms. Firms with ${a_D}^{1-\sigma} < a^{1-\sigma} \leq {a_X}^{1-\sigma}$ use strategy $D$. Cutoffs, ${a_D}^{1-\sigma}$ and ${a_X}^{1-\sigma}$, are given as:

$${a_D}^{1-\sigma} = \frac{\alpha^{1-\sigma} f_D}{(1-\alpha)B}, \tag{2.16}$$

$${a_X}^{1-\sigma} = \frac{\alpha^{1-\sigma}(f_X - f_D)}{(1-\alpha)\,\tau^{1-\sigma}\,B}. \tag{2.17}$$

Profits made by $X$ firms satisfy the inequality, $\pi_H^X(a) \leq \pi_H^{EP}(a)$. If we put (2.12) = (2.13), we obtain the highest productivity level of X firms, ${a_{EP}}^{1-\sigma}$. Thus, firms with ${a_X}^{1-\sigma} < a^{1-\sigma} \leq {a_{EP}}^{1-\sigma}$ use strategy $X$. $EP$-FDI firms have the profits, $\pi_H^P(a) \leq \pi_H^I(a)$ and the highest productivity level, ${a_I}^{1-\sigma}$, can be yielded by putting (2.13) = (2.14). Therefore, firms with ${a_{EP}}^{1-\sigma} < a^{1-\sigma} \leq {a_I}^{1-\sigma}$ use strategy $EP$. If firms use $I$ strategy, their profits are larger than $\pi_H^I(a)$. Hence, the firms

[7] The $M$-FDI is a major FDI form when a source country is outside of RTAs while destination and less developed countries are in RTAs. Then, firms of the source country tend to use $M$-FDI (Neary, 2009; Head and Mayer, 2019). We consider the another equilibrium where all strategies exist in Section 4.

become $I$-FDI firms with ${a_I}^{1-\sigma} < a^{1-\sigma}$. Cutoffs, ${a_{EP}}^{1-\sigma}$ and ${a_I}^{1-\sigma}$, are given as:

$$
\begin{aligned}
{a_{EP}}^{1-\sigma} &= \frac{\alpha^{1-\sigma}(f_{EP} - f_X)}{(1-\alpha)\left[2(\tau\gamma_S w_S)^{1-\sigma} - \tau^{1-\sigma} - 1\right]B}, &(2.18)\\
{a_I}^{1-\sigma} &= \frac{\alpha^{1-\sigma}(f_I - f_{EP})}{(1-\alpha)\left[1 + {\gamma_N}^{1-\sigma} - 2(\tau\gamma_S w_S)^{1-\sigma}\right]B}. &(2.19)
\end{aligned}
$$

From (2.18) and (2.19), conditions that ${a_{EP}}^{1-\sigma}$ and ${a_I}^{1-\sigma}$ are positive are given as:

$$
\begin{aligned}
{a_{EP}}^{1-\sigma} > 0 &\Leftrightarrow 2(\tau\gamma_S w_S)^{1-\sigma} > 1 + \tau^{1-\sigma},\\
{a_I}^{1-\sigma} > 0 &\Leftrightarrow 2(\tau\gamma_S w_S)^{1-\sigma} < 1 + {\gamma_N}^{1-\sigma}.
\end{aligned}
$$

Combining these conditions, we have:

$$
\frac{1 + \tau^{1-\sigma}}{2} < (\tau\gamma_S w_S)^{1-\sigma} < \frac{1 + {\gamma_N}^{1-\sigma}}{2}.
$$

This condition means the relationship that the slope of the profit functions of the strategy $X$ is smaller than that of the strategy $EP$ and that of the strategy $EP$ is smaller than that of the strategy $I$. Recalling the assumptions, $\tau > 1$ and $\gamma_N > 1$, the above condition leads:

$$
\begin{aligned}
&\frac{1 + \tau^{1-\sigma}}{2} < (\tau\gamma_S w_S)^{1-\sigma} < \frac{1 + {\gamma_N}^{1-\sigma}}{2} < 1\\
&\Rightarrow \tau\gamma_S w_S > 1.
\end{aligned}
$$

This inequality implies that the variable cost in less developed cannot be too low. If the variable cost in less developed is too low, the firms consider that building a plant in less developed is more profitable than exporting and having a plant in Foreign. Under that situation, strategies $X$ and $I$ are dominated by strategy $EP$.

In addition, we assume the the profit of $I$-FDI firms is always larger than that of $M$-FDI firms. This assumption leads: ${\gamma_N}^{1-\sigma} > (\tau\gamma_S w_S)^{1-\sigma}$. Combining all conditions, we have:

$$
\frac{1 + \tau^{1-\sigma}}{2} < (\tau\gamma_S w_S)^{1-\sigma} < {\gamma_N}^{1-\sigma} < \frac{1 + {\gamma_N}^{1-\sigma}}{2} < 1.
$$

The above condition ensures that the productivity cutoffs of $EP$-FDI and $I$-FDI strategies are positive and the firms using $M$-FDI strategy do not exist in the equilibrium.

For the four strategies to coexist in an industry, the relationship among productivity cutoffs must be[8] :

$$ {a_D}^{1-\sigma} < {a_X}^{1-\sigma} < {a_{EP}}^{1-\sigma} < {a_I}^{1-\sigma}. $$

### 2.2.6 Productivity distribution

To do an analytical analysis for welfare, applying a Pareto distribution for firms' productivity levels, $1/a$ is useful. Firms draw unknown productivity levels from the Pareto distribution with a sharp parameter $k$ and $[b, \infty)$ independently before entering the market. Define $O_H(a) \equiv \int_0^a \tilde{a}^{1-\sigma} dG_H(\tilde{a})$ as in Helpman *et al.* (2004), $G_H(a)$ and $O_H(a)$ are given by:

$$ \begin{aligned} G_H(a) &= (\frac{a}{b})^k, 0 < a < b \\ O_H(a) &= \frac{k}{k-\sigma+1}(\frac{a}{b})^k a^{1-\sigma}, \ \ 0 < a < b \end{aligned} $$

Helpman *et al.* (2004) find that if firms' productivity levels are distributed as Pareto, then firms' sales also have a Pareto distribution with $k - \sigma + 1 > 0$. Hence, we assume $k - \sigma + 1 > 0$ for the following analysis.[9] Additionally, because we consider the symmetric developed countries, both countries have the same productivity distribution, that is, $G_H(a) = G_F(a) \equiv G(a)$ and $O_H(a) = O_F(a) \equiv O(a)$.

### 2.2.7 Market equilibrium and consumption

The price levels follow a Pareto distribution and are same in both developed countries, $G(a)$. Define the CES aggregate: $X_H \equiv X_{HH} + X_{HF}$. The partial consumption aggregate, $X_{HH}$, denotes the amount of goods consumed by Home consumers which are produced by Home firms. Similarly, another partial consumption aggregate, $X_{HF}$, represents the amount of consumed by Home consumers which are produced by Foreign firms. We can rewrite these two partial aggregates

[8]Conditions for having $D$, $X$, $EP$, and $I$ exists: ${a_D}^{1-\sigma} < {a_X}^{1-\sigma} \Leftrightarrow \tau^{1-\sigma} < \frac{f_X - f_D}{f_D}$, ${a_X}^{1-\sigma} < {a_{EP}}^{1-\sigma} \Leftrightarrow \frac{2(\tau\gamma_S w_S)^{1-\sigma} - \tau^{1-\sigma} - 1}{\tau^{1-\sigma}} < \frac{f_{EP} - f_X}{f_X - f_D}$, and ${a_{EP}}^{1-\sigma} < {a_I}^{1-\sigma} \Leftrightarrow \frac{1 + {\gamma_N}^{1-\sigma} - 2(\tau\gamma_S w_S)^{1-\sigma}}{2(\tau\gamma_S w_S)^{1-\sigma} - \tau^{1-\sigma} - 1} < \frac{f_I - f_{EP}}{f_{EP} - f_X}$ .

[9]Chor (2009) also assumes $k - \sigma + 1 > 0$. Moreover, to make the mean and the variance of the distribution finite, the condition $k > 2$ must hold.

as:

$$X_{HH} = m_e \int_0^{a_I} \left(\frac{a}{\alpha}\right)^{1-\sigma} dG(a) + m_e \int_{a_I}^{a_P} \left[\frac{(a\tau\gamma_S w_S)}{\alpha}\right]^{1-\sigma} dG(a)$$
$$+ m_e \int_{a_{EP}}^{a_X} \left(\frac{a}{\alpha}\right)^{1-\sigma} dG(a) + m_e \int_{a_X}^{a_D} \left(\frac{a}{\alpha}\right)^{1-\sigma} dG(a) \quad (2.20)$$
$$X_{HF} = m_e \int_0^{a_I} \left[\frac{(a\gamma_N)}{\alpha}\right]^{1-\sigma} dG(a) + m_e \int_{a_I}^{a_{EP}} \left[\frac{(a\tau\gamma_S w_S)}{\alpha}\right]^{1-\sigma} dG(a),$$
$$+ m_e \int_{a_P}^{a_X} \left[\frac{(a\tau)}{\alpha}\right]^{1-\sigma} dG(a), \quad (2.21)$$

where $m_e$ is the mass of entrants in Home. The first terms of the two aggregates (2.20) and (2.21) denote the mass of goods supplied by $I$-FDI firms. Foreign $I$-FDI firms incur communication costs between Foreign and Home ($\gamma_N$). The second terms are the mass of varieties supplied by $EP$-FDI firms. Considering that both countries' plants are located in the less developed country, those prices incur both transportation ($\tau$) and communication ($\gamma_S$ and $\gamma_S$) costs. The third terms denote the mass of goods produced by $X$ firms. Foreign $X$ firms incur transportation costs. The last term of (2.20) denotes the mass of varieties produced by $D$ firms.

Applying a Pareto distribution for (2.20) and (2.21) and using the productivity cutoff levels from (2.16) to (2.19) and the definition of the total demand: $B = \frac{1-\alpha}{\alpha^{1-\sigma}}\beta^{\sigma} L(X)^{1-\sigma}$, we can rewrite the CES aggregate as:

$$X_H = \beta^{\frac{\sigma k - \sigma + 1}{k(\sigma-1)}} \left[\frac{m_e k}{k-\sigma+1}\left(\frac{\alpha}{b}\right)^k (1-\alpha)^{\frac{k-\sigma+1}{\sigma-1}}\right]^{\frac{1}{k}} L^{\frac{k-\sigma+1}{k(\sigma-1)}} (\delta_{HH} + \delta_{HF})^{\frac{1}{k}}. \quad (2.22)$$

The terms $\delta_{HH}$ and $\delta_{FH}$ are price components. The sum of both price components is explicitly given by:

$$\delta_{HH} + \delta_{HF} = \left(1 + {\gamma_N}^{1-\sigma}\right) \breve{a}_I^{k-\sigma+1} + 2\left(\tau\gamma_S w_S\right)^{1-\sigma}\left(\breve{a}_{EP}^{k-\sigma+1} - \breve{a}_I^{k-\sigma+1}\right)$$
$$+ \left(1 + \tau^{1-\sigma}\right)\left(\breve{a}_X^{k-\sigma+1} - \breve{a}_{EP}^{k-\sigma+1}\right) + \left(\breve{a}_D^{k-\sigma+1} - \breve{a}_X^{k-\sigma+1}\right), \quad (2.23)$$

where

$$\check{a}_I \equiv \left[\frac{1+{\gamma_N}^{1-\sigma}-2(\tau\gamma_S w_S)^{1-\sigma}}{f_I - f_{EP}}\right]^{\frac{1}{\sigma-1}}, \check{a}_{EP} \equiv \left[\frac{2(\tau\gamma_S w_S)^{1-\sigma}-1-\tau^{1-\sigma}}{f_{EP}-f_X}\right]^{\frac{1}{\sigma-1}},$$
$$\check{a}_X \equiv \left(\frac{\tau^{1-\sigma}}{f_X - f_D}\right)^{\frac{1}{\sigma-1}}, and\ \check{a}_D \equiv \left(\frac{1}{f_D}\right)^{\frac{1}{\sigma-1}}.$$

To fully close the model, we have to pin down the number of the entrants, $m_e$, with the free entry condition. However, by the characteristic of the Cobb-Douglass utility function and the assumption of symmetric developed countries, endogenous $m_e$ consists of exogenous parameters. Concretely, we obtain endogenous entrants as: $m_e = (\sigma-1)(1-\alpha)(1-\beta)L/(kf_e)$. For simplicity, we treat $m_e$ as the exogenous parameter for the following analysis.[10]

## 2.3 Welfare analysis

In this section, we compare welfare effect of the reduction in $\gamma_N$ and $\gamma_S$. We focus on the change in welfare in Home because Home and Foreign are symmetric. Thus, the reduction in communication costs also have the symmetric effects on both countries. In addition, welfare in the less developed country does not change because it depends only on the mass of the homogeneous goods.[11]

### 2.3.1 General case

In this subsection, we do not impose the assumption of the mass of firms using each strategy. Using (2.22), we can rewrite (2.5) as:

$$V_H = \psi_1 + \frac{\beta}{k} ln\,(\delta_{HH} + \delta_{HF}), \tag{2.24}$$

[10]See Appendix for details of deriving the endogenous $m_e$.

[11]Welfare in the less developed country is represented as: $W_S = Z_S L_S$. It is constant and does not change when communication costs change. Thus, we do not consider welfare in the less developed country.

where $\psi_1$ is a positive and constant term.[12] Differentiating (2.24) with respect to $\gamma_S$ and $\gamma_N$, we have:

$$\frac{\partial V_H}{\partial \gamma_S} = -\psi_2 \cdot (\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} \left(2\check{a}_{EP}^{k-\sigma+1} - 2\check{a}_I^{k-\sigma+1}\right), \tag{2.25}$$

$$\frac{\partial V_H}{\partial \gamma_N} = -\psi_2 \cdot {\gamma_N}^{-\sigma} \check{a}_I^{k-\sigma+1}, \tag{2.26}$$

where $\psi_2 \equiv \beta/(\delta_{HH} + \delta_{HF})$. Naturally, the reduction in both communication costs exerts positive impact on welfare. Using (2.25) and (2.26), we define the comparison of welfare effect by the reduction in communication costs as follow:

$$\begin{aligned} \Delta V_H|_{S-N} &\equiv \left| -\frac{\partial V_H}{\partial \gamma_S} \right| - \left| -\frac{\partial V_H}{\partial \gamma_N} \right| \\ &= \psi_2 \left\{ 2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} \check{a}_{EP}^{k-\sigma+1} - \left[ 2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma} \right] \check{a}_I^{k-\sigma+1} \right\}. \end{aligned} \tag{2.27}$$

This equation basically means that the reduction in communication costs between developed and less developed countries is larger (smaller) than those between developed countries, $\Delta V_H|_{S-N} > (\leq) 0$, when the relative mass of $EP$-FDI firms to $I$-FDI firms is large (small). The explanation for the above fact is as follows. When $V_H|_{S-N} > (\leq) 0$ holds, the condition is:

$$\begin{aligned} \Delta V_H|_{S-N} \gtreqless 0 &\Leftrightarrow \frac{\check{a}_{EP}}{\check{a}_I} \gtreqless \left[ \frac{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma}} \right]^{\frac{1}{k-\sigma+1}} \\ &\Leftrightarrow \frac{G(a_{EP})}{G(a_I)} \gtreqless \left[ \frac{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma}} \right]^{\frac{k}{k-\sigma+1}} \equiv \zeta_V. \end{aligned} \tag{2.28}$$

This inequality tends to hold when $\check{a}_{EP}$ is large and $\check{a}_I$ is small. Recall that the term, $\check{a}_i$ ($i = D, X, EP, I$), implies the inverse of the productivity cutoff of each mode. Thus, the larger $\check{a}_{EP}$ means the smaller ${a_{EP}}^{1-\sigma}$ and the smaller $\check{a}_{EP}$ implies the larger ${a_I}^{1-\sigma}$. The relative mass of $EP$-FDI firms to $I$-FDI firms is given as[13]:

$$\frac{m_e \left[G(a_{EP}) - G(a_I)\right]}{m_e G(a_I)} = \frac{G(a_{EP})}{G(a_I)} - 1. \tag{2.29}$$

[12] $\psi_1 \equiv (1-\beta) ln(1-\beta) + \beta \, ln \left\{ \beta^{\frac{\sigma k - \sigma + 1}{k(\sigma-1)}} \left[ \frac{m_e k}{k-\sigma+1} \left(\frac{\alpha}{b}\right)^k (1-\alpha)^{\frac{k-\sigma+1}{\sigma-1}} \right]^{\frac{1}{k}} L^{\frac{k-\sigma+1}{k(\sigma-1)}} \right\}$.

[13] The mass of firms using each strategy is represented as: $m_D = m_e G(a_D) - m_e G(a_X)$, $m_X = m_e G(a_X) - m_e G(a_{EP})$, $m_{EP} = m_e G(a_{EP}) - m_e G(a_I)$, and $m_I = m_e G(a_I)$.

Therefore, when $\check{a}_{EP}$ is large and $\check{a}_I$ is small, the relative mass of $EP$-FDI firms to $I$-FDI firms is large. We summarize the results as the following proposition.

**Proposition 2.1.** *The reduction in $\gamma_S$ ($\gamma_N$) has a larger effect than that in $\gamma_N$ ($\gamma_S$) on welfare when the relative mass of EP-FDI firms to I-FDI firms is large (small).*

Figure 2.1 describes the comparison of welfare effects. The intuition of this proposition is simple. When the relative mass of $EP$-FDI firms to $I$-FDI firms is large; $G(a_{EP})/G(a_I) > \zeta_V$ (small; $G(a_{EP})/G(a_I) < \zeta_V$), the reduction in $\gamma_S$ leads the lower price of the differentiated goods produced by $EP$-FDI firms and large (small) mass of the goods. On the other hand, the reduction in $\gamma_N$ leads the lower price of the differentiated goods supplied by $I$-FDI firms and small (large) mass of the goods. Hence, the reduction in $\gamma_S$ has a larger (smaller) impact on welfare than that in $\gamma_N$ when the relative mass of $EP$-FDI firms to $I$-FDI firms is large (small).

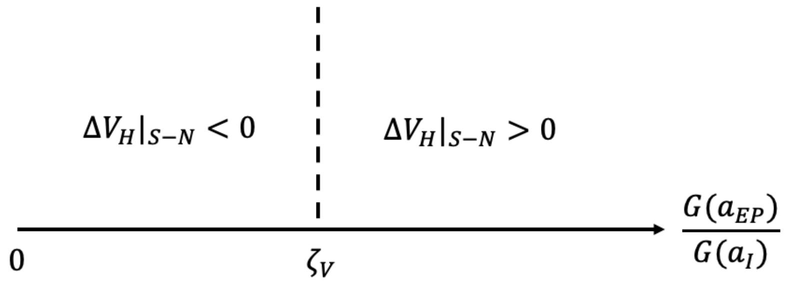



**Figure 2.1.** Comparison of welfare effects.

### 2.3.2 Some specific cases

According to Girma *et al.* (2005) and Tomiura (2007), the mass of exporting firms is larger than the mass of FDI firms in the U.K. and Japan. From these empirical facts, we assume that ($i$) the mass of $X$ firms is larger than the mass of firms using FDI strategies: $m_X > m_e G(a_{EP})$, ($ii$) the mass of $X$ firms is larger than the mass of $EP$-FDI firms: $m_X > m_{EP}$, and ($iii$) the mass of $X$ firms is larger than the mass of $I$-FDI firms: $m_X > m_I$. These conditions are explicitly given as:

$$(i) : \frac{m_e\left[G(a_X) - G(a_{EP})\right]}{m_e G(a_{EP})} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}, \tag{2.30}$$

$$(ii) : \frac{m_e\left[G(a_X) - G(a_{EP})\right]}{m_e\left[G(a_{EP}) - G(a_I)\right]} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)} + \frac{1}{2}, \tag{2.31}$$

$$(iii) : \frac{m_e\left[G(a_X) - G(a_{EP})\right]}{m_e G(a_I)} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} < \frac{G(a_X)}{G(a_I)} - 1. \tag{2.32}$$

The left hand side of the above inequalities represents a relative mass of $EP$-FDI firms to $I$-FDI firms in (2.29). Regarding the relative mass, Head and Mayer (2019) show that the mass of market acquiring FDI ($I$-FDI) is small among the multinationals.[14] Thus, we assume the mass of $EP$-FDI is larger than that of $I$-FDI ($m_{EP} > m_I$). Using (2.29), we yield:

$$\frac{m_e \left[G(a_{EP}) - G(a_I)\right]}{m_e G(a_I)} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} > 2. \tag{2.33}$$

Given (2.33), a range where the conditions (2.30), (2.31), and (2.32) are satisfied is given as[15]:

$$2 < \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}. \tag{2.34}$$

With (2.34), we consider the cases where the cutoff, $\zeta_V$, exists within or outside of the range.[16] Given these restrictions, the result of welfare analysis in general cases is divided into the following three cases.

**Case of low $\boldsymbol{\tau}$**

If the cutoff, $\zeta_V$, is smaller than or equal to 2, we have the following inequality:

$$\left[\frac{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma}}\right]^{\frac{k}{k-\sigma+1}} \leq 2 < \frac{1}{2}\frac{G(a_X)}{G(a_I)}.$$

If this inequality holds, the condition is:

$$\tau w_S \leq \left(\frac{2{\gamma_S}^{-\sigma}}{{\gamma_N}^{-\sigma}}\right)^{\frac{1}{\sigma-1}} \left(2^{\frac{k-\sigma+1}{k}} - 1\right)^{\frac{1}{\sigma-1}} \equiv \zeta_{min}. \tag{2.35}$$

This inequality holds if $\tau$ is sufficiently low. We establish the proposition.

**Proposition 2.2.** *The reduction in $\gamma_S$ has larger effects on welfare than that in $\gamma_N$ when transportation costs, $\tau$, are sufficiently low.*

Figure 2.2 illustrates the comparison of welfare effects when $\tau$ is low. The underlying rationale

[14]They also show that $EP$-FDI is common in the EU multinational car brands invest in other EU countries (see also Head and Mayer 2017). Baldwin and Okubo (2016) also state that the mass of firms using purely horizontal motivated FDI is small while that of firms using complex FDI including $EP$-FDI is large.

[15]See Appendix for the proof.

[16]See Appendix for the conditions that the inequality (2.34) tends to hold.

is as follows. The prices of differentiated goods offered by $EP$-FDI and $I$-FDI firms are given as:

$$p_{EP}(a) = \frac{a\tau\gamma_S w_S}{\alpha},$$
$$p_I(a) = \frac{a\gamma_N}{\alpha}.$$

When transportation costs are low, the price of the goods supplied by $EP$-FDI firms becomes low. This implies that the demand of the differentiated goods is large. If transportation costs are sufficiently small, the demand for the differentiated goods supplied by $EP$-FDI firms becomes sufficiently large. In addition, by the reduction in $\gamma_S$, the price of the differentiated goods supplied by $EP$-FDI firms becomes lower. This implies that the positive effect of the lower price of the differentiated goods supplied by $EP$-FDI firms on welfare is greatly enlarged. Thus, the significantly large demand for the goods supplied by $EP$-FDI firms results in the much larger improvement in consumer utility by the reduction in $\gamma_S$ than that in $\gamma_N$. Therefore, regardless of the relative mass of $EP$-FDI firms to $I$-FDI firms, the reduction in $\gamma_S$ has a greater impact on welfare than that in $\gamma_N$.

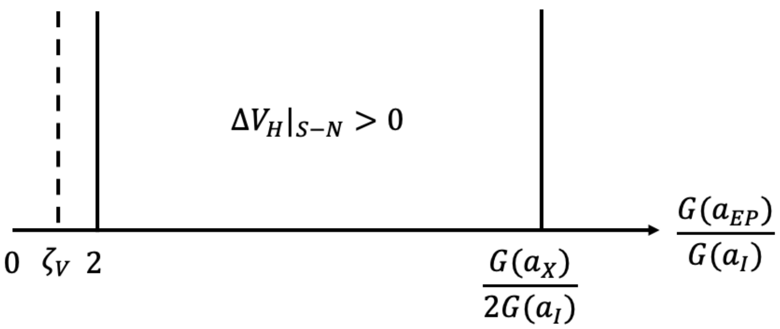



**Figure 2.2.** Comparison of welfare effects with low $\tau$.

### Case of intermediate $\tau$

If the cutoff is larger than 2 but smaller than $G(a_X)/2G(a_I)$, we have the following inequality:

$$2 < \left[\frac{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma} + \gamma_N{}^{-\sigma}}{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}}\right]^{\frac{k}{k-\sigma+1}} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}.$$

If this inequality holds, the conditions are:

$$\zeta_{min} < \tau w_S < \left(\frac{2\gamma_S{}^{-\sigma}}{\gamma_N{}^{-\sigma}}\right)^{\frac{1}{\sigma-1}} \left\{\left[\frac{G(a_X)}{2G(a_I)}\right]^{\frac{k-\sigma+1}{k}} - 1\right\}^{\frac{1}{\sigma-1}} \equiv \zeta_{max}. \tag{2.36}$$

This inequality implies that $\tau$ is at an intermediate level. We can establish the following proposition.

**Proposition 2.3.** *Given the intermediate level of $\tau$ ($\zeta_{min} < \tau w_S < \zeta_{max}$), the reduction in $\gamma_S$ has a larger impact on welfare than that in $\gamma_N$ with large relative mass of $EP$-FDI firms to $I$-FDI firms. While, the reduction in $\gamma_N$ has a larger impact on welfare than that in $\gamma_S$ when the relative share of $EP$-FDI is large.*

Figure 2.3 presents a welfare impact for an intermediate level of $\tau$. The intuition is as follows. When $\tau$ is at an intermediate level, the price the differentiated goods supplied by $EP$-FDI firms is also at an intermediate level. This implies that the difference between the prices, $p_{EP}(a)$ and $p_I(a)$, is not substantial. In addition, the difference between the demand for differentiated goods supplied by both firms is not considerable. Thus, the difference in the improvement in consumer utility resulting from the reduction in $\gamma_S$ and $\gamma_N$ is not significant and a welfare impact is contingent upon the relative mass of $EP$-FDI firms to $I$-FDI firms. As observed from Figure 2.3, when the relative mass of $EP$-FDI firms is small with $2 < G(a_{EP})/G(a_I) < \zeta_V$, the reduction in $\gamma_S$ has a smaller impact on welfare compared to the reduction in $\gamma_N$. Conversely, when the relative share of $EP$-FDI firms is large with $\zeta_V < G(a_{EP})/G(a_I) < G(a_X)/2G(a_I)$, the reduction in $\gamma_S$ has a larger impact on welfare than that in $\gamma_N$.

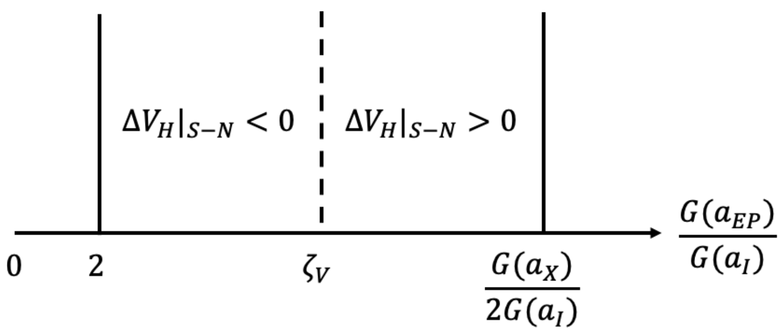



**Figure 2.3.** Comparison of welfare effects with intermediate $\tau$.

**Case of high $\tau$**

If the cutoff is larger than or equal to $G(a_X)/2G(a_I)$, we have the following inequality:

$$2 < \frac{1}{2}\frac{G(a_X)}{G(a_I)} \leq \left[\frac{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma}}\right]^{\frac{k}{k-\sigma+1}}.$$

If this inequality holds, the condition is:

$$\tau w_S \geq \zeta_{max}. \tag{2.37}$$

This immediately yields the following proposition.

**Proposition 2.4.** *Given the sufficiently high level of $\tau$ ($\tau w_S \geq \zeta_{max}$), the reduction in $\gamma_N$ has a larger impact on welfare than that in $\gamma_S$.*

Figure 2.4 illustrates welfare comparison under high $\tau$. The rationale behind this proposition is as follows. In contrast to case of low $\tau$, high transportation costs results in the high price of the goods supplied by $EP$-FDI firms. Along with the high price, the mass of the differentiated goods produced by $EP$-FDI firms becomes small. If transportation costs are sufficiently high, it leads the significantly small mass of the differentiated goods offered by $EP$-FDI firms. With the sufficiently small demand for the goods supplied by $EP$-FDI firms, the improvement in consumer utility by the lower price of the differentiated goods resulting from the reduction in $\gamma_S$ is much smaller than $\gamma_N$. Consequently, regardless of the relative mass of $EP$-FDI firms to $I$-FDI firms, the reduction in $\gamma_N$ has a more substantial impact on welfare than that in $\gamma_S$.

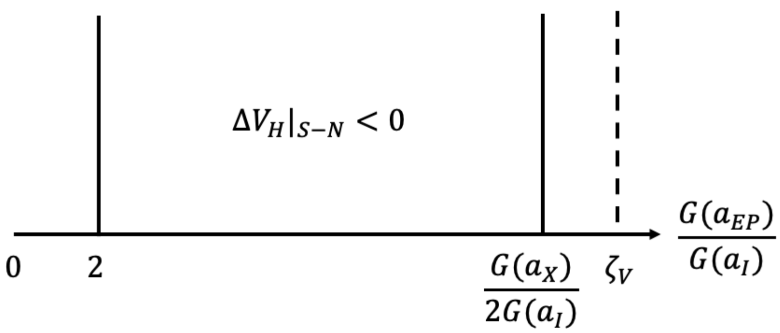



**Figure 2.4.** Comparison of welfare effects with high $\tau$.

## 2.4 Extension

We have analyzed the equilibrium without $M$-FDI firms. Our main results from Proposition 2.1 to Proposition 2.4 still hold when $M$-FDI firms exist and the mass of the $I$-FDI firms is small.[17] For Proposition 2.1, the reduction in $\gamma_S$ has a larger impact than that in $\gamma_N$ in a wider range if $M$-FDI firms exist. This is because the reduction in $\gamma_S$ decreases the costs of $M$-FDI firms, thereby increasing the profit of those firms. This implies that the reduction in $\gamma_S$ has an additional positive impact on welfare through $M$-FDI firms. On the other hand, the reduction in $\gamma_N$ does not change the profit of $M$-FDI firms. Furthermore, the existence of $M$-FDI firms implies that the range of productivity of $I$-FDI firms is reduced from $a^{1-\sigma} \in (a_I^{1-\sigma}, \infty)$ to $a^{1-\sigma} \in (a_I^{1-\sigma}, a_M^{1-\sigma}]$. This leads to the result that the effects of the reduction in $\gamma_N$ is weakened because the mass of $I$-FDI firms becomes smaller with $M$-FDI firms. Specifically, if $M$-FDI firms exist, the condition (2.28) becomes:

$$\Delta\tilde{V}_H|_{S-N} \gtreqless 0 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} \gtreqless \left\{ \frac{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma} + \gamma_N{}^{-\sigma}}{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}} - \frac{(\tau w_S)^{1-\sigma}+1}{2(\tau w_S)^{1-\sigma}} \left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k}{k-\sigma+1}} \right\}^{\frac{k-\sigma+1}{k}} \equiv \tilde{\zeta}_V.$$

Comparing the cutoff values, $\tilde{\zeta}_V$ and $\zeta_V$, we can prove the following relationship:

$$\tilde{\zeta}_V < \zeta_V.$$

This inequality implies the reduction in $\gamma_S$ has a larger impact than that in $\gamma_N$ with a wider range if the $M$-FDI firms exist. This intuition is as follows. As discussed above, the reduction in $\gamma_N$ is weakened because the mass of $I$-FDI firms becomes smaller with the $M$-FDI firms. Furthermore, the reduction in $\gamma_S$ has an additional positive effects by increasing profits of the $M$-FDI firms. Therefore, the reduction in $\gamma_S$ has larger effects on welfare in a wider range than that in $\gamma_N$ with $M$-FDI firms. Corresponding to this results, the level of $\tau$ to hold Proposition 2.2, Proposition 2.3, and Proposition 2.4 becomes larger because the reduction in $\gamma_S$ has an additional positive effects through the $M$-FDI firms' profit increase.

[17] See Appendix 2.$B$ for details.

## 2.5 Conclusion

In this paper, we incorporate firm heterogeneity, as in Melitz (2003) and Helpman *et al.* (2004), and integrate the difference in communication costs between developed countries, as well as between developed and less developed countries, into a three-country model. We derive the industry equilibrium where $EP$-FDI firms, $I$-FDI firms, exporting firms, and domestic firms coexist, and demonstrate a welfare impact of the reduction in communication costs between developed countries and developed and less developed countries.

The study yields three key findings. First, in a case where transportation costs are low, the reduction in communication costs between the developed and less developed countries consistently has a larger impact on welfare than that between the developed countries. Second, in a situation where transportation costs are at an intermediate level, welfare effects of reducing communication costs depend on the relative mass of $EP$-FDI firms to $I$-FDI firms. Third, when transportation costs are high, the decrease in communication costs between the developed countries consistently has a larger impact on welfare than that between the developed and less developed countries.

The non-monotonic welfare impact identified in this study have significant implications for the current economic landscape, particularly in light of the increasing investment in ICTs for the fiber optic broadband network, driven by the emergence of $5G$ technology. The adoption of $5G$ technology leads to a reduction in communication costs, which prompts governments in developed countries to carefully consider the optimal countries in which to invest in ICT infrastructure to achieve welfare improvement more. In the context of real economy, such as the EU, where transportation costs are generally considered to be at a low level because of the free trade area, our model demonstrates that the decrease in communication costs between developed countries yields a more favorable impact on welfare than that between developed and less developed countries.

While we anticipate that these findings will make a valuable contribution to existing literature, it is crucial to acknowledge that they rest on some restrictive assumptions. Specifically, we impose the assumption that the consumption of differentiated goods by the less developed country is absent. However, it would be more comprehensive to incorporate the consumption patterns of the less developed country, as demonstrated in the study by Grossman *et al.* (2006). As part of our research agenda, we are committed to addressing this assumption and conducting a more thorough analysis of the interplay between FDI and communication costs, with the aim of enhancing our understanding of this complex relationship.

# Appendix 2.A

## 2.A.1 Endogenous mass of entrants

To pin down the mass of entrants, we equalize the expected profits to entry costs. This equation is expressed as:

$$\begin{aligned}
&\int_{a_X}^{a_D} \pi_D(a)\, G(a) + \int_{a_{EP}}^{a_X} \pi_X(a)\, G(a) + \int_{a_I}^{a_{EP}} \pi_P(a)\, G(a) + \int_{0}^{a_I} \pi_I(a)\, G(a) = f_e \\
&\Leftrightarrow [O(a_D) - O(a_X)]\, B + (1+\tau^{1-\sigma})[O(a_X) - O(a_{EP})]B \\
&\quad + 2(\tau\gamma_S w_S)^{1-\sigma}[O(a_{EP}) - O(a_{I)}]B + (1+{\gamma_N}^{1-\sigma})O(a_I)B \\
&\quad - f_D[G(a_D) - G(a_X)] - f_X[G(a_X) - G(a_{EP})] - f_{EP}[G(a_{EP}) - G(a_I)] - f_I G(a_I) = f_e.
\end{aligned}$$

With the symmetric assumption of developed countries and using the expressions for productivity cutoffs from (2.16) to (2.19), $O(a) = (k/(k-\sigma+1))\ b^{-k}\ a^{k-\sigma+1}$, $G(a) = b^{-k}a^k$, and $B = \frac{1-\alpha}{\alpha^{1-\sigma}}\beta^\sigma L(X)^{1-\sigma}$, we can rewrite the above equation as follows:

$$\begin{aligned}
\frac{\sigma-1}{k}(1-\alpha)(1-\beta)L\frac{1}{m_e} &= f_e \\
\Leftrightarrow m_e &= \frac{(\sigma-1)(1-\alpha)(1-\beta)L}{kf_e}.
\end{aligned}$$

Thus, the mass of entrants only consists of exogenous parameters, which is fixed.

## 2.A.2 Related detail for (2.34)

**Detail for deriving (2.34)**

Comparing the right hand side of (2.30) with (2.31), we have:

$$\underbrace{\frac{1}{2}\frac{G(a_X)}{G(a_I)}}_{RHS\ of\ (2.30)} < \underbrace{\frac{1}{2}\frac{G(a_X)}{G(a_I)} + \frac{1}{2}}_{RHS\ of\ (2.31)}.$$

This inequality implies that (2.30) is a necessary and sufficient condition for both (2.30) and (2.31) to hold. The conditions that the right hand side of (2.30) is greater than that of (2.32) is given as:

$$\underbrace{\frac{1}{2}\frac{G(a_X)}{G(a_I)}}_{RHS\ of\ (2.30)} < \underbrace{\frac{G(a_X)}{G(a_I)} - 1}_{RHS\ of\ (2.32)} \Leftrightarrow G(a_X) > 2G(a_I). \tag{2.A.1}$$

Combining $G(a_X) > 2G(a_{EP})$ by (2.30) with $G(a_{EP}) > 2G(a_I)$ by (2.31), we must have: $G(a_X) > 4G(a_I)$. With this condition, the inequality (2.A.1) always holds. This implies that (2.30) is necessary and sufficient conditions for both (2.30) and (2.33) hold. Therefore, the condition that (2.30), (2.31), (2.32), and (2.33) are all satisfied is given as:

$$2 < \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}.$$

This condition is the exactly same as (2.34).

**The conditions that (2.34) tends to hold**

To have the inequality, $2 < \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}$, hold, the following two conditions must be satisfied

$$2 < \frac{G(a_{EP})}{G(a_I)} \Leftrightarrow \left[\frac{f_{EP} - f_X}{f_I - f_{EP}} \cdot \frac{1 + {\gamma_N}^{1-\sigma} - 2(\tau\gamma_S w_s)^{1-\sigma}}{2(\tau\gamma_S w_s)^{1-\sigma} - \tau^{1-\sigma} - 1}\right]^{\frac{k}{\sigma-1}} < \frac{1}{2},$$
$$\frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)} \Leftrightarrow \left[\frac{f_X - f_D}{f_{EP} - f_X} \cdot \frac{2(\tau\gamma_S w_s)^{1-\sigma} - \tau^{1-\sigma} - 1}{\tau^{1-\sigma}}\right]^{\frac{k}{\sigma-1}} < \frac{1}{2}.$$

The left hand side of the first inequality is decreasing in $f_I - f_{EP}$ but increasing in $f_{EP} - f_X$. On the other hand, the left hand side of the second inequality is decreasing in $f_{EP} - f_X$. This implies that the range, (2.34), tends to hold when $f_I - f_{EP}$ is sufficiently greater than $f_{EP} - f_X$.

# Appendix 2.B

In this section, we analyze the case where all strategies exist. Set (2.14) = (2.15), the productivity cutoff of $M$-FDI is represented as:

$${a_M}^{1-\sigma} = \frac{\alpha^{1-\sigma}(f_M - f_I)}{(1-\alpha)\left[(\tau\gamma_S w_S)^{1-\sigma} - {\gamma_N}^{1-\sigma}\right]B}.$$

The partial aggregates with $M$-FDI firms yield the new CES aggregates as follows:

$$\tilde{X}_H = \beta^{\frac{\sigma k - \sigma + 1}{k(\sigma-1)}} \left[ \frac{m_e k}{k - \sigma + 1} \left( \frac{\alpha}{b} \right)^k (1-\alpha)^{\frac{k-\sigma+1}{\sigma-1}} \right]^{\frac{1}{k}} L^{\frac{k-\sigma+1}{k(\sigma-1)}}$$
$$\cdot \left\{ \delta_{HH} + \delta_{HF} + \left[ (\tau \gamma_S w_S)^{1-\sigma} - {\gamma_N}^{1-\sigma} \right] \breve{a}_M^{k-\sigma+1} \right\}^{\frac{1}{k}},$$

where $\breve{a}_M \equiv \left[ \frac{(\tau\gamma_S w_S)^{1-\sigma} - {\gamma_N}^{1-\sigma}}{f_M - f_I} \right]^{\frac{1}{\sigma-1}}$. Using the CES aggregate, we can derive the indirect utility function as:

$$\tilde{V}_H = \psi_1 + \frac{\beta}{k} ln \left\{ \delta_{HH} + \delta_{HF} + \left[ (\tau \gamma_S w_S)^{1-\sigma} - {\gamma_N}^{1-\sigma} \right] \breve{a}_M^{k-\sigma+1} \right\}.$$

The derivatives, (2.25) and (2.26), become:

$$\frac{\partial \tilde{V}_H}{\partial \gamma_S} = -\tilde{\psi}_2 \cdot (\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} \left( 2\breve{a}_{EP}^{k-\sigma+1} - 2\breve{a}_I^{k-\sigma+1} + \breve{a}_M^{k-\sigma+1} \right),$$
$$\frac{\partial \tilde{V}_H}{\partial \gamma_N} = -\tilde{\psi}_2 \cdot {\gamma_N}^{-\sigma} \left( \breve{a}_I^{k-\sigma+1} - \breve{a}_M^{k-\sigma+1} \right),$$

where $\tilde{\psi}_2 \equiv \beta / \left\{ \delta_{HH} + \delta_{HF} + [(\tau\gamma_S w_S)^{1-\sigma} - {\gamma_N}^{1-\sigma}] \breve{a}_M^{k-\sigma+1} \right\}$. Define the difference between the effects on welfare by the redaction in communication cost as follows:

$$\Delta \tilde{V}_H|_{S-N} \equiv \left| -\frac{\partial \tilde{V}_H}{\partial \gamma_S} \right| - \left| -\frac{\partial \tilde{V}_H}{\partial \gamma_N} \right|$$
$$= \tilde{\psi}_2 \left\{ 2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} \breve{a}_{EP}^{k-\sigma+1} - \left[ 2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma} \right] \breve{a}_I^{k-\sigma+1} \right.$$
$$\left. + \left[ (\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma} \right] \breve{a}_M^{k-\sigma+1} \right\}.$$

The condition of the signs of the difference is:

$$\Delta \tilde{V}_H|_{S-N} \gtreqless 0$$
$$\Leftrightarrow \frac{G(a_{EP})}{G(a_I)} \gtreqless \left\{ \frac{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma}} - \frac{(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma} {\gamma_S}^{-\sigma}} \left[ \frac{G(a_M)}{G(a_I)} \right]^{\frac{k-\sigma+1}{k}} \right\}^{\frac{k}{k-\sigma+1}} \equiv \tilde{\zeta}_V.$$

Figure 2.A.1 shows the movement of the cutoff of welfare effects with $M$-FDI.

The assumptions that $(\tilde{i})$ the mass of $X$ firms is larger than the mass of firms using FDI strategies ($m_X > m_e G(a_{EP})$ ) and $(\tilde{ii})$ the mass of $X$ firms is larger than the mass of $EP$-FDI

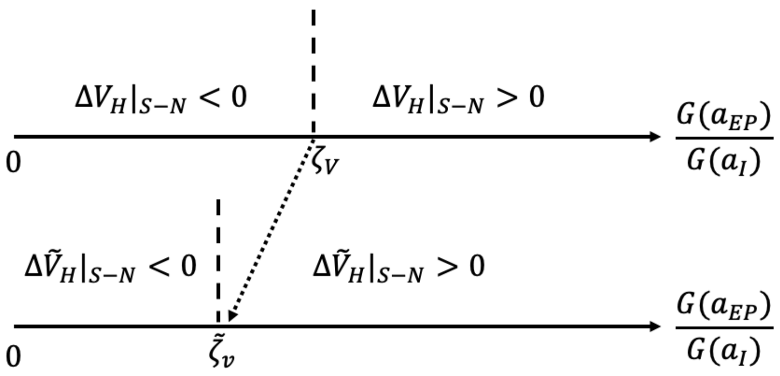



**Figure 2.A.1.** The cutoff change with $M$-FDI firms.

firms ($m_X > m_{EP}$ ) are the same conditions as (2.30) and (2.31). However, the assumption that $(\tilde{iii})$ the mass of $X$ firms is larger than the mass of $I$-FDI firms ($m_X > m_I$ ) is different from (2.32) and becomes:

$$(\tilde{iii}) : \frac{m_e\left[G(a_X) - G(a_{EP})\right]}{m_e\left[G(a_I) - G(a_M)\right]} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} < \frac{G(a_X)}{G(a_I)} + \frac{G(a_M)}{G(a_I)} - 1.$$

The assumption that the mass of $EP$-FDI firms is larger than that of $I$-FDI firms is:

$$\frac{m_e\left[G(a_{EP}) - G(a_I)\right]}{m_e\left[G(a_I) - G(a_M)\right]} > 1 \Leftrightarrow \frac{G(a_{EP})}{G(a_I)} > 2 - \frac{G(a_M)}{G(a_I)}.$$

The analysing area is given as:

$$2 - \frac{G(a_M)}{G(a_I)} < \frac{G(a_{EP})}{G(a_I)} < \frac{1}{2}\frac{G(a_X)}{G(a_I)}.$$

Next we consider the cutoff values, $\zeta_{min}$ and $\zeta_{max}$, with $M$-FDI firms.

**Comparison of $\tilde{\zeta}_{min}$ with $\zeta_{min}$**

The condition for low $\tau$ with $M$-FDI firms is represented as:

$$\left\{\frac{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}+\gamma_N{}^{-\sigma}}{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}}-\frac{(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}+\gamma_N{}^{-\sigma}}{2(\tau w_S)^{1-\sigma}\gamma_S{}^{-\sigma}}\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}\right\}^{\frac{k}{k-\sigma+1}}\le 2-\frac{G(a_M)}{G(a_I)}$$

$$\Leftrightarrow \tau w_S \le \left(\frac{\gamma_S{}^{-\sigma}}{\gamma_N{}^{-\sigma}}\right)^{\frac{1}{\sigma-1}}\left\{\frac{2\left[2-\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}-2+\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}}{1-\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}}\right\}^{\frac{1}{\sigma-1}}\equiv \tilde{\zeta}_{min}.$$

Differentiating $\tilde{\zeta}_{min}$ with respect to $G(a_M)/G(a_I)$, we obtain:

$$\frac{\partial\tilde{\zeta}_{min}}{\partial\frac{G(a_M)}{G(a_I)}}=\frac{2\left(\frac{\gamma_S{}^{-\sigma}}{\gamma_N{}^{-\sigma}}\right)^{\frac{1}{\sigma-1}}\left(\frac{k-\sigma+1}{k}\right)\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{1-\sigma}{k}}\left(2-\frac{G(a_M)}{G(a_I)}\right)^{\frac{1-\sigma}{k}}\underbrace{\left\{2-\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{\sigma-1}{k}}-\frac{1}{2}\left(2-\frac{G(a_M)}{G(a_I)}\right)^{\frac{\sigma-1}{k}}\right\}}_{\equiv J}}{(\sigma-1)\left(\tilde{\zeta}_{min}\right)\left\{1-\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}\right\}^2}.$$

The sign of the derivative depends on the sign of $J$. Differentiating $J$ with respect to $G(a_M)/G(a_I)$ gives:

$$\frac{\partial J}{\partial\frac{G(a_M)}{G(a_I)}}=\frac{\sigma-1}{k}\left\{\frac{1}{2}\left[2-\frac{G(a_M)}{G(a_I)}\right]^{\frac{-(k-\sigma+1)}{k}}-\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{-(k-\sigma+1)}{k}}\right\}.$$

Suppose $\partial J/\partial[G(a_M)/G(a_I)]\ge 0$. This implies:

$$\frac{1}{2}\left[2-\frac{G(a_M)}{G(a_I)}\right]^{\frac{-(k-\sigma+1)}{k}}-\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{-(k-\sigma+1)}{k}}\ge 0$$
$$\Leftrightarrow 2^{\frac{-k}{k-\sigma+1}}\frac{G(a_M)}{G(a_I)}+\frac{G(a_M)}{G(a_I)}-2\ge 0.$$

The left hand side of the above inequality is increasing in $G(a_M)/G(a_I)$. Substituting $G(a_M)/G(a_I)=1$ into the left hand side of the above inequality, we have:

$$2^{\frac{-k}{k-\sigma+1}}-1\ge 0.$$

This is a contradiction. Thus, we must have:

$$\frac{\partial J}{\partial \frac{G(a_M)}{G(a_I)}} < 0.$$

Now we know that $J$ is decreasing in $G(a_M)/G(a_I)$. This implies that the around $G(a_M)/G(a_I) = 1$, the value of $J$ becomes a minimum. Substituting $G(a_M)/G(a_I) = 1$ into $J$, we have:

$$J|_{\frac{G(a_M)}{G(a_I)}=1} = \frac{1}{2} > 0.$$

From this relationship, $J$ is positive with $G(a_M)/G(a_I) \in (0, 1)$. Therefore, we have:

$$\frac{\partial \tilde{\zeta}_{min}}{\partial \frac{G(a_M)}{G(a_I)}} > 0.$$

From this relationship, $\tilde{\zeta}_{min}$ assumes a minimum value around $G(a_M)/G(a_I) = 0$. Substituting $G(a_M) = 0$ into $\tilde{\zeta}_{min}$, we have:

$$\tilde{\zeta}_{min}|_{G(a_M)=0} = \left(\frac{2{\gamma_S}^{-\sigma}}{{\gamma_N}^{-\sigma}}\right)^{\frac{1}{\sigma-1}} \left(2^{\frac{k-\sigma+1}{k}} - 1\right)^{\frac{1}{\sigma-1}} \equiv \zeta_{min}.$$

With $G(a_M)/G(a_I) \in (0, 1)$, we have:

$$\tilde{\zeta}_{min} > \zeta_{min}.$$

**Comparison of $\tilde{\zeta}_{max}$ with $\zeta_{max}$**

The condition for high $\tau$ with $M$-FDI firms is represented as:

$$\frac{1}{2}\frac{G(a_X)}{G(a_I)} \leq \left\{\frac{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma}} - \frac{(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma} + {\gamma_N}^{-\sigma}}{2(\tau w_S)^{1-\sigma}{\gamma_S}^{-\sigma}}\left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}\right\}^{\frac{k}{k-\sigma+1}}$$

$$\Leftrightarrow \tau w_S \geq \left(\frac{{\gamma_S}^{-\sigma}}{{\gamma_N}^{-\sigma}}\right)^{\frac{1}{\sigma-1}} \left\{\frac{2\left[\frac{G(a_X)}{2G(a_I)}\right]^{\frac{k-\sigma+1}{k}} - 2 + \left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}}{1 - \left[\frac{G(a_M)}{G(a_I)}\right]^{\frac{k-\sigma+1}{k}}}\right\}^{\frac{1}{\sigma-1}} \equiv \tilde{\zeta}_{max}.$$

We can easily prove that $\tilde{\zeta}_{max}$ is increasing in $G(a_M)/G(a_I)$. This implies $\tilde{\zeta}_{max}$ is minimum around $G(a_M)/G(a_I) = 0$. Substituting $G(a_M) = 0$ into $\tilde{\zeta}_{max}$, we have:

$$\tilde{\zeta}_{max}|_{G(a_M)=0} = \left(\frac{2\gamma_S{}^{-\sigma}}{\gamma_N{}^{-\sigma}}\right)^{\frac{1}{\sigma-1}} \left\{\left[\frac{G(a_X)}{2G(a_I)}\right]^{\frac{k-\sigma+1}{k}} - 1\right\}^{\frac{1}{\sigma-1}} \equiv \zeta_{max}.$$

With $G(a_M)/G(a_I) \in (0, 1)$, we have:

$$\tilde{\zeta}_{max} > \zeta_{max}.$$

Figure 2.A.2 below describes the change in $\zeta_{min}$ and $\zeta_{max}$ with $M$-FDI firms.

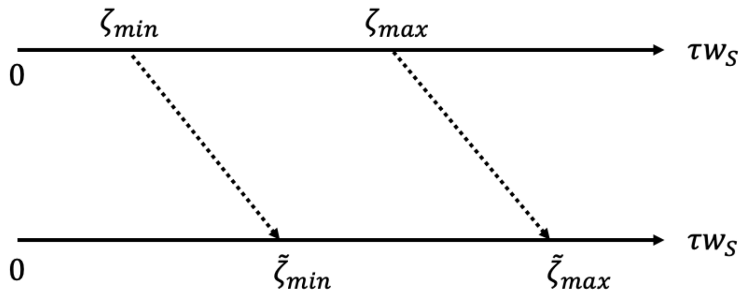



**Figure 2.A.2.** Change in $\zeta_{min}$ and $\zeta_{max}$ with $M$-FDI firms.

The above $\tilde{\zeta}_{min}$ and $\tilde{\zeta}_{max}$ imply that a higher level of $\tau$ is required for Propositions 2.2 – 2.4 to hold with $M$-FDI firms.

# Chapter 3

# FDI Subsidies in a General Oligopolistic Equilibrium Model

## 3.1 Introduction

According to a report by UNCTAD (2022), the amount of foreign direct investment (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 currently 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 by MNEs are evaluated as benefits for the host country's interests. Thus, the policymakers have thus been open to the foreign affiliates of MNEs. Countries with favorable attitudes toward FDI seek to attract it through incentives like tax breaks, employment subsidies, and industrial facility construction. In fact, these measures affect the MNE's behavior.

A typical example is 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. Consequently, 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 considered crucial in investment decision-making.[1] However, policies aiming to attract FDI do not automatically guarantee an immediate enhancement of the host country's welfare.[2] Ultimately, it is crucial to weigh the benefits of subsidies attracting MNEs against the fiscal costs incurred.

In developed countries, 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, some governments face challenges in collecting income taxes. According to OECD Revenue Statistics, labor income taxes account for a very small percentage of the total tax revenue in Chile and Colombia (approximately 10.8% and 6.7%, respectively) in 2021. The main source of tax revenue in these two countries is consumption tax, accounting for approximately 50% of total tax revenue. Regarding less developed countries such as China, Indonesia, Thailand, and Vietnam, the proportion of labor income tax to total tax revenue is low, at 5.6%, 10.8%, 11.3%, and 8.0%, respectively. Conversely, 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 toward FDI affect welfare. Specifically, the question is how welfare effects vary when providing FDI subsidies for "fixed costs" to attract foreign monopoly firms such as TSMC, depending on the financing source

To answer this question, we utilize a general oligopolistic equilibrium (GOLE) model devel-

[1]Host 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. However, Lim (2008) reveals that the establishment of a investment promotion agency (IPA) in a host country leads to an increase in FDI inflows.

[2]The 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. However, Borensztein *et al.* (1998) and Carkovic and Levine (2005) reveal that FDI does not have an impact on the host country's economic growth.

oped 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 where they operate, but they are small economic players in the overall economy. Therefore, the GOLE model allows analyzing the significant 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]

We construct a model assuming two symmetric countries (Home and Foreign) with the presence of export industries, Home FDI industries, and Foreign FDI industries using the fundamental GOLE model developed by Neary (2016). In each export industry, Home and Foreign firms produce goods under oligopolistic competition. In each Home FDI industry, only the Home monopolistic firm produces goods, and in each Foreign FDI industry, only the Foreign monopolistic firm produces goods. To produce goods, we assume the labor coefficients of the export industries and the FDI industries are different. Furthermore, we assume the labor coefficients of the Home and Foreign FDI firms 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 symmetrically. The results show that the small subsidies financed by consumption taxes can improve welfare.

Concerning the welfare impact of FDI subsidies financed by labor income taxes, the result shows that these subsidies do not influence welfare. This is because labor income taxes do not distort consumption, and subsidies do not impact firm production levels. 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, they distort demand and supply. This negative shock affects the labor market, resulting in a decrease in the wage

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

[4]The literature using a GOLE model has been expanding. See Bastos and Kreickemeier (2009), Egger and Etzel (2012), Fujiwara (2017), and Beladi and Chakrabarti (2019).

when the government provides a small subsidy. The wage reduction leads to lower producer prices. Assuming the labor coefficient of the exporting industries is smaller than that of Home and Foreign FDI industries, consumer prices (producer prices plus consumption taxes) of exporting industries increase, while those of Home and Foreign FDI industries decrease.

Welfare tends to improve when the consumer prices of exporting industries are low and those of FDI industries are high. Specifically, welfare tends to increase when trade costs are small, fixed costs of FDI are at an intermediate level, and the exporting industries' labor coefficient is sufficiently large. With low trade costs, consumer prices in exporting industries are low, whereas those in FDI industries are high. When fixed costs of FDI are at the intermediate level, it confirms that the wage, outputs, and prices are positive. Additionally, the size of the negative shock on the producer prices in the both industries is not so different with the intermediate level of the fixed costs. If the labor coefficient of exporting industries is sufficiently large, the response to wage changes increases. This leads the result that a negative shock induced by wage reduction on producer prices of exporting industries is significantly large. In addition, this large negative shock results in the small increase in the consumer prices of the exporting industries. Thus, welfare tends to increase under these conditions.

This paper is a pioneering contribution to the extensive literature on the welfare effects of FDI subsidies. It represents the first attempt, to the best of my knowledge, to apply a GOLE framework to the policy issue of FDI. The model allows 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 an under-explored question within this model.

This study 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. Unlike this study, 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) extend the model presented by Chor (2009).

They compare the welfare effects of variable-cost subsidies for FDI financed by labor income taxes with consumption taxes and corporate income taxes. They reveal that subsidies financed by labor income taxes have 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 additional negative effects on demand and supply. In contrast to their papers, we assume monopolistic FDI firms and compare the welfare effects of fixed-cost FDI subsidies financed by labor income and consumption taxes. Additionally, we analyze the welfare effects under the general equilibrium model.[5]

The remainder of this paper is organized as follows. Section 3.2 describes the basic model. Section 3.3 examines the welfare effect of subsidies for fixed costs financed by labor income taxes. Section 3.4 analyzes the welfare effect of subsidies for fixed costs financed by consumption taxes. Section 3.5 concludes the paper.

## 3.2 Basic Model

### 3.2.1 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:

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

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

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

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

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

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

where $\lambda$ is the Lagrangean multiplier and the marginal utility of income. A crucial assumption commonly made in the GOLE model is that all firms take $\lambda$ as given when maximizing their profit. In other words, oligopolistic firms are "large" in their product market but "small" in the overall economy, including the labor market. Furthermore, as discussed in Neary (2003a), this model has one degree of freedom when solving for nominal variables. This means that we can choose an arbitrary numéraire without affecting the model's properties. Thus, we choose the marginal utility of income as the numéraire: $\lambda = 1$. With $\lambda = 1$, the demand function becomes:

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

Substituting the demand function into the utility function yields the indirect utility function:

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

This expression is a convenient method for evaluating consumer welfare because the indirect utility only depends on the second moment of prices.

### 3.2.2 Supply

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

$$p_X^H = a - q_X^{HH} - q_X^{FH}$$
$$p_X^F = a - q_X^{FF} - q_X^{HF}$$

where $q_X^{HH}$ is Home exporting firm's goods for Home, $q_X^{FH}$ is Foreign exporting firm's goods for Home, $q_X^{FF}$ is Foreign exporting firm's goods for Foreign, and $q_X^{HF}$ is Home exporting firm's goods for Foreign.

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

$$p_{I_H}^{HH} = a - q_{I_H}^{HH}, \quad p_{I_H}^{FH} = a - q_{I_H}^{FH},$$

where $q_{I_H}^{HH}$ is Home FDI firm's goods for Home and $q_{I_F}^{FH}$ is Foreign FDI firm's goods for Home. The inverse demand functions in Foreign become:

$$p_{I_F}^{FF} = a - q_{I_F}^{FF}, \quad p_{I_F}^{HF} = a - q_{I_F}^{HF}.$$

where $q_{I_F}^{FF}$ is Foreign FDI firm's goods for Foreign and $q_{I_H}^{HF}$ is Home FDI firm's goods for Foreign.

Regarding the production technology, constant marginal labor input for exporting industries is $\alpha_X$ and that for Home and Foreign FDI industries is $\alpha_I$. Firms in the exporting industries incur specific trade costs, $\tau$, to provide goods for 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 source country. Considering these assumptions, profit functions of Home exporting and FDI firms become:

$$\pi_X^H = p_X^H q_X^{HH} + p_X^F q_X^{HF} - w\alpha_X(q_X^{HH} + q_X^{HF}) - \tau q_X^{HF}, \tag{3.1}$$

$$\pi_I^H = p_I^{HH} q_I^{HH} + p_I^{HF} q_I^{HF} - w\alpha_I(q_I^{HH} + q_I^{HF}) - wf, \tag{3.2}$$

where $w$ is the wage in Home, which is the same level as in Foreign owing to symmetric assumption. Naturally, the foreign firms' profit is determined analogously. In the exporting industries, the firms produce goods under a Cournot competition. First order conditions of a 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 $q_X^{HF} = q_X^{FH}$. Given these conditions, the Cournot equilibrium outputs become:

$$q_X^{HH} = \frac{a - w\alpha_X + \tau}{3}, \quad q_X^{HF} = \frac{a - w\alpha_X - 2\tau}{3}. \tag{3.3}$$

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

$$q_I^{HH} = \frac{a - w\alpha_I}{2}, \quad q_I^{HF} = \frac{a - w\alpha_I}{2}. \tag{3.4}$$

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

### 3.2.3 Labor market equilibrium

In the GOLE model, the wage is endogenously determined. To close the model, an additional condition is required. 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:

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

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

$$w = \frac{[2(1-2z^*)\alpha_X + 3z^*\alpha_I]a - (1-2z^*)\alpha_X\tau - 3(L - z^* f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.5}$$

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

**Lemma 3.1.** *Trade costs decrease the wage, but fixed costs increase 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, $\int_{2z^*}^{1} (q_X^{HH} + q_X^{HF}) dX$, 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. Conversely, if the fixed costs decrease, the outputs of Home and Foreign FDI firms for the Home consumer, $\int_0^{z^*} q_I^{HH} dI_H$ and $\int_{z^*}^{2z^*} q_I^{HF} dI_F$, 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.

### 3.2.4 General equilibrium

In this subsection, we derive the general equilibrium outputs and prices explicitly. Substituting (3.5) into (3.3), We can yield general equilibrium outputs of a Home firm in an exporting industry as follows:

$$q_X^{HH} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)a + [(1-2z^*)\alpha_X^2 + z^*\alpha_I^2]\tau + \alpha_X(L - z^*f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \tag{3.6}$$

$$q_X^{HF} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)a - [(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau + \alpha_X(L - z^*f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.7}$$

Using (3.6) and (3.7), a general equilibrium price of the Home exporting industry becomes:

$$p_X^H = \frac{[2(1-2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2]a + z^*\alpha_I^2\tau - 2\alpha_X[L - z^*f]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.8}$$

We obtain the following lemma immediately:

**Lemma 3.2.** *Both trade costs and fixed costs of FDI increase the general equilibrium price of the Home exporting industries.*

*Proof.* See Appendix. □

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 (3.1), decrease. Lemma 3.1 suggests an additional effect resulting from the wage reduction caused by decreased trade costs. This effect contributes positively to the marginal costs. However, 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. However, the decrease in fixed costs of FDI only affects the marginal costs negatively, owing to the wage reduction explained in Lemma 3.1. Therefore, as the fixed costs of FDI decrease, the price of the exporting industries also decreases.

Substituting (3.5) into (3.4), we obtain the general equilibrium outputs of a Home FDI firms as follows:

$$q_I^{HH} = q_I^{HF} = \frac{2(1-2z^*)\alpha_X(\alpha_X - \alpha_I)a + (1-2z^*)\alpha_X\alpha_I\tau + 3\alpha_I[L - z^*f]}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \tag{3.9}$$

Using (3.9) and the symmetric assumption, general equilibrium prices of goods supplied by the Home and Foreign FDI firms in Home become:

$$p_I^{HH} = p_I^{FH} = \frac{[2(1-2z^*)\alpha_X^2 + 2(1-2z^*)\alpha_X\alpha_I + 6z^*)\alpha_I^2]a - (1-2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^* f]}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \tag{3.10}$$

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

**Lemma 3.3.** *Trade costs decrease the general equilibrium prices of the Home and Foreign FDI firms in Home, but fixed costs of the FDI firms increase them.*

*Proof.* See Appendix. □

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 3.1. Therefore, the equilibrium prices of the FDI firms in Home increase due to the reduction in trade costs. However, 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 decrease.

## 3.3 Subsidies financed by labor income taxes

In this section, we demonstrate how small FDI subsidies financed by labor income taxes affect welfare in Home. We assume both countries provide the same level of subsidies for fixed costs of FDI. The mathematics symbol hat indicates economic variables under subsidies financed by labor income taxes.

### 3.3.1 Demand and supply with subsidies financed by labor income taxes

The utility maximization problem of the Home consumer becomes:

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

where $t$ is labor income taxes and $s_{lit}$ is subsidies financed by labor income taxes. A national income, $\hat{Y}$, consist of profits of Home exporting firms, $\int_{2z^*}^{1} \hat{\pi}_X^H dX$, those of Home FDI firms, $\int_0^{z^*} \hat{\pi}_I^H dI_H$, and total wages, $\hat{w}L$. In this study, we impose the budget neutral condition. Thus, the government revenue ($t\hat{Y}$) is equalized to total subsidies for Foreign FDI firms ($\int_{z^*}^{2z^*} \hat{w}fdI_F$). The symmetric assumption results into $\int_{z^*}^{2z^*} \hat{w}fdI_F = \int_0^{z^*} \hat{w}fdI_H$. This implies that the equation, $-t\hat{Y} + s_{lit}\int_0^{z^*} \hat{w}fdI_H = 0$, holds.

Subsidies for fixed costs of FDI change the profit function of a Home FDI firm in (3.2) as follows:

$$\hat{\pi}_I^H = \hat{p}_I^{HH}\hat{q}_I^{HH} + \hat{p}_I^{HF}\hat{q}_I^{HF} - \hat{w}\alpha_I(\hat{q}_I^{HH} + \hat{q}_I^{HF}) - \hat{w}(1 - s_{lit})f, \tag{3.11}$$

Total profits of Home FDI firms become:

$$\begin{aligned}\int_0^{z^*} \hat{\pi}_I^H dI_H &= \int_0^{z^*} \left[\hat{p}_I^{HH}\hat{q}_I^{HH} + \hat{p}_I^{HF}\hat{q}_I^{HF} - \hat{w}\alpha_I(\hat{q}_I^{HH} + \hat{q}_I^{HF}) - \hat{w}f\right] dI_H + s_{lit}\int_0^{z^*} \hat{w}fdI_H, \\ &= \underbrace{\int_0^{z^*} \left[\hat{p}_I^{HH}\hat{q}_I^{HH} + \hat{p}_I^{HF}\hat{q}_I^{HF} - \hat{w}\alpha_I(\hat{q}_I^{HH} + \hat{q}_I^{HF}) - \hat{w}f\right] dI_H}_{\equiv \int_0^{z^*} \tilde{\pi}_I^H dI_H} + t\hat{Y}. \end{aligned} \tag{3.12}$$

Substituting (3.12) into a budget constraint, $(1-t)\hat{Y}$, we have:

$$(1-t)\hat{Y} = \int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \tilde{\pi}_I^H dI_H + \hat{w}L.$$

The right hand side of the equation is the same as a national income in the basic model, that is, we have:

$$(1-t)\hat{Y} = Y$$

Therefore, outputs, prices, and wages in the general equilibrium become the same with subsidies financed by labor income taxes. We then consider a Home government's budget condition.

### 3.3.2 Budget neutral with subsidies financed by labor income taxes

We assume that the Home government uses all revenues from labor income taxes for subsidies for the Foreign FDI firm. Using (3.1) and (3.11), the Home government's revenue from the labor income taxes is given as:

$$t\hat{Y} = t(\int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI_H + \hat{w}L).$$

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

$$s_{lit} \int_{z^*}^{2z^*} \hat{w} f dI_F = z^* s_{lit} \hat{w} f.$$

The budget neutral conditions leads the relationship of $t$ and $s_{lit}$ as follows:

$$\begin{aligned} t &= \frac{z^* s_{lit} \hat{w} f}{\int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI_H + \hat{w}L} \\ &= \frac{z^* s_{lit} \hat{w} f}{\int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \tilde{\pi}_I^H dI_H + \hat{w}L + z^* s_{lit} \hat{w} f}. \end{aligned}$$

Differentiating $t$ in the above equation with respect to $s_{lit}$ around $s_{lit} = 0$, we have:

$$\left.\frac{\partial t}{\partial s_{lit}}\right|_{s_{lit}=0} = \frac{z^* \hat{w} f \left( \int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI_H + \hat{w}L \right)}{\left( \int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI_H + \hat{w}L \right)^2} = \frac{z^* \hat{w} f}{\int_{2z^*}^{1} \hat{\pi}_X^H dX + \int_0^{z^*} \hat{\pi}_I^H dI_H + \hat{w}L} > 0.$$

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

### 3.3.3 Welfare analysis with subsidies financed by labor income taxes

An indirect utility function can be explicitly rewritten as:

$$\hat{V}^H = \frac{a - \int_0^{z^*} \left[\hat{p}_I^{HH}(z)\right]^2 dI_H - \int_{z^*}^{2z^*} \left[\hat{p}_I^{FH}(z)\right]^2 dI_F - \int_{2z^*}^{1} \left[\hat{p}_X^H(z)\right]^2 dX}{2}.$$

As aforementioned, the demand and supply are the same as in 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:

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

We immediately establish the following proposition.

**Proposition 3.1.** *Small subsidies financed by labor income taxes have no effects on welfare. This is because subsidies financed by labor income taxes have no impact on the budget and do not affect prices, output, or wages.*

The intuition behind 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 demand and supply. Ultimately, 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.

## 3.4 Subsidies financed by consumption taxes

In this section, we analyze 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 that are different from the basic model.

### 3.4.1 Demand with subsidies financed by consumption taxes

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

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

[6] Consumption 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.

Solving this problem, we have:

$$\bar{q}^H(z) = \bar{\lambda}[a - t - \bar{p}^H(z)].$$

With $\bar{\lambda} = 1$, we have the following demand function:

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

Naturally, demand decreases with consumption taxes. Substituting the demand function into the utility function, we have:

$$\bar{V}^H = \frac{a - \bar{\sigma}_H^2}{2} \text{ where } \bar{\sigma}_H^2 = \int_0^1 [\bar{p}^H(z) + t]^2 dz \tag{3.13}$$

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

### 3.4.2 Supply with subsidies financed by consumption taxes

The producers face the inverse demand function under consumption taxes as:

$$\bar{p}^H(z) = a - t - \bar{q}^H(z). \tag{3.14}$$

As 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:

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

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:

$$\bar{q}_X^{HH} = \frac{a - t - \bar{w}\alpha_X + \tau}{3}, \quad \bar{q}_X^{HF} = \frac{a - t - \bar{w}\alpha_X - 2\tau}{3}, \tag{3.15}$$

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

$$\bar{q}_I^{HH} = \frac{a-t-\bar{w}\alpha_I}{2}, \quad \bar{q}_I^{HF} = \frac{a-t-\bar{w}\alpha_I}{2} \tag{3.16}$$

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

### 3.4.3 Labor market equilibrium with subsidies financed by consumption taxes

In this subsection, we endogenize the wage with subsidies financed by consumption taxes. The labor market clearing condition becomes:

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

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

$$\bar{w} = \frac{[2(1-2z^*)\alpha_X + 3z^*\alpha_I](a-t) - (1-2z^*)\alpha_X\tau - 3(L-z^*f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.17}$$

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 significantly large.[7]

### 3.4.4 General equilibrium with subsidies financed by consumption taxes

Substituting (3.17) into (3.15), we have the general equilibrium outputs of the Home exporting firm. They are explicitly given as:

$$\bar{q}_X^{HH} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)(a-t) + [(1-2z^*)\alpha_X^2 + z^*\alpha_I^2]\tau + \alpha_X(L-z^*f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \tag{3.18}$$

$$\bar{q}_X^{HF} = \frac{-z^*\alpha_I(\alpha_X - \alpha_I)(a-t) - [(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau + \alpha_X(L-z^*f)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.19}$$

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

Using (3.18) and (3.19), a general equilibrium price of the Home exporting firm becomes:

$$\bar{p}_X^H = \frac{[2(1-2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2](a-t) + z^*\alpha_I^2\tau - 2\alpha_X[L - z^*f]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}. \tag{3.20}$$

With subsidies financed by consumption taxes, lemma 3.2 still hold.

Furthermore, substituting (3.17) into (3.16), the general equilibrium outputs of the Home FDI firm are given as:

$$\bar{q}_I^{HH} = \bar{q}_I^{HF} = \frac{2(1-2z^*)\alpha_X(\alpha_X - \alpha_I)(a-t) + (1-2z^*)\alpha_X\alpha_I\tau + 3\alpha_I[L - z^*f]}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \tag{3.21}$$

Using (3.21) and symmetric assumption, the general equilibrium prices of goods supplied by the Home and Foreign FDI firms in Home are given as:

$$\begin{aligned}\bar{p}_I^{HH} &= \bar{p}_I^{FH} \\ &= \frac{[2(1-2z^*)\alpha_X^2 + 2(1-2z^*)\alpha_X\alpha_I + 6z^*)\alpha_I^2](a-t) - (1-2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^*f]}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}.\end{aligned} \tag{3.22}$$

### 3.4.5 Budget neutral with subsidies financed by consumption taxes

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

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

From the above equation, consumption taxes can be expressed as a function of subsidies as follows [8]:

$$t = \frac{B - \sqrt{B^2 - 4AC}}{2A}, \tag{3.23}$$

[8] See Appendix for details

where

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

Using (3.23), we investigate the effects of small subsidies on consumption taxes. Differentiating consumption taxes with respect to subsidies around $s_{ct}=0$, we have:

$$
\begin{aligned}
\left.\frac{\partial t}{\partial s_{ct}}\right|_{s_{ct}=0} &= \frac{\left.\frac{\partial C}{\partial s_{ct}}\right|_{s_{ct}=0}}{B|_{s_{ct}=0}} \\
&= \frac{3z^* f\left\{[2(1-2z^*)\alpha_X + 3z^*\alpha_I]a - (1-2z^*)\alpha_X\tau - 3(L-z^*f)\right\}}{B|_{s_{ct}=0}} > 0. \qquad (3.24)
\end{aligned}
$$

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

### 3.4.6 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 producer prices. First, we reveal the effect of small subsidies on the wage. Differentiating (3.17) 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 3.4.** *Small FDI subsidies for fixed costs financed by consumption taxes decreases the wage.*

The intuition behind this lemma is straightforward. The small subsidies decrease demand and supply through the increase in consumption taxes explained in (3.24). This implies that the Home firms require less labor force. Thus, the wage becomes smaller if the subsidies increase.

Second, we investigate the effect of small subsidies on the producer price of the Home exporting firm. Differentiating (3.20) 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 3.5.** *Small FDI subsidies for fixed costs financed by consumption taxes decrease the producer price of the exporting industries in Home.*

The intuition behind this lemma is as follows. When consumption taxes increase, the change in the outputs of the Home exporting firm, as shown in (3.18) and (3.19), depends on the size of the labor coefficients, $\alpha_X$ and $\alpha_I$. However, according to (3.14), consumption taxes have negative effects on prices. Considering this direct effect of consumption taxes on the prices, subsidies have negative effects on the price of the Home exporting industries due to the relationship in (3.24).

Finally, we show the effect of small subsidies on prices of Home and Foreign FDI industries. Differentiating (3.22) with respect to subsidies around $s_{ct} = 0$, we obtain:

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

From this result, we obtain the following lemma:

**Lemma 3.6.** *Small FDI subsidies for fixed costs financed by consumption taxes decrease the producer prices of the Home and Foreign FDI firms in Home.*

The intuition behind this lemma is similar to Lemma 3.5. When subsidies increase, the change in the outputs of both the Home and Foreign FDI firms in the Home market, as shown in (3.21), relies on the difference between the labor coefficients. However, with the direct negative effect of consumption taxes on prices, small subsidies have negative effects on the prices of both Home and Foreign FDI goods in the Home market.

### 3.4.7 Welfare analysis with subsidies financed by consumption taxes

In this subsection, we analyze the effect of subsidies for FDI fixed costs financed by consumption taxes on welfare. The indirect utility function (3.13) can be rewritten as:

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

where

$$\bar{p}_X^H + t = \frac{[2(1-2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2]a - 2z^*\alpha_I(\alpha_X - \alpha_I)t + z^*\alpha_I^2\tau - 2\alpha_X[L - z^* f]}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2}, \tag{3.25}$$

$$\begin{aligned}\bar{p}_I^{HH} + t &= \bar{p}_I^{FH} + t \\ &= \frac{\left\{\begin{array}{l}[2(1-2z^*)\alpha_X^2 + 2(1-2z^*)\alpha_X\alpha_I + 6z^*)\alpha_I^2]a + 2(1-2z^*)\alpha_X(\alpha_X - \alpha_I)t \\ -(1-2z^*)\alpha_X\alpha_I\tau - 3\alpha_I[L - z^* f]\end{array}\right\}}{2[2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2]}. \end{aligned}\tag{3.26}$$

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

$$\begin{aligned}\left.\frac{\partial \bar{V}^H}{\partial s_{ct}}\right|_{s_{ct}=0} &= \frac{-z^*(1-2z^*)(\alpha_I - \alpha_X)}{2(1-2z^*)\alpha_X^2 + 3z^*\alpha_I^2} \\ &\quad \cdot \left\{2\alpha_I(\bar{p}_X^H + t)|_{s_{ct}=0} - \alpha_X[(\bar{p}_I^{HH} + t)|_{s_{ct}=0} + (\bar{p}_I^{FH} + t)|_{s_{ct}=0}]\right\} \cdot \left.\frac{\partial t}{\partial s_{ct}}\right|_{s_{ct}=0}, \end{aligned}\tag{3.27}$$

From (3.27), 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 study, 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 industries.

**Proposition 3.2.** *The consumer price of exporting goods becomes higher while that of FDI goods becomes lower with the small FDI subsidies financed by consumption taxes.*

*Proof.* Differentiating (3.25) and (3.26) with respect to $s_{ct}$ around $s_{ct} = 0$ with $\alpha_X - \alpha_I < 0$, we

[9]See Appendix for the result 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. This is because small subsidies do not affect the outputs in general equilibrium, (3.18), (3.19), and (3.21). This implies that the consumer prices, (3.25) and (3.26), are equal to (3.8) and (3.10). Thus, the subsidies do not affect welfare.

have:

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

□

The intuition behind this lemma is as follows. Subsidies provide greater advantages for FDI firms compared to exporting firms, given the condition $\alpha_X - \alpha_I < 0$. This is due to the reduction in variable costs by wage reductions. Lemma 3.5 and Lemma 3.6 show that the producer prices of both exporting and FDI goods decrease, which has a downward effect on consumer prices. However, consumption taxes have upward effects on consumer prices. Regarding consumer prices of goods in the exporting industries 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 industries's goods. We can rewrite (3.27) as:

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

where

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

With the condition, $\alpha_X - \alpha_I < 0$, and (3.24), equation (3.27) indicates that welfare improves when the consumer prices of the exporting industries are low and those of the Home and Foreign FDI industries are high. Thus, welfare improvement occurs when the term, $\Omega_{ct}$, is negative. Specifically, we obtain the following proposition.

**Proposition 3.3.** *Suppose $\alpha_X - \alpha_I < 0$, small FDI subsidies for fixed costs tend to enhance welfare when trade costs are small, fixed costs of FDI are at an intermediate level, and the labor coefficient of exporting industries is sufficiently large.*

*Proof.* See Appendix. □

Around $s_{ct} = 0$, equations (3.25) and (3.26) become equal to (3.8) and (3.10). When trade costs become smaller, we can observe that consumer prices of goods in exporting industries become lower, while those in FDI industries become higher, as shown in Lemma 3.2 and Lemma 3.3.

When the fixed costs of FDI become smaller, all consumer prices become smaller from Lemma 3.2 and Lemma 3.3. However, the size of the drop in the consumer prices in exporting industries is smaller than that in the addition of consumer prices in Home and Foreign FDI industries. This implies that the fixed costs of FDI cannot be too small to have a negative $\Omega_{ct}$. However, when the fixed costs of FDI become larger, the rise in consumer prices in exporting industries is smaller than that in the addition of the consumer prices in Home and Foreign FDI industries. This implies that welfare change tends to be positive. However, if the the fixed costs of FDI are too large, it violates the condition of the positive wage.[10] From the above discussions, the fixed costs of FDI must be at an intermediate level.

When the labor coefficient of exporting industries is sufficiently large, the producer price of exporting firms around $s_{ct} = 0$, denoted as $\bar{p}_X^H = (a - \tau + 2\bar{w}\alpha_X)/3$, decreases significantly due to the wage reduction, as shown in Lemma 3.4. This implies that the increase in consumer prices of exporting firms become significantly smaller. The sufficiently small increase in consumer prices of exporting industries leads to only minor negative effects on welfare. With this condition, the term, $\Omega_{ct}$, tends to be negative and thus welfare tends increase with the subsidies.

## 3.5 Conclusion

We employ Neary's (2016) GOLE model to assess the welfare impact of host country small FDI subsidies for a monopolistic foreign firm.

Specifically, we examine the welfare implications of small subsidies for fixed costs of FDI, while considering the differences in financing sources for these subsidies.

In our analysis, we demonstrate that small FDI subsidies financed through labor income taxes had no impact on welfare. Labor income taxes do not cause distortions in consumption, and subsidies do not affect the production level of firms. Therefore, the wage and prices of goods remain constant, and subsidies do not affect welfare. This contrasts with the result of Chor

[10] See Appendix for details

(2009) that small subsidies financed by labor income taxes consistently enhance welfare in the host country.

However, 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. Assuming that the labor coefficient of exporting industries is smaller than that of FDI industries, consumer prices for exporting industries increase, whereas those for FDI industries decrease. Welfare improves when the consumer prices of exporting industries are low and those in FDI industries are high. Specifically, welfare improves with the subsidy when trade costs are small, the fixed costs of FDI are at an intermediate level, and the exporting industries' labor coefficient is sufficiently large. When trade costs are small, producer prices in exporting industries are low, whereas those in FDI industries are high. When fixed costs of FDI are at the intermediate level, it confirms that the wage, outputs, and prices are positive. When the exporting industries' labor coefficient is sufficiently large, the response to the change in wage reduction becomes larger, resulting in a larger negative shock on the producer prices of exporting firms. 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 provided by labor income taxes do.

These novel findings, diverging from prior literature, hold significance for government economic policy. For example, trade costs between Japan and Korea are low. Therefore, if Japan provides subsidies to Samsung Electronics, it would be more effective to use consumption taxes as a source of financing. However, trade costs between Japan and the United States are high. Therefore, if Japan provides subsidies to Micron Technology, using labor income taxes is a better financing source for subsidies. However, the careful implementation and governance of such schemes are crucial to determining the suitable financing source for FDI subsidy levels. In addition, this study does not consider the effect of subsidies on the supply form of firms. The phenomenon that firms previously supplied overseas through exports but changed their strategy using FDI due to subsidies happens in the real world. This is a crucial issue for future work to investigate within a GOLE model setting.

The results of this paper heavily depend on the assumption of symmetric countries and governments' policies. Removing this assumption would render analytical analysis impossible, and it is uncertain whether results similar to those presented in this paper would be obtained. Additionally, while analyses have been conducted on foreign direct investment prior to the introduction of subsidies, analyzing models where foreign direct investment occurs after the introduction of subsidies would be more reflective of reality. These are challenges for future research.

# Appendix 3.A

## 3.A.1 Proof of lemma 3.1

Differentiating (3.5) with respect to $\tau$ and $f$, we have:

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

## 3.A.2 Proof of lemma 3.2

Differentiating (3.8) with respect to $\tau$ and $f$, we obtain:

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

## 3.A.3 Proof of lemma 3.3

Differentiating (3.10) with respect to $\tau$ and $f$, we yield:

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

## 3.A.4 Detail for the budget neutral condition

Using (3.15) and (3.16), the government's revenue is

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

The government's spending is

$$s_{ct} \int_{z^*}^{2z^*} \bar{w} f dI_F = z^* s_{ct} \bar{w} f. \tag{3.A.2}$$

Equating (3.A.1) to (3.A.2) gives:

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

Define $\bar{w}$ as follow:

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

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

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

The term $A$, $B$, and $C$ are defined as:

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

First, we show $A$, $B$, and $C$ are positive. $A$ is positive obviously. As for $C$, we assume that the wage in (3.17) is positive. Thus $C$ is also positive. Regarding $B$, we can rewrite $B$ as:

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

The sign of (3.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 $B\le 0$. We can rewrite (3.A.5) as:

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

From (3.6) and (3.7), the condition of the positive outputs of the exporting industries can be expressed as:

$$\begin{aligned} \bar{q}_X^{HH}+\bar{q}_X^{HF}>0 & \Leftrightarrow 2z^*\alpha_I(\alpha_I-\alpha_X)a - z^*\alpha_I^2\tau + 2\alpha_X(L-z^*f)>0. \\ & \Leftrightarrow 2(\alpha_I-\alpha_X)a > \alpha_I\tau - \frac{2\alpha_X(L-z^*f)}{z^*\alpha_I} + 2(\alpha_I-\alpha_X)t. \end{aligned} \tag{3.A.7}$$

Combining (3.A.6) and (3.A.7), we have:

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

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

Second, we consider the condition that equation (3.A.4) has real solutions. To have real solutions, equation (3.A.4) needs to satisfy the following condition: $B^2-4AC>0$. We can rewrite $B$ and $4AC$ as:

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

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

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

If the condition, $2Aw_{N1}(w_{N3} - 3s_{ct}z^* f)a > 0$, holds, (3.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:

$$t = \frac{B \pm \sqrt{B^2 - 4AC}}{2A} \tag{3.A.9}$$

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 (3.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 (3.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 (3.23).

### 3.A.5 Proof of Proposition 3.3.

We show the conditions that the inequality, $\Omega_{ct} < 0$, holds. The procedure of the proof is divided into three steps. In step 1, we derive conditions of the positive wage, outputs, and prices in general equilibrium around $s_{ct} = 0$ respectively. In step 2, we derive combining conditions that all positive wages, outputs, and prices hold. In step 3, given the combining conditions in step 2, we derive conditions that welfare increases by small subsidies. In other words, we derive the conditions that $\Omega_{ct} < 0$ holds.

#### Step 1: Deriving each condition of the positive wage, outputs, and prices

We consider the positive wage, outputs, and prices in general equilibrium around $s_{ct} = 0$. Around $s_{ct} = 0$, the wage is equal to (3.5), the outputs and prices with the consumption tax in exporting industries are equal to (3.6), (3.7), and (3.8) and in FDI industries are equal to (3.9) and (3.10). First, we consider the condition of the positive wage. Recall $w_{N1} = 2(1 - 2z^*)\alpha_X + 3z^*\alpha_I$. From (3.5), the condition of the positive wage can be written as:

$$w > 0 \Leftrightarrow w_{N1}a - (1 - 2z^*)\alpha_X\tau > 3\underbrace{(L - z^*f)}_{\equiv \tilde{L}}$$

To foster the analysis, we multiply the above inequality by $2\alpha_X\alpha_I$. We can rewrite the condition as:

$$w > 0 \Leftrightarrow \underbrace{2\alpha_X\alpha_I w_{N1}a - 2(1-2z^*)\alpha_X^2\alpha_I\tau}_{\equiv w_{N4}} > 6\alpha_X\alpha_I\tilde{L}$$

Second, we consider variables in exporting industries. With $\alpha_X - \alpha_I < 0$, the condition, $q_X^{HH} > 0$, always holds. From (3.7) and (3.8), we have following conditions:

$$q_X^{HF} > 0 \Leftrightarrow 2\alpha_X\tilde{L} > 2[\underbrace{(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2}_{\equiv X_1}]\tau - 2z^*\alpha_I(\alpha_I - \alpha_X)a$$

$$p_X^H > 0 \Leftrightarrow [\underbrace{2(1-2z^*)\alpha_X^2 + 2z^*\alpha_X\alpha_I + z^*\alpha_I^2}_{\equiv X_2}]a + z^*\alpha_I^2\tau > 2\alpha_X\tilde{L}$$

Combining these conditions and multiplying $3\alpha_I$, we have the following condition that satisfies positive outputs and prices in exporting industries:

$$\underbrace{3\alpha_I X_2 a + 3z^*\alpha_I^3\tau}_{\equiv X_3} > 6\alpha_X\alpha_I\tilde{L} > \underbrace{6\alpha_I X_1\tau - 6z^*\alpha_I^2(\alpha_I - \alpha_X)a}_{\equiv X_4}$$

Finally, we consider variables in FDI industries. From (3.9) and (3.10), we have:

$$q_I^{HH} = q_I^{HF} > 0 \Leftrightarrow 3\alpha_I\tilde{L} > 2(1-2z^*)\alpha_X(\alpha_I - \alpha_X)a - (1-2z^*)\alpha_X\alpha_I\tau$$

$$p_X^H > 0 \Leftrightarrow [\underbrace{2(1-2z^*)\alpha_X^2 + 2(1-2z^*)\alpha_X\alpha_I + 6z^*\alpha_I^2}_{\equiv I_1}]a - (1-2z^*)\alpha_X\alpha_I\tau > 3\alpha_I\tilde{L}$$

Combining these conditions and multiplying $2\alpha_X$, we obtain the following condition satisfying positive outputs and prices in FDI industries:

$$\underbrace{2\alpha_X I_1 a - 2(1-2z^*)\alpha_X^2\alpha_I\tau}_{\equiv I_2} > 6\alpha_X\alpha_I\tilde{L} > \underbrace{4(1-2z^*)\alpha_X^2(\alpha_I - \alpha_X)a - 2(1-2z^*)\alpha_X^2\alpha_I\tau}_{\equiv I_3}$$

**Step 2: Deriving the combining conditions of the positive wage, outputs, and prices**

We derive the overall condition that satisfies the positive wage, outputs, and prices in all industries. First, we consider the relationships of $w_{N4}$, $X_3$, and $I_2$. Comparing $w_{N4}$ with $X_3$ and $I_2$, we can easily show the following relationships:

$$w_{N4} < X_3 \quad \text{and} \quad w_{N4} < I_2$$

Second, we consider the relationships of $w_{N4}$, $X_4$, and $I_3$. Comparing $w_{N4}$ with $X_4$ and $I_3$, we can easily show the following relationships:

$$w_{N4} > X_4 \quad \text{and} \quad w_{N4} > I_3$$

From the above discussions, we have two conditions that ensure the positive wage, outputs, and prices in each industry as follows:

$$X_4 < 6\alpha_X\alpha_I\tilde{L} < w_{N4} \quad \text{for exporting industries}$$
$$I_3 < 6\alpha_X\alpha_I\tilde{L} < w_{N4} \quad \text{for FDI industries}$$

To combine the above conditions, we need to derive the size relationship of $X_4$ and $I_3$. Comparing $X_4$ with $I_3$, we have:

$$X_4 \gtreqless I_3 \Leftrightarrow \tau \gtreqless \frac{\alpha_I - \alpha_X}{2\alpha_I}a$$

This relationship is divided into two cases below:

$$X_4 \leq I_3 \quad \text{with} \quad 0 < \tau \leq \frac{\alpha_I - \alpha_X}{2\alpha_I}a$$
$$X_4 > I_3 \quad \text{with} \quad \tau > \frac{\alpha_I - \alpha_X}{2\alpha_I}a$$

Considering these two cases, we have the two conditions satisfying the positive wage, outputs, and prices in all industries as follows With $\alpha_I \geq 2\alpha_X$, we have the following two conditions:

$$X_4 \leq I_3 < 6\alpha_X\alpha_I\tilde{L} < w_{N4} \quad \text{with} \quad 0 < \tau \leq \frac{\alpha_I - \alpha_X}{2\alpha_I}a \tag{3.A.10}$$

$$I_3 < X_4 < 6\alpha_X\alpha_I\tilde{L} < w_{N4} \quad \text{with} \quad \tau > \frac{\alpha_I - \alpha_X}{2\alpha_I}a \tag{3.A.11}$$

**Step 3: Deriving the condition of welfare improvement by subsidies**

Recall that welfare improves when $\Omega_{ct} < 0$ holds. The condition, $\Omega_{ct} < 0$, can be written as:

$$\begin{aligned}\Omega_{ct} < 0 &\Leftrightarrow 2(\alpha_I - \alpha_X)[(1-2z^*)a_X^2 + 2z^* a_I^2]a + \alpha_I[(1-2z^*)a_X^2 + 2z^* a_I^2]\tau < \alpha_X \alpha_I (L - z^* f) \\ &\Leftrightarrow 2(\alpha_I - \alpha_X)X_1 a + \alpha_I X_1 \tau < \alpha_X \alpha_I \tilde{L} \\ &\Leftrightarrow \underbrace{12(\alpha_I - \alpha_X)X_1 a + 6\alpha_I X_1 \tau}_{\equiv \omega_1} < 6\alpha_X \alpha_I \tilde{L}\end{aligned}$$

First, we consider the size relationship of $\omega_1$, $X_4$, and $I_3$. Comparing $\omega_1$ with $X_4$ and $I_3$, we have:

$$\omega_1 > X_4 \quad \text{and} \quad \omega_1 > I_3$$

*Proof.* Suppose $\omega_1 \leq X_4$ and $\omega_1 \leq I_3$. Then, we have:

$$\begin{aligned}\omega_1 \leq X_4 &\Leftrightarrow 12(\alpha_I - \alpha_X)X_1 a + 6\alpha_I X_1 \tau \leq 6\alpha_I X_1 \tau - 6z^* \alpha_I^2 (\alpha_I - \alpha_X)a \\ &\Leftrightarrow 6(\alpha_I - \alpha_X)(2X_1 + z^* \alpha_I^2)a \leq 0\end{aligned}$$

and

$$\begin{aligned}\omega_1 \leq I_3 &\Leftrightarrow 12(\alpha_I - \alpha_X)X_1 a + 6\alpha_I X_1 \tau \leq 4(1-2z^*)(\alpha_I - \alpha_X)\alpha_X^2 a - 2(1-2z^*)\alpha_X^2 \alpha_I \tau \\ &\Leftrightarrow 8(\alpha_I - \alpha_X)[(1-z^*)\alpha_X^2 + 3z^* \alpha_I^2]a + 2\alpha_I[3X_1 + (1-2z^*)\alpha_X^2]\tau \leq 0\end{aligned}$$

These are contradiction. Thus, we have: $\omega_1 > X_4$ and $\omega_1 > I_3$. □

From these inequalities and (3.A.10) and (3.A.11), welfare increase may occur if the following relationships hold.

$$X_4 \leq I_3 < \omega_1 < 6\alpha_X \alpha_I \tilde{L} < w_{N4} \quad \text{with} \quad 0 < \tau \leq \frac{\alpha_I - \alpha_X}{2\alpha_I} a \tag{3.A.12}$$

$$I_3 < X_4 < \omega_1 < 6\alpha_X \alpha_I \tilde{L} < w_{N4} \quad \text{with} \quad \tau > \frac{\alpha_I - \alpha_X}{2\alpha_I} a \tag{3.A.13}$$

Second, we derive conditions that welfare increases by the subsidy. Specifically, we need two conditions that (3.A.12) and (3.A.13) hold. The conditions are

$$\omega_1 < 6\alpha_X \alpha_I \tilde{L} < w_{N4} \quad \text{and} \quad \omega_1 < w_{N4}$$

We require the intermediate level of $\tilde{L}$ for the condition that the first inequality, $\omega_1 < 6\alpha_X\alpha_I\tilde{L} < w_{N4}$, holds. Recall $\tilde{L} = L - z^*f$. In words, we need the intermediate level of fixed costs of FDI, $f$, to have the increase in welfare ($\omega_1 < 6\alpha_X\alpha_I$) and the positive wage ($6\alpha_X\alpha_I\tilde{L} < w_{N4}$) hold.

We next consider the condition that the second inequality, $\omega_1 < w_{N4}$, holds. Recall $w_{N1} = 2(1-2z^*)\alpha_X + 3z^*\alpha_I$ and $X_1 = (1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2$. The inequality, $\omega_1 < w_{N4}$, can be rewritten as:

$$\begin{aligned}\omega_1 < w_{N4} &\Leftrightarrow 12(\alpha_I - \alpha_X)X_1 a + 6\alpha_I X_1\tau < 2\alpha_X\alpha_I w_{N1}a - 2(1-2z^*)\alpha_X^2\alpha_I\tau \\ &\Leftrightarrow 6(\alpha_I - \alpha_X)X_1 a + 3\alpha_I X_1\tau < \alpha_X\alpha_I w_{N1}a - (1-2z^*)\alpha_X^2\alpha_I\tau \\ &\Leftrightarrow 2[2(1-2z^*)\alpha_X^2\alpha_I + 3z^*\alpha_I^3]\tau < [\underbrace{6(1-2z^*)\alpha_X^3 - 4(1-2z^*)\alpha_X^2\alpha_I + 15z^*\alpha_X\alpha_I^2 - 12z^*\alpha_I^3}_{\equiv v(\alpha_X,\alpha_I)}]a\end{aligned} \tag{3.A.14}$$

The left hand side of (3.A.14) is decreasing in $\tau$. Differentiating $v(\alpha_X, \alpha_I)$ with respect to $\alpha_X$, we have:

$$\frac{\partial v(\alpha_X,\alpha_I)}{\partial \alpha_I} = 18(1-2z^*)\alpha_X^2 - 8(1-2z^*)\alpha_X\alpha_I + 15z^*\alpha_I^2$$

If the labor coefficient of exporting industries is large enough ($\alpha_I \approx \alpha_X$), we have:

$$\frac{\partial v(\alpha_X,\alpha_I)}{\partial \alpha_I} = 10(1-2z^*)\alpha_X^2 + 15z^*\alpha_X^2 > 0$$

Thus, the right hand side of (3.A.14) is increasing in $\alpha_X$ when tthe labor coefficient of exporting industries is large enough ($\alpha_I \approx \alpha_X$). If we substitute $\tau = \frac{\alpha_I - \alpha_X}{2\alpha_I}a$ and $\alpha_I \approx \alpha_X$ into (3.A.14), we have:

$$0 < 2(1-2z^*)\alpha_X^3 + 3z^*\alpha_X^3$$

From this result, the inequality, $\omega_1 < w_{N4}$, holds in both cases, (3.A.12) and (3.A.13) with small $\tau$ and small enough $\alpha_I$ ($\alpha_I \approx \alpha_X$).

Combining the conditions that the fist inequality, $\omega_1 < 6\alpha_X\alpha_I < w_{N4}$ , and the second inequality, $\omega_1 < w_{N4}$, hold, we require intermediate fixed costs of FDI ($f$), small trade costs ($\tau$), and the large enough labor coefficient of exporting firms ($\alpha_X$). Under these conditions, we have: $\Omega_{ct} < 0$.

### 3.A.6 Welfare analysis with $\alpha_X - \alpha_I > 0$

We show $\Omega_{ct} < 0$ holds with $\alpha_X - \alpha_I > 0$. Suppose $\Omega_{ct} \geq 0$ holds. We can rewrite $\Omega_{ct} \geq 0$ as:

$$\Omega_{ct} \geq 0 \Leftrightarrow \underbrace{\alpha_I[(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau - \alpha_X\alpha_I(L - z^*f)}_{\equiv \omega_2} > 2(\alpha_X - \alpha_I)[(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]a$$

Around $s_{ct} = 0$, we have: $\bar{q}_X^{HF}$ in (3.19) is equal to $q_X^{HF}$ in (3.7). The condition of positive $q_X^{HF}$ in (3.7) is:

$$\begin{aligned} q_X^{HF} > 0 &\Leftrightarrow -z^*\alpha_I(\alpha_X - \alpha_I)a > [(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau - \alpha_X(L - z^*f) \\ &\Leftrightarrow -z^*\alpha_I^2(\alpha_X - \alpha_I)a > \underbrace{\alpha_I[(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]\tau - \alpha_X\alpha_I(L - z^*f)}_{\equiv \omega_2} \end{aligned}$$

Combining these two conditions, we have:

$$\underbrace{-z^*\alpha_I^2(\alpha_X - \alpha_I)a}_{<0} > \omega_2 > \underbrace{2(\alpha_X - \alpha_I)[(1-2z^*)\alpha_X^2 + 2z^*\alpha_I^2]a}_{>0}$$

This inequality cannot hold. Therefore, with the condition that $q_X^{HF}$ in (3.7) is positive, we must have: $\Omega_{ct} < 0$. This implies welfare decreases by the small subsidies financed by consumption taxes affect welfare negatively with $\alpha_X - \alpha_I > 0$.

# Chapter 4

# Cross-border E-commerce and Trade Policy

*This chapter is based on a joint work with Professor Jota Ishikawa.*

## 4.1 Introduction

According to the report by the Ministry of Economy, Trade and Industry of Japan (METI, 2023), the global Business-to-Consumer (BtoC) e-commerce market size is approximately 800 trillion yen and continues to expand. The growth of this market is associated with the remarkable increase in the global internet population due to the development and widespread adoption of information and communication technology (ICT).

Generally, there are two different selling modes for online platform operators: (1) online marketplaces or (2) resellers. In this study, we focus on the situation where online platform operators provide online marketplace services that facilitate a direct connection between buyers and sellers. The success of online marketplaces has been well-documented. For example, in the second quarter of 2023, direct sales from third-party sellers accounted for 60% of the products sold on Amazon.com.[1] Additionally, a leading Japanese online platform operator, Rakuten, has offered only an online marketplace Rakuten Ichiba since 2001.[2]

[1]https://www.marketplacepulse.com/stats/amazon-percent-of-units-by-third-party-sellers (accessed date November 10, 2023).

[2]Some online platform operators (e.g., BestBuy.com and Zappos.com) are still working as pure resellers.

The advancement of e-commerce has expanded opportunities for firms, particularly small- and medium-sized enterprises (SMEs), to engage in international trade. This is attributed to factors such as enhanced access to the global market, direct interaction with consumers, and alleviation of trade barriers due to the development of e-commerce. Lendle and Olarreaga (2017) demonstrate that online marketplaces offer SMEs the opportunity to enter international markets. Lanz *et al.* (2018) observe that SMEs tend to engage more in global value chains in nations with a greater proportion of the population subscribing to fixed broadband services. Furthermore, Sun (2021) observes an increase in the export share of SMEs due to the development of e-commerce platforms and Carballo *et al.* (2022) show that firms participating in the e-commerce market increase their exports, particularly to countries without trade agreements.

There are relatively few papers considering the impact of the e-commerce market on international trade, considering that impact is deemed a highly significant topic by the following decision in the European union (EU). On 17 May 2023, the European Commission announced the reform proposal for the customs system, aiming for further integration of the EU customs union.[3] In this announcement, when consumers within the region import goods from outside the region using online platforms, the online platform operator, rather than the consumer, takes responsibility as the deemed importer for customs procedures and payment of duties. Additionally, the decision was made to abolish the duty-free exemption for goods valued at less than 150 euros.

Based on these observations, this study aims to address the following general question: If there are foreign firms using an online marketplace operated by an online platform operator (e.g., Amazon.com or Rakuten Ichiba) and the home government introduces a tariff, what impact does this have on the foreign firms' profits, the online platform operators' profits, and home welfare?

To answer the above question, we first construct a model in which a foreign monopolist exports its good to a home country. Second, we consider a case in which two foreign firms export their products to the home country. To export goods to the home country, firms incur a per-unit tariff. The home country does not have any firms and there is an online marketplace is operated by the foreign online platform operator. Using the online marketplace, firms must pay ad valorem sale fees to the online platform operator. Under the above economic situation, home welfare consists of the consumer surplus and government revenue. With these assumptions, we analyze the effects of introducing a tariff on the economy in the following three cases: $(O)$ where a foreign monopolist

[3] https://taxation-customs.ec.europa.eu/customs-4/eu-customs-reform_en (accessed date November 10, 2023)

exports its good using the online marketplace, ($OO$) where both foreign firms export their goods using the online marketplace, and ($OX$) where a foreign firm exports its good using the online marketplace and the other foreign firm exports its good directly.

The key findings of our study can be summarized as follows. Under case $O$, profits of the foreign monopolist and online platform operator decrease and home welfare may decrease with the introduction of a tariff. Under case $OO$, both firms' profits decrease and home welfare may decrease with the introduction of a tariff. However, the online platform operator's profit may increase. Under case $OX$, the profit of the firm using the online marketplace decreases, the profit of the online platform operator may increase, and home welfare may decrease with the introduction of a tariff. Furthermore, the profit of the direct exporting firm may increase.

In cases $O$ and $OO$, a tariff reduces the output of both firms and leads to higher prices in the equilibrium. Since equilibrium profits depend on both outputs, a tariff leads to a decrease in profits for these firms. In case $OX$, the firm using the online marketplace loses from a tariff while the direct exporting firm may gain.

This outcome is contingent upon the extent of market power wielded by the direct exporting firm. When the sales fees are large, market power of the direct exporting firm becomes large but that of the firm using the online marketplace becomes small. Therefore, the impact of a tariff on the equilibrium output of the direct exporting firm becomes negatively small or positive but that of the firm using the online marketplace becomes negatively large. Consequently, the profit of the direct exporting firm may increase by a tariff.

The profit of the online platform operator is determined by the equilibrium price and total outputs of firms. The effect of introducing a tariff decreases the total equilibrium output but increases the equilibrium price. The results depends on the price elasticity for demand. In case $O$, where the price elasticity of demand is greater than one, the introduction of a tariff decreases the online platform operator's profit. However, in cases $OO$ and $OX$, if the marginal labor costs of both firms and the sales fees are low, the price elasticity of demand can be less than 1, potentially resulting in an increase in the online platform operator's profit.

In all three cases, the effect of introducing a tariff on home welfare depends on the equilibrium total outputs and the sales fees. High sales fees decrease the total equilibrium outputs largely when a tariff is introduced, potentially leading to a decrease in home welfare.

### Related literature

This study is related to the papers of traditional intermediaries in international trade. Two general explanations are proposed to elucidate the emergence of intermediaries in an economy: (i) facilitating the matchmaking between buyers and sellers (e.g., Rubinstein and Wolinsky 1987), and (ii) serving as quality guarantors to mitigate adverse selection (e.g., Biglaiser 1993 and Spulber 1999). According to Blum *et al.* (2010), approximately 41% of all imports into Chile are conducted through trade intermediaries, which includes wholesalers and retailers. Furthermore, Bernard *et al.* (2010) report that 43% of U.S. exporting firms and 55% of importing firms function as trade intermediaries, contributing to 9% and 16% of the total trade volumes, respectively. In the context of international trade, empirical evidence underscores the significance of trade intermediation.

Initial theoretical studies on the function of intermediaries in international trade, such as Rauch and Watson (2004) and Petropoulou (2007), conceptualize international trade as a result of search and networks. Recent theoretical papers on intermediaries and international trade include Ahn *et al.* (2011), Felbermayr and Jung (2011), Bernard *et al.* (2015), and Akerman (2018). These papers construct a model with the heterogeneous firm trade model of Melitz (2003) by introducing intermediaries (wholesalers), which allows wholesalers to exploit economies of scope in exporting. Whereas all active firms serve a home market, manufacturers have the option to choose how they serve a foreign market. Home manufacturing firms can decide between directly exporting to foreign market consumers or utilizing intermediary firms to export their goods. While intermediary exports allow firms to avoid fixed costs, additional variable costs reduce export sales profits. The result shows that high-productivity firms choose direct exports, and those with intermediate productivity opt for intermediary export This result is supported by the exporting data of China, U.S., Sweden, and Italy.[4] These papers focus on revealing which firms utilize intermediaries for exports and the sorting patterns that emerge á la Helpman *et al.* (2004).

With the advancement of ICTs, firms with a distinct business model from traditional intermediaries have emerged. These firms typically began as online resellers (e.g., Amazon.com), but

[4]Some studies focus on the relationship between intermediaries and quality of goods. Tang and Zhang (2012) and Crozet *et al.* (2013) analyze intermediary trade considering quality sorting. In these papers, intermediaries have lower fixed costs for exports but weaker consumer quality signals than direct exports due to incomplete contracts. Tang and Zhang (2012) show that firms with higher product quality choose direct exports, while those with intermediate quality prefer intermediary exports, as demonstrated using Chinese data. Crozet *et al.* (2013) show firms with high productivity/quality choose direct exports, while those with intermediate productivity/quality opt for intermediary exports. Intermediary exports lead to exporting to markets with lower demand and higher transportation costs, demonstrated with French data.

they now primarily operate online marketplaces. A key distinction between online marketplaces and traditional intermediaries is that online marketplaces enable direct transactions between manufacturers and consumers, eliminating the negotiation between manufacturers and consumers or double marginalization. This is because there are huge numbers of consumers in online marketplaces and manufacturers can search consumers without intermediaries and complete sales by themselves using online marketplaces. This distinction is attributed to the vast consumer base within online marketplaces, enabling manufacturers to set prices of products and access consumers without intermediaries and autonomously execute sales transactions.

Sun (2021) demonstrates that the expansion of e-platforms has significantly increased the share of exports by SMEs. The theoretical model of Sun (2021), an extension of Helpman *et al.* (2004), assumes that the productivity of firms using e-platforms for export is lower than that of firms engaged in direct exports. This assumption is akin to those using intermediaries for exports, where fixed costs are lower than direct exports, but variable costs are higher. Carballo *et al.* (2022) demonstrates that firms joining online platforms increase exports, especially small-scale firms producing differentiated goods that increase exports to unfamiliar markets.

In contrast to literature on intermediaries (traditional intermediaries and online platform operators) and international trade, our study focuses on the effects of a tariff on an economy with the online marketplace and a monopolistic producer and oligopolistic producers.

Finally, our study is also related to Brander and Spencer (1984a,b) and Lahiri and Ono (1999). Brander and Spencer (1984a,b) examine how introducing a tariff for a foreign monopolist and foreign oligopolistic firms affects home welfare. The results of these studies are that introducing a tariff improves home welfare. Lahiri and Ono (1999) extend Brander and Spencer (1984a,b) adding traditional intermediaries (wholesalers). They analyze the effect of a tariff on home welfare considering whether the pricing authority resides with the intermediaries or manufacturing firms. Our model is based on the framework used in Brander and Spencer (1984a,b). However, we consider the effect of introducing a tariff on home welfare and the profits of manufacturing firms and the online platform operator with existence of the online marketplace.

The paper is structured as follows. Section 4.2 develops a model with a foreign monopolist which uses the online marketplace to exports its good and examines the effect of a tariff. Section 4.3 extends the model with two foreign firms using the online marketplace for exporting their goods. Section 4.4 constructs a model with one of foreign firms using the online marketplace for exporting its good while the other foreign firm exports its good directly. Section 4.5 concludes the paper.

## 4.2 A foreign monopolist using an online marketplace

There is a destination country (Home) where firms do not exist. To supply goods to Home, there are a foreign firm (firm 1) and a foreign online platform operator ($O$). Firm 1 exports homogeneous goods to Home using an online marketplace, which is operated by the online platform operator. The foreign online platform operator does not produce goods and it focuses only on running the online marketplace. We denote this case as $O$. The firm incurs the unit tariff, $\tau > 0$, for the export. In addition, firm 1 must pay a proportion of total sales, which is the total sales multiplied by the ad valorem sales fees, $r \in (0.1)$, for using the online marketplace, that is, the online platform operator receives part of total sales of firm 1.[5] Regarding marginal labor costs, firms 1 incurs $c_1$.

### 4.2.1 Equilibrium analysis: case $O$

Firm 1 produces goods as a monopolist. We assume that the inverse demand function in Home is as follows:

$$p = \alpha - \beta q_1,$$

where $p$ is the price of the goods, $q_1$ is the goods supplied by firm 1, and $\alpha$ and $\beta$ are positive and constant terms. Given the inverse demand function, the profit functions of firm 1 and the online platform operator are:

$$\pi_1^O = (1-r)pq_1 - \tau q_1 - c_1 q_1 = [(1-r)(\alpha - \beta q_1) - \tau - c_1]q_1$$
$$\pi_O^O = rpq_1 = r(\alpha - \beta q_1)q_1$$

[5] Typically, firms pay a fixed participation fee for using the online marketplace. However, in practice, this fee is often relatively small. For instance, Amazon imposes a $39.99 monthly subscription fee on sellers intending to sell more than 40 items per month. Similarly, Sears.com charges a $39.99 fee to suppliers whose monthly sales surpass $400.

Solving the profit maximization problem, we have a equilibrium quantity of firm 1 as follows:

$$q_1^O = \frac{(1-r)\alpha - \tau - c_1}{2(1-r)\beta} \tag{4.1}$$

Naturally, the equilibrium quantity decreases in a tariff, $\tau$, and the sales fees, $r$. Ensuring the positive output in (4.1), the following condition must be satisfied:

$$q_1^O > 0 \Leftrightarrow r < 1 - \frac{\tau + c_1}{\alpha} \equiv r_{max}^O. \tag{4.2}$$

The sales fees, $r_{max}^O$, must be in the range $(0, 1)$. The conditions of $r_{max}^O \in (0, 1)$ become:

$$0 < r_{max}^O < 1 \Leftrightarrow 0 < \tau + c_1 < \alpha \tag{4.3}$$

Substituting (4.1) into the inverse demand function, we have the equilibrium price in Home as follows:

$$p^O = \frac{(1-r)\alpha + \tau + c_1}{2(1-r)} \tag{4.4}$$

Contrary to the equilibrium output, the equilibrium price is increasing in $\tau$ and $r$. Using (4.1) and (4.4), we can rewrite the profit functions as:

$$\pi_1^O = (1-r)\beta \left[\frac{(1-r)\alpha - (\tau + c_1)}{2(1-r)\beta}\right]^2 \tag{4.5}$$

$$\pi_O^O = r \left[\frac{(1-r)^2\alpha^2 - (\tau + c_1)^2}{4(1-r)^2\beta}\right] \tag{4.6}$$

### 4.2.2 Effects of introducing a tariff on equilibrium profits: case $O$

We consider the effects of the introduction of a tariff by the Home government on the equilibrium profits of firm 1 and the online platform operator. Differentiating (4.5) and (4.6) with respect to $\tau$ around $\tau = 0$, we have:

$$\Delta\pi_1^O \equiv \left.\frac{\partial \pi_1^O}{\partial \tau}\right|_{\tau=0} = \frac{-[(1-r)\alpha - c_1]}{2(1-r)\beta} < 0$$

$$\Delta\pi_O^O \equiv \left.\frac{\partial \pi_O^O}{\partial \tau}\right|_{\tau=0} = \frac{-r[(1-r)\alpha - c_1]}{2(1-r)^2\beta} < 0$$

From these results, the introduction of a tariff decreases the profits of firm 1 and the online platform operator. The intuition of the decrease in the profits of the foreign firms is straightforward. The profit function of firm 1 consists of the equilibrium quantity, $q_1^O$, in (4.1). The equilibrium quantity is decreasing in a tariff, $\tau$. Thus, the profit of firm 1 is decreasing in a tariff. The intuition of the effects of a tariff on the profit of the online platform operator is complex. The profit function of the online platform operator consists of the equilibrium quantity, $q_1^O$, and price, $p^O$. A tariff increases the equilibrium quantity and decreases the equilibrium price. This implies that the effect of the introduction of a tariff on the profit of the online platform operator depends on the price elasticity of demand for $q_1^O$. The elasticity when the Home government introduces a tariff is explicitly given as:

$$\epsilon^O|_{\tau=0} = \left( -\frac{\frac{\partial q_1^O}{\partial \tau}}{q_1^O} \Big/ \frac{\frac{\partial p^O}{\partial \tau}}{p^O} \right)\Bigg|_{\tau=0} = \frac{(1-r)\alpha + c_1}{(1-r)\alpha - c_1} > 1.$$

The elasticity is larger than 1. This indicates that the size of the decrease in the equilibrium quantity is larger than that of the reduction in the equilibrium price by the introduction of a tariff. In other words, the negative effect of the introduction of a tariff outweighs the positive effect on the online platform operator's equilibrium profit. Therefore, the profit of the online platform operator decreases with the introduction of a tariff. We summarize these results as follows.

**Proposition 4.1.** *The introduction of a tariff by the Home government decreases the profit of firm* 1 *and the online platform operator.*

### 4.2.3 Welfare analysis with the introduction of a tariff: case $O$

We analyze the effect of the introduction of a tariff (around $\tau = 0$) by the Home government on Home welfare. Home welfare consists of the consumer surplus ($CS$) and the government revenue ($GR$). The consumer surplus and government revenue are defined as follows:

$$CS^O \equiv \frac{(\alpha - p^O)q_1^O}{2} = \frac{\beta\left(q_1^O\right)^2}{2}, \quad GR^O \equiv \tau q_1^O$$

Differentiating $CS^O$ and $GR^O$ with respect to $\tau$ around $\tau = 0$, we have:

$$\left.\frac{\partial CS^O}{\partial \tau}\right|_{\tau=0} = \beta q_1^O|_{\tau=0} \left.\frac{\partial q_1^O}{\partial \tau}\right|_{\tau=0} = \frac{-1}{2(1-r)}\, q_1^O\big|_{\tau=0} < 0$$
$$\left.\frac{\partial GR^O}{\partial \tau}\right|_{\tau=0} = \underbrace{\tau|_{\tau=0} \left.\frac{\partial q_1^O}{\partial \tau}\right|_{\tau=0}}_{Output\ change} + \underbrace{q_1^O|_{\tau=0}}_{Tariff\ change} = q_1^O\big|_{\tau=0} > 0$$

Summing both effects, we have the total effects of the introduction of a tariff on Home welfare as follows:

$$\Delta TS^O \equiv \left.\frac{\partial CS^O}{\partial \tau}\right|_{\tau=0} + \left.\frac{\partial GR^O}{\partial \tau}\right|_{\tau=0} = \frac{1-2r}{2(1-r)}\, q_1^O\big|_{\tau=0} \gtreqless 0$$

Then, we can derive the condition of the change in Home welfare by the introduction of a tariff as follows:

$$\Delta TS^O \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{2}$$

With the positive outputs condition in (4.2), we consider $r = 1/2$ exists in or out side of the range $(0, r^O_{max})$. Comparing $r = 1/2$ with $r^O_{max}$, we have:

$$\frac{1}{2} \lesseqgtr r^O_{max} \Leftrightarrow \alpha \gtreqless 2c_1 \tag{4.7}$$

This relationship implies that $r = 1/2$ tends to exist in (outside of) $r^O_{max}$ with small (large) $c_1$. Combining (4.3) around $\tau = 0$ with (4.7), we have the following two cases:

$$c_1 < \alpha \leq 2c_1, \quad 2c_1 < \alpha$$

Figure 4.1(a) and 4.1(b) describe the sign of change in Home welfare by the introduction of a tariff.


**(a)** $c_1 < \alpha \leq 2c_1$ **(b)** $2c_1 < \alpha$

**Figure 4.1.** Change in Home welfare in case $O$

With $r = 0$, the introduction of a tariff increases Home welfare. This is the result of the conventional international trade theory (Brander and Spencer, 1984a). Unlike what was previously thought, the introduction of a tariff may harm Home welfare. The intuition of this result is following. The government revenue consists of the equilibrium output, $q_1^O$, and a tariff, $\tau$. The effect of the introduction of a tariff on the government revenue is divided into two: the change in $q_1^O$ and $\tau$. Around $\tau = 0$, the former effect can be negligible and the latter effect is positive. This implies that the effect of the introduction of a tariff on the government revenue is positive. Meanwhile, the consumer surplus consists of the equilibrium price, $p^O$, and the equilibrium output, $q_1^O$. The introduction of a tariff increases $p^O$ and decreases $q_1^O$. This indicates that the consumer surplus decreases in a tariff. With $r > 1/2$, the size of introducing a tariff effect on the consumer surplus becomes larger. This is because the price elasticity of demand for $q_1^O$ is increasing in $r$.[6] Furthermore, small $c_1$ is needed to hold the positive effect of introducing a tariff on Home welfare in Figure 4.1(b) and the sales fees, $r$, can be larger than $r = 1/2$. This is because with small $c_1$, firm 1 can ensure a positive output with high $r$. Thus, $r^O_{max}$ in (4.2) can become large. We summarize the effect of the introduction of a tariff on Home welfare as follows.

**Proposition 4.2.** *The introduction of a tariff by the Home government decreases Home welfare when the sales fees, $r$, is sufficiently large and the marginal labor costs of firm* 1*, $c_1$, are sufficiently small.*

[6] Differentiating $\epsilon^O|_{\tau=0}$ with respect to $r$, we have:

$$\frac{\partial \epsilon^O|_{\tau=0}}{\partial r} = \frac{2\alpha c_1}{[(1-r)\alpha - c_1]^2} > 0$$

## 4.3 Two foreign firms using an online marketplace

In this section, we extend case $O$ by adding a foreign firm (firm 2) which incurs marginal labor costs, $c_2$. We then analyze the economy where both foreign firms export goods to Home through an online marketplace which is run by an online platform operator. Firms 1 and 2 produce the same goods and compete under the Cournot competition. We denote this case as case $OO$. In case $OO$, the online platform operator receives part of total sales of firms 1 and 2.

### 4.3.1 Equilibrium analysis: case $OO$

The foreign firms set the quantities under the Cournot competition. We assume the inverse demand function in Home is as follows:

$$p = \alpha - \beta(q_1 + q_2), \tag{4.8}$$

where $q_1$ and $q_2$ are the goods supplied by firms 1 and 2. Given the demand function, profit functions of firms 1 and 2 and the online platform operator are:

$$\begin{aligned}
\pi_1^{OO} &= [(1-r)p - \tau - c_1]q_1 = \{(1-r)[\alpha - \beta(q_1+q_2)] - \tau - c_1\}q_1 \\
\pi_2^{OO} &= [(1-r)p - \tau - c_2]q_2 = \{(1-r)[\alpha - \beta(q_1+q_2)] - \tau - c_2\}q_2 \\
\pi_O^{OO} &= rp(q_1+q_2) = r[\alpha - \beta(q_1+q_2)](q_1+q_2)
\end{aligned}$$

Solving the profit maximization problems for each firm, we have equilibrium quantities and the equilibrium price in Home as follows:

$$q_1^{OO} = \frac{(1-r)\alpha - \tau - 2c_1 + c_2}{3(1-r)\beta} \tag{4.9}$$

$$q_2^{OO} = \frac{(1-r)\alpha - \tau + c_1 - 2c_2}{3(1-r)\beta} \tag{4.10}$$

$$p^{OO} = \frac{(1-r)\alpha + 2\tau + c_1 + c_2}{3(1-r)} \tag{4.11}$$

We assume the relationship $c_1 > c_2$. Ensuring the positive outputs in (4.9) and (4.10), the following condition must be satisfied:[7]

$$q_1^{OO} > 0 \Leftrightarrow r < 1 - \frac{\tau + 2c_1 - c_2}{\alpha} \equiv r_{max}^{OO} \text{ if } c_1 > c_2 \tag{4.12}$$

The sales fees, $r_{max}^{OO}$, must be in the range $(0, 1)$. The conditions of $r_{max}^{OO} \in (0, 1)$ are as follows:

$$0 < r_{max}^{OO} < 1 \Leftrightarrow 0 < \tau + 2c_1 - c_2 < \alpha \tag{4.13}$$

Under this condition, the equilibrium quantities of each firm decrease in a tariff, $\tau$, and the sales fees, $r$, while the equilibrium price increases in $\tau$ and $r$. The effects of $\tau$ and $r$ on the equilibrium quantities and price are same as case $O$. Using (4.9), (4.10), and (4.11), we can rewrite the profit functions as follows:

$$\pi_1^{OO} = (1-r)\beta \left[ \frac{(1-r)\alpha - \tau - 2c_1 + c_2}{3(1-r)\beta} \right]^2 \tag{4.14}$$

$$\pi_2^{OO} = (1-r)\beta \left[ \frac{(1-r)\alpha - \tau + c_1 - 2c_2}{3(1-r)\beta} \right]^2 \tag{4.15}$$

$$\pi_O^{OO} = r \left[ \frac{2(1-r)^2\alpha^2 + (1-r)\alpha(2\tau + c_1 + c_2) - (2\tau + c_1 + c_2)^2}{9(1-r)^2\beta} \right] \tag{4.16}$$

### 4.3.2 Effects of introducing a tariff on equilibrium profits: case $OO$

First, we analyze the effect of introducing a tariff on the equilibrium profits of firms 1 and 2. Differentiating (4.14) and (4.15) with respect to $\tau$ around $\tau = 0$, we have:

$$\Delta\pi_1^{OO} \equiv \left. \frac{\partial \pi_1^{OO}}{\partial \tau} \right|_{\tau=0} = \frac{-2[(1-r)\alpha - 2c_1 + c_2]}{9(1-r)\beta} < 0$$

$$\Delta\pi_2^{OO} \equiv \left. \frac{\partial \pi_2^{OO}}{\partial \tau} \right|_{\tau=0} = \frac{-2[(1-r)\alpha + c_1 - 2c_2]}{9(1-r)\beta} < 0$$

From these results, the introduction of a tariff decreases the profits of the foreign firms. The intuition behind these results is straightforward. The profit functions of the foreign firms consist

[7] If $c_1 < c_2$ holds, the positive outputs are satisfied with the following condition:

$$q_2^{OO} > 0 \Leftrightarrow r < 1 - \frac{\tau - c_1 + 2c_2}{\alpha} \text{ if } c_1 < c_2.$$

The other conditions are the same with $c_1 < c_2$.

of the equilibrium quantities (4.9) and (4.10). These quantities are decreasing in the tariff, $\tau$. Thus, the profits of both firms are decreasing in the tariff. This result is the same as case $O$.

Second, we consider the effect of the introduction of a tariff on the equilibrium profit of the online platform operator. Differentiating (4.16) with respect to $\tau$ around $\tau = 0$, we have:

$$\Delta\pi_O^{OO} \equiv \left.\frac{\partial \pi_O^{OO}}{\partial \tau}\right|_{\tau=0} = 2r\left[\frac{(1-r)\alpha - 2(c_1+c_2)}{9(1-r)^2\beta}\right] \gtreqless 0$$

Compared to the result of case $O$, the effect of introducing a tariff on the profit of the online platform operator is ambiguous. In other words, the profit of the online platform operator may increase by the introduction of a tariff in case $OO$. The condition that the sign of the effect of the introduction of a tariff on online platform operator's profit around $\tau = 0$ becomes:

$$\Delta\pi_O^{OO} \gtreqless 0 \Leftrightarrow r \lesseqgtr 1 - \frac{2(c_1+c_2)}{\alpha} \equiv r_O^{OO}. \tag{4.17}$$

Comparing $r_O^{OO}$ with $r_{max}^{OO}$ in (4.12) with $\tau = 0$, we can easily show $r_O^{OO} < r_{max}^{OO}$. The condition that $r_O^{OO}$ exists in or outside of the range $(0, 1)$ is as follows:

$$\alpha \gtreqless 2(c_1+c_2) \tag{4.18}$$

Combining the conditions, (4.13) and (4.18) with $\tau = 0$, we have the following two cases:

$$2c_1 - c_2 < \alpha \leq 2(c_1+c_2), \quad 2(c_1+c_2) < \alpha.$$

The following figures describe the change in the sign of the tariff effect on the online platform operator's profit.


**(a)** $2c_1 - c_2 < \alpha \leq 2(c_1+c_2)$ **(b)** $2(c_1+c_2) < \alpha$

**Figure 4.2.** Change in the profit of the online platform operator in case $OO$

The profit function of the online platform operator consists of the equilibrium price in (4.11) and the sum of the equilibrium quantities. The equilibrium price is increasing in a tariff, but the sum of the equilibrium quantities is decreasing in a tariff. Considering the price elasticity of the demand when the Home government introduces a tariff, it can be rewritten as:

$$\epsilon^{OO}|_{\tau=0} = \left( -\frac{\frac{\partial q_1^{OO}+q_2^{OO}}{\partial \tau}}{q_1^{OO}+q_2^{OO}} \Bigg/ \frac{\frac{\partial p^{OO}}{\partial \tau}}{p^{OO}} \right)\Bigg|_{\tau=0} = \frac{(1-r)\alpha + c_1 + c_2}{2(1-r)\alpha - (c_1+c_2)} \gtreqless 1$$

$$= r \gtreqless r_O^{OO}$$

In case $OO$, the elasticity can become equal or less than 1. The price elasticity of demand is increasing in $c_1 + c_2$.[8] In addition, the price elasticity of demand is increasing in $r$ owing to $r > r_O^{OO}$.[9] Figure 4.2(a) presents the case where the price elasticity of demand is greater than 1. In this case, the size of the increase in the price is lower than that of the decrease in the sum of the quantities. Thus, the introduction of a tariff decreases the profit of the online platform operator with any values of $r$ when $c_1 + c_2$ is high. Figure 4.2(b) describes the case where the price elasticity of demand is low. In this case, the sign of the effect of introducing a tariff depends on the values of $r$. When $r$ becomes larger, the price elasticity of demand becomes larger. Along with that, the introduction of a tariff increases the profit of the online platform operator. The price elasticity of demand becomes small with small $r$. Therefore, ensuring that the introduction of a tariff increases the profit of the online platform operator, the sufficiently low marginal labor costs, $c_1 + c_2$, and sales fees, $r$, must be satisfied. We can summarize the above discussion as the following proposition.

**Proposition 4.3.** *The introduction of a tariff by the Home government may increase the profit of the online platform operator when the sum of the marginal labor costs, $c_1 + c_2$, and the sales fees, $r$, are sufficiently low.*

[8]Differentiating $\epsilon^{OO}|_{\tau=0}$ with respect to $c_1 + c_2$ and $r$, we have:

$$\frac{\partial \epsilon^{OO}|_{\tau=0}}{\partial c_1 + c_2} = \frac{3(1-r)\alpha}{[2(1-r)\alpha - (c_1+c_2)]^2} > 0.$$

[9]Differentiating $\epsilon^{OO}|_{\tau=0}$ with respect to $r$, we have:

$$\frac{\partial \epsilon^{OO}|_{\tau=0}}{\partial r} = \frac{\alpha[-(1-r)\alpha + 2\alpha(c_1+c_2)]}{[2(1-r)\alpha - (c_1+c_2)]^2} \begin{cases} < 0 & \text{if} \quad r < 1 - \frac{2(c_1+c_2)}{\alpha} \equiv r_O^{OO} \\ > 0 & \text{if} \quad r > r_O^{OO} \end{cases}$$

### 4.3.3 Welfare analysis: case $OO$

We analyze the effect of the introduction of a tariff (around $\tau = 0$) on Home welfare in case $OO$. As with case $O$, Home welfare consists of the consumer surplus ($CS$) and government revenue ($GR$). The consumer surplus and government revenue are defined as follows:

$$CS^{OO} \equiv \frac{(\alpha - p^{OO})(q_1^{OO} + q_2^{OO})}{2} = \frac{\beta(q_1^{OO} + q_2^{OO})^2}{2}, \quad GR^{OO} \equiv \tau(q_1^{OO} + q_2^{OO})$$

Differentiating $CS^{OO}$ and $GR^{OO}$ with respect to $\tau$ around $\tau = 0$, we have:

$$\left.\frac{\partial CS^{OO}}{\partial \tau}\right|_{\tau=0} = \frac{-2}{3(1-r)} \left.(q_1^{OO} + q_2^{OO})\right|_{\tau=0} < 0, \quad \left.\frac{\partial GR^{OO}}{\partial \tau}\right|_{\tau=0} = \left.(q_1^{OO} + q_2^{OO})\right|_{\tau=0} > 0$$

Summing both effects, we have the total effects of introducing a tariff on Home welfare as follows:

$$\Delta TS^{OO} \equiv \left.\frac{\partial CS^{OO}}{\partial \tau}\right|_{\tau=0} + \left.\frac{\partial GR^{OO}}{\partial \tau}\right|_{\tau=0} = \frac{1-3r}{3(1-r)} \left.(q_1^{OO} + q_2^{OO})\right|_{\tau=0} \gtreqless 0$$

Then, we derive the condition of the change in Home welfare by the introduction of a tariff. The condition that the sign of Home welfare changes is as follows:

$$\Delta TS^{OO} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{3}$$

With the positive outputs condition in (4.12), we consider the $r = 1/3$ exists inside or outside of the range $(0, r_{max}^{OO})$. Comparing $r = 1/3$ with $r_{max}^{OO}$, we have:

$$\frac{1}{3} \lesseqgtr r_{max}^{OO} \Leftrightarrow \alpha \gtreqless \frac{3}{2}(2c_1 - c_2) \tag{4.19}$$

This relationship implies that $r = 1/3$ tends to exist inside (outside) of $r_{max}^{OO}$ with small (large) $c_1$ and large (small) $c_2$. Combining (4.13) with (4.19), we have the following two cases:

$$2c_1 - c_2 < \alpha \leq \frac{3}{2}(2c_1 - c_2), \quad \frac{3}{2}(2c_1 - c_2) < \alpha$$

Figure 4.3(a) and 4.3(b) describe the sign for change in Home welfare by the introduction of a tariff.


**(a)** $2c_1 - c_2 < \alpha \leq \frac{3}{2}(2c_1 - c_2)$ **(b)** $\frac{3}{2}(2c_1 - c_2) < \alpha$

**Figure 4.3.** Change in Home welfare in case $OO$

Compared to case $O$, the government revenue consists of the sum of the equilibrium output, $q_1^{OO} + q_2^{OO}$ and the tariff. The tariff effect on the government revenue is twofold: the change in the tariff and the sum of the equilibrium output. As with case $O$, the former effect can be negligible, and the latter effect is positive around $\tau = 0$. Thus, the effect of introducing a tariff on the government revenue is positive.

Regarding the consumer surplus, it consists of the equilibrium price, $p^{OO}$, and the sum of the equilibrium output, $q_1^{OO} + q_2^{OO}$. Home welfare decreases in $p^{OO}$ but increases in $q_1^{OO} + q_2^{OO}$. The price elasticity of demand for the sum of the equilibrium output is increasing in $c_2$. In addition, the elasticity becomes larger with larger $r$.[10] This implies that the effect of introducing a small tariff on the consumer surplus becomes smaller when $c_2$ and $r$ are larger. Thus, the size of the negative effects, the increase in $p^{OO}$ and the reduction in $q_1^{OO} + q_2^{OO}$, becomes larger. In addition, the price elasticity of demand for the sum of the equilibrium output is also increasing in $c_1$. This leads to larger negative effects on welfare. However, we need to small $c_1$ ensuring $1/3 < r_{max}^{OO}$ because $r_{max}^{OO}$ decreases in $c_1$.

In terms of Home welfare, it is clear that the negative impact of reduced consumer surplus outweighs the positive impact of increased government revenue with $3(2c_1 - c_2)/2 < \alpha$ and $r > 1/3$. Thus, Home welfare decreases with $3(2c_1 - c_2)/2 < \alpha$ and $r > 1/3$. We formally state this result in the following proposition.

**Proposition 4.4.** *The introduction of a tariff by the Home government decreases Home welfare with the sufficiently small marginal labor costs of firm* 1, $c_1$, *and the sufficiently large sales fees,* $r$, *and marginal labor costs of firm* 2, $c_2$.

[10] Taking the second derivative of $\epsilon^{OX}|_{\tau=0}$ with respect to $r$, we have:

$$\frac{\partial^2 \epsilon^{OX}|_{\tau=0}}{\partial r^2} = \frac{3\alpha^2}{[2(1-r)\alpha - (c_1 + c_2)]^2} > 0.$$

## 4.4 One of foreign firms using an online marketplace

According to Sun (2021) and Carballo *et al.* (2022), a firm exporting its goods using the online marketplace and a firm exporting its goods directly coexist in the same industry. Thus, in this subsection, we analyze the case where foreign duopolists export their goods when only one of them uses an online marketplace. Specifically, one of foreign firms, firm 1, exports its goods to Home using the online marketplace same as that in case $OO$. Regarding the other foreign firm, firm 2 exports its goods directly (not using the online marketplace). We denote this case as $OX$. Both firms still incur the unit tariff, $\tau > 0$, for the export. Firm 1 must pay part of the total sales which is the total sales multiplied by the ad valorem sales fees, $r \in (0.1)$, while firm 2 does not have to pay it. The online platform operator which operates the online marketplace receives part of the total sales of firm 1. Regarding marginal labor costs, firm 1 incurs $c_1$ and firm 2 incurs $c_2$ like case $OO$.

### 4.4.1 Equilibrium analysis: case $OX$

Given the inverse demand function in (4.8), profit functions of both foreign firms and the online platform operator are:

$$\begin{aligned}
\pi_1^{OX} &= (1-r)pq_1 - \tau q_1 - c_1 q_1 = \{(1-r)[\alpha - \beta(q_1+q_2)] - \tau - c_1\}q_1 \\
\pi_2^{OX} &= pq_2 - \tau q_2 - c_2 q_2 = [\alpha - \beta(q_1+q_2) - \tau - c_2]q_2 \\
\pi_O^{OX} &= rpq_1 = r[\alpha - \beta(q_1+q_2)]q_1
\end{aligned}$$

Solving the profit maximization problems for each exporting firm, we have equilibrium outputs and price as follows:

$$q_1^{OX} = \frac{(1-r)\alpha - (1+r)\tau - 2c_1 + (1-r)c_2}{3(1-r)\beta} \tag{4.20}$$

$$q_2^{OX} = \frac{(1-r)\alpha - (1-2r)\tau + c_1 - 2(1-r)c_2}{3(1-r)\beta} \tag{4.21}$$

$$p^{OX} = \frac{(1-r)\alpha + (2-r)\tau + c_1 + (1-r)c_2}{3(1-r)} \tag{4.22}$$

The equilibrium output of the firm using the online marketplace (firm 1) is decreasing in $\tau$ while the equilibrium price is increasing in $\tau$. We cannot see a clear relationship between the equilibrium output of the direct exporting (firm 2) and $\tau$. In the later section, we analyze the effect of $\tau$ around $\tau = 0$ on $q_2^{OX}$.

From here, we assume the relationship $c_1 > c_2$.[11] The condition for the positive outputs in (4.20) and (4.21) is as follows:

$$q_1^{OX} > 0 \Leftrightarrow r < \frac{\alpha - \tau - 2c_1 + c_2}{\alpha + c_2 + \tau} \equiv r_{max}^{OX} \tag{4.23}$$

The conditions of $r_{max}^{OX} \in (0, 1)$ are as follows:

$$r_{max}^{OX} > 0 \Leftrightarrow \alpha > \tau + 2c_1 - c_2, \quad r_{max}^{OX} < 1 \Leftrightarrow 2(c_1 + \tau) > 0 \tag{4.24}$$

Using (4.20), (4.21), and (4.22), we can rewrite the profit functions as follows:

$$\pi_1^{OX} = (1 - r)\beta \left[\frac{(1 - r)\alpha - (1 + r)\tau - 2c_1 + (1 - r)c_2}{3(1 - r)\beta}\right]^2 \tag{4.25}$$

$$\pi_2^{OX} = \beta \left[\frac{(1 - r)\alpha - (1 - 2r)\tau + c_1 - 2(1 - r)c_2}{3(1 - r)\beta}\right]^2 \tag{4.26}$$

$$\begin{aligned}\pi_O^{OX} = r &\left[\frac{(1 - r)^2(\alpha + c_2)^2 + (1 - r)(1 - 2r)(\alpha + c_2)\tau - (1 - r)(\alpha + c_2)c_1}{9(1 - r)^2\beta}\right. \\ &\left. + \frac{-(1 + r)(2 - r)\tau^2 - (5 - r)\tau c_1 - 2{c_1}^2}{9(1 - r)^2\beta}\right]\end{aligned} \tag{4.27}$$

### 4.4.2 Effects of introducing a tariff on equilibrium profits: case $OX$

First, we analyze the effect of the introduction of a tariff on the equilibrium profit of firm 1. Differentiating (4.25) with respect to $\tau$ around $\tau = 0$, we have:

$$\left.\frac{\partial \pi_1^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{-2(1 + r)[(1 - r)\alpha - 2c_1 + (1 - r)c_2]}{9(1 - r)\beta} < 0$$

The profit of firm 1 in (4.25) consists of the equilibrium output of firm 1 in (4.20). Tariff decreases the equilibrium output of firm 1 in (4.20). Therefore, the introduction of a tariff decreases the profit of firm 1.

Second, we study the effect of introducing a tariff on the equilibrium profit of firm 2. Differ-

[11] Sun (2021) shows that the productivity level of the firm exporting goods through the online marketplace is lower than that of the firms directly exporting goods. Thus, we assume $c_1 > c_2$. We analyze the tariff effect on the economy around $\tau = 0$. In this situation, the positive outputs are ensured by $r_{max}^{OX}$. See Appendix for details.

entiating (4.26) with respect to $\tau$ around $\tau = 0$, we have:

$$\left.\frac{\partial \pi_2^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{-2(1-2r)[(1-r)\alpha + c_1 - 2(1-r)c_2]}{9(1-r)^2\beta} \gtreqless 0.$$

Compared to case $OO$, the introduction of a tariff may increase the equilibrium profit of the direct exporting firm. The condition of the sign of change in the equilibrium profit of firm 2 is as follows:

$$\Delta\pi_2^{OX} \gtreqless 0 \Leftrightarrow r \gtreqless \frac{1}{2}$$

Comparing $r = 1/2$ with $r_{max}^{OX}$ with $\tau = 0$, we have:

$$\frac{1}{2} \gtreqless r_{max}^{OX} \Leftrightarrow \alpha \lesseqgtr 4c_1 - c_2 \tag{4.28}$$

Combining the conditions, (4.24) and (4.28), with $\tau = 0$, we have the following two cases:

$$2c_1 - c_2 < \alpha \leq 4c_1 - c_2, \quad 4c_1 - c_2 < \alpha.$$

Figure 4.4(a) and 4.4(b) describe the sign of the introduction of a tariff effect on the profit of the direct exporting firm.


**(a)** $2c_1 - c_2 < \alpha \leq 4c_1 - c_2$ **(b)** $4c_1 - c_2 < \alpha$

**Figure 4.4.** Change in the profit of the direct exporting firm in case $OX$

From the figures, the effect of the introduction of a tariff on the equilibrium profit of the direct exporting firm is summarized in the following proposition.

**Proposition 4.5.** *The introduction of a tariff by the Home government increases the profit of firm* 2 *when the sales fees,* $r$*, are sufficiently large, the marginal labor costs of firm* 1, $c_1$*, are sufficiently low, and the marginal labor costs of firm* 2, $c_2$*, are sufficiently large.*

The intuition behind Proposition 4.5 is as follows. The effect of the sales fees on the equilibrium outputs $q_1^{OX}$ and $q_2^{OX}$ around $\tau = 0$ are:

$$\left.\frac{\partial q_1^{OX}}{\partial r}\right|_{\tau=0} = -\frac{2c_1}{3(1-r)^2} < 0, \quad \left.\frac{\partial q_2^{OX}}{\partial r}\right|_{\tau=0} = \frac{c_1}{3(1-r)^2} > 0.$$

These indicate that firm 1 loses market power, whereas firm 2 gains market power when $r$ is large. The effects of the introduction of a tariff on the equilibrium output of the firm using the online marketplace, firm 1, and that of the direct exporting firm, firm 2, are:

$$\left.\frac{\partial q_1^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{-(1+2r)}{3(1-r)\beta} < 0, \quad \left.\frac{\partial q_2^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{-(1-2r)}{3(1-r)\beta} \gtreqless 0 \Leftrightarrow r \gtreqless \frac{1}{2}$$

With $r > 1/2$, there exists a positive spillover effect on the equilibrium output of firm 1. With large $r$, the increase in the equilibrium price with the introduction of a tariff depends largely on the reduction in $q_1^{OX}$. This is because the market share of firm 2 becomes larger than that of firm 1. This indicates that the equilibrium output of firm 2 decreases slightly and thus the equilibrium profit of firm 2 decreases with $r \leq 1/2$ as shown in Figure 4.4(a). However, when $r$ is sufficiently large, $r > 1/2$, market power of firm 1 becomes sufficiently low. Then, the equilibrium output of firm 1 drops considerably with the introduction of a tariff. As a result, the equilibrium output of firm 2 can increase in the introduction of a tariff with $r > 1/2$. The equilibrium price increases by introducing a tariff, and thus the equilibrium profit of firm 2 rises by the introduction of a tariff with $r > 1/2$. This result is shown in Figure 4.4(b).

Regarding the marginal labor costs, $c_1$ and $c_2$, if $c_1$ is small and $c_2$ is large, market power of firm 1 becomes large and that of firm 2 becomes small. This suggeests that the change in the equilibrium profit of firm 2 is negative. However, with small $c_1$ and large $c_2$, $r_{max}^{OX}$ becomes large. Thus, we must have $c_1$ that is sufficiently small and $c_2$ that is sufficiently large to ensure the relationship, $1/2 < r_{max}^{OX}$.

Third, we analyze the effect of the introduction of a tariff on the equilibrium online platform operator's profit. Differentiating (4.27) with respect to $\tau$ around $\tau = 0$, we have:

$$\left.\frac{\partial \pi_R^{OX}}{\partial \tau}\right|_{\tau=0} = r\left[\frac{(1-r)(1-2r)(\alpha+c_2)-(5-r)c_1}{9(1-r)^2\beta}\right] \gtreqless 0$$

The sign of the effect of introducing a tariff is summarized as:

$$\Delta\pi_O^{OX}\begin{cases} <0 & \text{if} \quad r>\frac{1}{2} \\ \leq 0 & \text{if} \quad r\leq\frac{1}{2} \quad \text{and} \quad (1-r)(1-2r)(\alpha+c_2)-(5-r)c_1\leq 0 \\ >0 & \text{if} \quad r\leq\frac{1}{2} \quad \text{and} \quad (1-r)(1-2r)(\alpha+c_2)-(5-r)c_1>0 \end{cases}$$

As discussed, the equilibrium price increases, the equilibrium output of firm 1 decreases, and the equilibrium output of firm 2 increases with the introduction of a tariff when $r$ is larger than $1/2$. This implies that the size of the reduction in $q_1^{OX}$ is larger than that of the rise in $p^{OX}$. The equilibrium profit of the online platform operator consists of $p^{OX}$ and $q_1^{OX}$. Therefore, the profit of the online platform operator decreases if a tariff is introduced with $r>1/2$.

If $r\leq 1/2$ holds, the effect of introducing a tariff on $\pi_O^{OX}$ becomes complex. We derive the cutoff of the sales fees for the online platform operator's profit change. We define $f(r)\equiv(1-r)(1-2r)(\alpha+c_2)-(5-r)c_1$. The function $f(r)$ is a concave function and the solution of $f(r)=0$ is less than $1/2$.[12] Specifically, we have:

$$r_O^{OX}\equiv\frac{3(\alpha+c_2)-c_1-\sqrt{(\alpha+c_2)^2+34(\alpha+c_2)c_1+{c_1}^2}}{4(\alpha+c_2)}<\frac{1}{2} \tag{4.29}$$

As the function $f(r)$ is a concave function, we can rewrite the sign of the effect of introducing a tariff with $r\leq 1/2$ as:

$$\Delta\pi_O^{OX}\begin{cases} \leq 0 & \text{if} \quad r\leq\frac{1}{2} \quad \text{and} \quad r\geq r_O^{OX} \\ >0 & \text{if} \quad r\leq\frac{1}{2} \quad \text{and} \quad r<r_O^{OX} \end{cases}$$

Then, we derive the condition that $r_O^{OX}$ is greater than or less than 0. The condition can be written as:

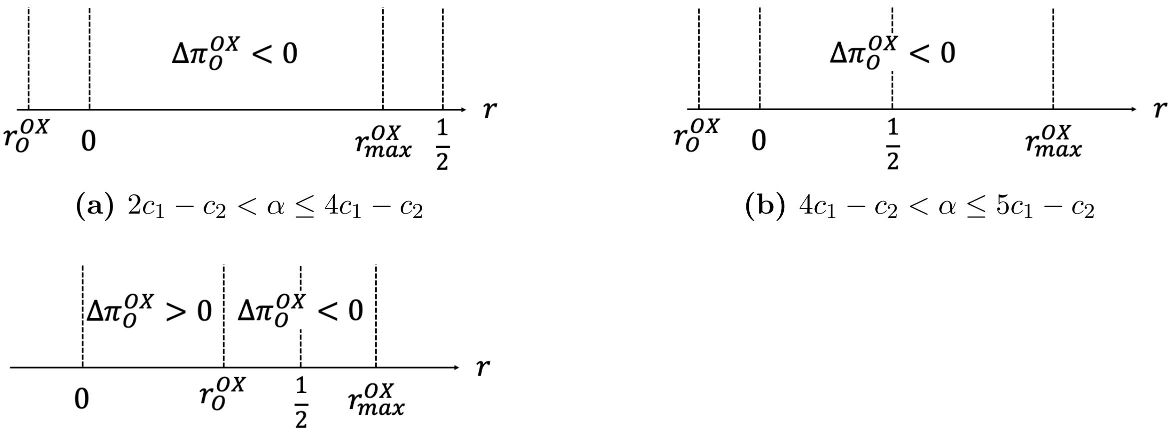
$$r_O^{OX}\gtreqless 0\Leftrightarrow\alpha\gtreqless 5c_1-c_2 \tag{4.30}$$

Combining the conditions, (4.23), (4.28), and (4.30), we have the following three cases:

$$2c_1-c_2<\alpha\leq 4c_1-c_2,\quad 4c_1-c_2<\alpha\leq 5c_1-c_2,\quad 5c_1-c_2<\alpha$$

[12]See Appendix for details.

The following figures describe the sign of the change in the online platform operator by the introduction of a tariff.




**(a)** $2c_1 - c_2 < \alpha \leq 4c_1 - c_2$

**(b)** $4c_1 - c_2 < \alpha \leq 5c_1 - c_2$

**(c)** $5c_1 - c_2 < \alpha$

**Figure 4.5.** Change in the profit of the online platform operator in case $OX$

From these figure, we can establish the following proposition.

**Proposition 4.6.** *The introduction of a tariff by the Home government increases the profit of the online platform operator when the sales fees, $r$, is sufficiently low, the marginal labor costs of firm 1, $c_1$, are sufficiently small, and the marginal labor costs of firm 2, $c_2$, are sufficiently large.*

The intuition behind Proposition 4.6 is following. Considering the price elasticity of demand for $q_1^{OX}$ when the Home government introduces a tariff, it can be written as:

$$\epsilon_1^{OX}|_{\tau=0} = \left( -\frac{\frac{\partial q_1^{OX}}{\partial \tau}}{q_1^{OX}} \Big/ \frac{\frac{\partial p^{OX}}{\partial \tau}}{p^{OX}} \right)\Bigg|_{\tau=0} = \frac{1+r}{2-r} \cdot \frac{(1-r)\alpha + c_1 + (1-r)c_2}{(1-r)\alpha - 2c_1 + (1-r)c_2}.$$

The elasticity is decreasing in $c_2$ but $r_O^{OX}$ is increasing in $c_2$.[13] Figure 4.5(a) and 4.5(b) describe cases where the marginal labor costs, $c_2$, are not large. In these cases, the elasticity is not small. In addition, smaller $c_2$ leads to smaller $r_O^{OX}$, $r_O^{OX} \leq 0$. In other words, the relative size of the reduction in $q_1^{OX}$ to the increase in $p^{OX}$ is not small with the any value of $r$. Thus, the profit of the online platform operator decreases because the profit consists of $p^{OX}$ and $q_1^{OX}$.

[13]Differentiating $\epsilon_1^{OX}|_{\tau=0}$ and $r_O^{OX}$ respectively with respect to $c_2$, we have:

$$\frac{\epsilon_1^{OX}|_{\tau=0}}{c_2} = \frac{-(1+r)(1-r)c_1}{(2-r)[(1-r)\alpha - 2c_1 + (1-r)c_2]} < 0, \quad \frac{\partial r_O^{OX}}{\partial c_2} = \frac{g(c_2)^{-\frac{1}{2}} g'(c_2)}{8(\alpha + c_2)^2} > 0,$$

where $g(c_2) = (\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + c_1^2 > 0$ and $g'(c_2) = 2(\alpha + c_2) + 34c_1 > 0$.

Figure 4.5(c) describes the case where the elasticity is large and the cutoff value, $r_O^{OX}$, is large, $r_O^{OX} > 0$. In this case, the elasticity is small. This implies that the size of the reduction in $q_1^{OX}$ relative to the increase in $p^{OX}$ is small. However, large $c_2$ alone does not ensure the positive change in the equilibrium profit of the online platform operator by the introduction of a tariff. This is because the elasticity is increasing in $r$.[14] As long as $c_2$ is large enough, the elasticity does not become small enough to attain the positive change in the equilibrium profit of the online platform operator with large $r$. Thus, the equilibrium profit of the online platform operator increases by the introduction of a tariff if $c_2$ is sufficiently large and $r$ is sufficiently low, $r_O^{OX} > 0$.

Regarding the marginal labor costs of firm 1, $c_1$, the elasticity rises in $c_1$. This implies that the elasticity is small when $c_1$ is small and the change in the profit of the online platform operator tends to become positive. However, small $c_1$ tends to lead small $r_O^{OX}$. Therefore, we must have sufficiently large $c_1$ for ensuring the relationship $r_O^{OX} > 0$.

### 4.4.3 Welfare analysis: case $OX$

We study the effect of the introduction of a tariff on Home welfare in case $OX$. The consumer surplus and government revenue in case $OX$ are as follows:

$$CS^{OX} \equiv \frac{(\alpha - p^{OX})(q_1^{OX} + q_2^{OX})}{2} = \frac{\beta(q_1^{OX} + q_2^{OX})^2}{2}, \quad GR^{OX} \equiv \tau(q_1^{OX} + q_2^{OX})$$

The effects of the introduction of a tariff on the consumer surplus and government revenue are:

$$\left.\frac{\partial CS^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{-(2-r)}{3(1-r)} \left.(q_1^{OX} + q_2^{OX})\right|_{\tau=0} < 0, \quad \left.\frac{\partial GR^{OX}}{\partial \tau}\right|_{\tau=0} = \left.(q_1^{OX} + q_2^{OX})\right|_{\tau=0} > 0$$

Thus, the effect of introducing a tariff on Home welfare becomes:

$$\Delta TS^{OX} \equiv \left.\frac{\partial CS^{OX}}{\partial \tau}\right|_{\tau=0} + \left.\frac{\partial GR^{OX}}{\partial \tau}\right|_{\tau=0} = \frac{1-2r}{3(1-r)} \left.(q_1^{OO} + q_2^{OO})\right|_{\tau=0} \gtreqless 0$$

[14] Differentiating $\epsilon_1^{OX}|_{\tau=0}$ with respect to $r$, we have:

$$\frac{\partial \epsilon_1^{OX}|_{\tau=0}}{\partial r} = \frac{3c_1(\alpha + c_2)(1+r)}{(2-r)[(1-r)\alpha - 2c_1 + (1-r)c_2]} + \frac{1}{(2-r)^2[(1-r)\alpha - 2c_1 + (1-r)c_2]} > 0.$$

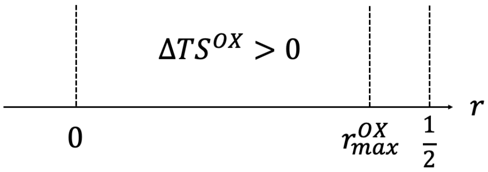
The condition that the sign of the change in Home welfare is as follows:

$$\Delta TS^{OX} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{2}$$

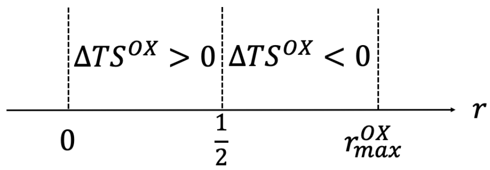
The condition whether $r = 1/2$ exists in the range $r \in (0, r^{OX}_{max})$ or not is the same as in (4.28). Thus, we have the following conditions for the effect of the introduction of a tariff on Home welfare:

$$2c_1 - c_2 < \alpha \leq 4c_1 - c_2, \quad 4c_1 - c_2 < \alpha$$

The following figures describe the sign of the change in Home welfare by the introduction of a tariff.



**(a)** $2c_1 - c_2 < \alpha \leq 4c_1 - c_2$



**(b)** $4c_1 - c_2 < \alpha$

**Figure 4.6.** Change in Home welfare in case $OX$

From these figures, we immediately yield the following proposition.

**Proposition 4.7.** *The introduction of a tariff by the Home government decreases Home welfare when the sales fees, $r$, is sufficiently high, the marginal labor costs of firm 1, $c_1$, are sufficiently small, and the marginal labor costs of firm 2, $c_2$, are sufficiently large.*

The intuition behind Proposition 4.7 is as follows. The effect of introducing a tariff on the government revenue consists solely of the sum of the equilibrium output of firm 1 and 2. This is the positive effect on Home welfare. Regarding the consumer surplus, it consists of the equilibrium price, $p^{OX}$, and the sum of the equilibrium output of firm 1 and 2, $q_1^{OX} + q_2^{OX}$. Consumer surplus is affected negatively by equilibrium price and positively by the sum of the equilibrium output. The introduction of a tariff increases $p^{OX}$ but decreases $q_1^{OX} + q_2^{OX}$ and thus the consumer surplus decreases with the introduction of a tariff. This has a negative effect on Home welfare. The price elasticity of demand for the sum of $q_1^{OX}$ and $q_2^{OX}$ when Home government introduces a tariff is given as:

$$\epsilon^{OX}|_{\tau=0} \equiv \left( -\frac{\frac{\partial q_1^{OX}+q_2^{OX}}{\partial \tau}}{q_1^{OX}+q_2^{OX}} \Bigg/ \frac{\frac{\partial p^{OX}}{\partial \tau}}{p^{OX}} \right)\Bigg|_{\tau=0} = \frac{(1-r)\alpha + c_1 + (1-r)c_2}{2(1-r)\alpha - c_1 - (1-r)c_2}$$

The elasticity, $\epsilon^{OX}|_{\tau=0}$ is increasing in $r$ and $c_2$.[15] In other words, the ratio of the reduction in the sum of $q_1^{OX}$ and $q_2^{OX}$ becomes much larger than the ratio of the increase in $p^{OX}$ with large $r$ and $c_2$. This indicates that the effect of the introduction of a tariff on $q_1^{OX} + q_2^{OX}$ becomes much larger than that on $p^{OX}$. When $r$ and $c_2$ is sufficiently large ($r > 1/2$ and $4c_1 - c_2 < \alpha$), introducing a tariff has the negative impact of reduced consumer surplus, which outweighs the positive impact of increased government revenue

Regarding the marginal labor costs of firm 1, $c_1$, the elasticity increases in $c_1$. This tends to mean that the change in Home welfare is positive. However, with large $c_1$, $r_{max}^{OX}$ becomes small, that is, large $c_1$ tends to lead the relationship, $r_{max}^{OX} \leq 1/2$. Large $c_2$ leads large $r_{max}^{OX}$ and tends to become $r_{max}^{OX} > 1/2$. Thus, we must have sufficiently small $c_1$ and sufficiently large $c_2$ to ensure the relationship, $r > 1/2$.

## 4.5 Extension

We analyze how the cutoffs of the welfare effect of the introduction of tariffs move if we assume the oligopoly in cases $OO$ and $OX$.[16] We assume that the number of symmetric firms 1 as $N_1 > 1$ and that of symmetric firms 2 as $N_2 > 1$. All firms produce same products. The inverse demand function (4.8) is rewritten as:

$$p = \alpha - \beta \left( \sum_{i=1}^{N_1} q_{1i} + \sum_{j=1}^{N_2} q_{2j} \right) \tag{4.31}$$

[15]Differentiating $\epsilon^{OX}|_{\tau=0}$ with respect to $r$ and $c_2$ respectively, we have:

$$\frac{\partial \epsilon^{OX}|_{\tau=0}}{\partial r} = \frac{3\alpha c_1}{[2(1-r) - c_1 - (1-r)c_2]^2} > 0, \quad \frac{\partial \epsilon^{OX}|_{\tau=0}}{\partial c_2} = \frac{3(1-r)^2\alpha}{[2(1-r) - c_1 - (1-r)c_2]^2} > 0$$

[16]See Appendix for details.

Given this inverse demand function, the cutoff of the welfare effect of the introduction of tariffs in case $OO$ becomes:

$$\Delta\overline{TS}^{OO} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{1+N_1+N_2} \equiv \bar{r}_{TS}^{OO}$$

Furthermore, that in case $OX$ becomes:

$$\Delta\overline{TS}^{OX} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{1+N_1} \equiv \bar{r}_{TS}^{OX}$$

Comparing the cutoffs in oligopolistic case with duopolistic case respectively, we have:

$$\bar{r}_{TS}^{OO} = \frac{1}{1+N_1+N_2} < \frac{1}{3}, \quad \bar{r}_{TS}^{OX} = \frac{1}{1+N_1} < \frac{1}{2}.$$

This implies that the welfare reduction occurs in each case with the lower sales share rate than the duopolistic case. The intuition of this result is as follows. If the number of firms exporting their goods via the online marketplace increases, the firms have less market power compared to the duopolistic case because each firm produces less products. This implies that each firm is more sensitive to the price change. Specifically, outputs of each firm decreases more than the duopolistsc case when the increase in prices by the introduction of tariffs arises. Recall that $r$ increases the price elasticity for demand. This means that lower $r$ is required to ensure the positive welfare effect than the duopolistic case. Therefore, the reduction in welfare occurs in each case with lower $r$.

## 4.6 Conclusion

In this study, we construct a model which foreign firms use an online marketplace to export their goods to the home country and have focused on effects of introducing a tariff by the home country's government on the economy. Specifically, we consider the following three cases: ($O$) where a foreign monopolist exports its product through the online marketplace, ($OO$) where both foreign firms export their products via the online marketplace, and ($OX$) where one foreign firm exports its product through the online marketplace, whereas the other foreign firm directly exports its product.

Our study's key findings can be summarized as follows. In case $O$, the imposition of a tariff results in diminished profits of the foreign monopolist and online platform operator. This potentially leads to a decrease in the home welfare. In case $OO$, the introduction of a tariff leads to a reduction in both of the foreign firms' profits. This may lead to a decline in the home country's welfare and a increase in the online platform operator's profits. In case $OX$, profits of the firm utilizing the online marketplace decreases while the profit of the direct exporting firm may increase. Furthermore, the online platform may experience a profit increase, whereas the introduction of a tariff could lead to a decrease in welfare in the home country. Our results which show how introducing small tariffs impacts the home country's welfare differ from the results of Brander and Spencer (1984a,b) and Lahiri and Ono (1999). In these studies, the effect of introducing a tariff on home welfare is either positive or negative.

Our results provide policy implications concerning the decision to abolish the duty-free exemption for goods valued less than 150 euros in the EU. Considering the sales fees of Amazon.com are at $8\% - 15\%$, if the EU eliminates the duty-free exemption, the profits of the firms using the online marketplace and direct exporting firms decrease, but welfare of the EU increases in all cases. The profits of the online platform operator decreases in case $O$, but may increases (decreases) in cases $OO$ and $OX$ if the marginal labor costs of firms using the online platform operator are small (large).

Future research is analyzing the effect of the introduction of consumption tax using the framework used in this study. In various countries, there is a growing trend of abolishing the exemption of consumption tax for imported goods through online platforms. For instance, the EU has abolished the previous exemption of consumption tax for low-value imports and introduced new regulations that impose the standard Value Added Tax (VAT) on low-value imported goods from non-EU countries as of July 1, 2021. Similarly, Australia and Canada have eliminated the exemption of consumption tax on low-value imported goods and introduced the Goods and Services Tax (GST) on low-value items. Thus, this topic is crucial to understand the relationship between e-commerce and international trade.

# Appendix 4.A Duopolistic cases

## 4.A.1 Ensuring positive outputs: case $OX$

The conditions of the positive outputs of firm 1 and 2 in (4.20) and (4.21) are:

$$q_1^{OX} > 0 \Leftrightarrow r < \frac{\alpha - \tau - 2c_1 + c_2}{\alpha + \tau + c_2} \equiv r_{max}^{OX} \tag{4.A.1}$$

$$q_2^{OX} > 0 \Leftrightarrow r < \frac{\alpha - \tau + c_1 - 2c_2}{\alpha - 2\tau - 2c_2} \tag{4.A.2}$$

We assume the positive outputs are ensured with $r = 0$. This implies that the numerators of (4.A.1) and (4.A.2), $\alpha - \tau - 2c_1 + c_2$ and $\alpha - \tau + c_1 - 2c_2$, are positive. Assuming that $r_{max}^{OX}$ is smaller than the right hand side of (4.A.2), we have:

$$\begin{aligned}
& r_{max}^{OX} < \frac{\alpha - \tau + c_1 - 2c_2}{\alpha - 2\tau - 2c_2} \\
& \Leftrightarrow \frac{\alpha - \tau - 2c_1 + c_2}{\alpha + \tau + c_2} < \frac{\alpha - \tau + c_1 - 2c_2}{\alpha - 2\tau - 2c_2} \\
& \Leftrightarrow \tau(-\alpha + \tau + c_1 + c_2) + c_1(-\alpha + c_2) < 0
\end{aligned} \tag{4.A.3}$$

Around $\tau = 0$, we have:

$$r_{max}^{OX} < \frac{\alpha - \tau + c_1 - 2c_2}{\alpha - 2\tau - 2c_2} \Leftrightarrow c_1(-\alpha + c_2) < 0$$

From (4.A.2), the denominator must be positive. This indicates $\alpha > 2c_2$ holds, the above inequality holds, and the inequality (4.A.3) holds around $\tau = 0$. Therefore, (4.A.1) is the condition for the positive outputs around $\tau = 0$.

## 4.A.2 Detail of deriving $r_O^{OX}$

Denote $f(r) = 2(\alpha + c_2)r^2 - (3\alpha + 3c_2 - c_1)r + \alpha + c_2 - 5c_1$. Differentiating $f(r)$ with respect to $r$, we have: $f'(r) = 4(\alpha + c_2)r - (3\alpha + 3c_2 - c_1) \gtreqless 0$. Taking second derivative of $f(r)$ with respect to $r$, we have: $f''(r) = 4(\alpha + c_2) > 0$. Thus, $f(r)$ is a concave function. Solving $f(r) = 0$, we have following two solutions:

$$r_O^{OX} = \frac{3(\alpha + c_2) - c_1 - \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}}{4(\alpha + c_2)}$$
$$\overline{r} = \frac{3(\alpha + c_2) - c_1 + \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}}{4(\alpha + c_2)}$$

We investigate whether each solution exists in the range $r \in (0, 1)$. The term, $3(\alpha + c_2) - c_1$, is positive owing to (4.24). Therefore, both solutions are larger than 0. If $r_O^{OX} < 1$ holds, we have:

$$\frac{3(\alpha + c_2) - c_1 - \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}}{4(\alpha + c_2)} < 1$$
$$\Leftrightarrow 0 < \alpha + c_2 + c_1 + \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}$$

This implies that $r_O^{OX}$ exists in the range $r \in (0, 1)$. On the other hand, if $\overline{r} < 1$ holds, we have:

$$\frac{3(\alpha + c_2) - c_1 + \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}}{4(\alpha + c_2)} < 1$$
$$\Leftrightarrow \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2} < \alpha + c_2 + c_1 \Leftrightarrow 32(\alpha + c_2)c_1 < 0$$

This is the contradiction. This implies that $\overline{r}$ does not exist in the range $r \in (0, 1)$. Therefore, the solution of $f(r) = 0$ with the range, $r \in (0, 1)$, is $r_O^{OX}$.

### 4.A.3 Proof of $r_O^{OX} < 1/2$

Comparing $r_O^{OX}$ with 1/2, we have:

$$\frac{3(\alpha + c_2) - c_1 - \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2}}{4(\alpha + c_2)} < \frac{1}{2}$$
$$\Leftrightarrow \alpha + c_2 - c_1 < \sqrt{(\alpha + c_2)^2 + 34(\alpha + c_2)c_1 + {c_1}^2} \Leftrightarrow 0 < 36(\alpha + c_2)c_1$$

This inequality holds and thus we have: $r_O^{OX} < 1/2$.

## Appendix 4.B Oligopolistic cases

We derive the welfare cutoffs in cases $OO$ and $OX$.

**case** *OO*

All firms in both groups 1 and 2 export their goods using the online marketplace. Given the inverse demand function (4.31), profit functions of firms $1i$ and $2j$ ($i \in N_1, j \in N_2$) in case $OO$ become:

$$\pi_{1i}^{OO} = [(1-r)p - \tau - c_1]q_{1i} = \left\{(1-r)\left[\alpha - \beta\left(\sum_{i=1}^{N_1} q_{1i} + \sum_{j=1}^{N_2} q_{2j}\right)\right] - \tau - c_1\right\} q_{1i}$$
$$\pi_{2j}^{OO} = [(1-r)p - \tau - c_2]q_{2j} = \left\{(1-r)\left[\alpha - \beta\left(\sum_{i=1}^{N_1} q_{1i} + \sum_{j=1}^{N_2} q_{2j}\right)\right] - \tau - c_2\right\} q_{2j}$$

Solving the profit maximization problems for each firm , we have equilibrium quantities for each firm and the equilibrium price in Home as follows:

$$q_{1i}^{OO} = \frac{(1-r)\alpha - \tau - (1+N_2)c_1 + N_2c_2}{(1+N_1+N_2)(1-r)\beta}$$
$$q_{2j}^{OO} = \frac{(1-r)\alpha - \tau + N_1c_1 - (1+N_1)c_2}{(1+N_1+N_2)(1-r)\beta}$$
$$\overline{p}^{OO} = \frac{(1-r)\alpha + (N_1+N_2)\tau + N_1c_1 + N_2c_2}{(1+N_1+N_2)(1-r)}$$

Home welfare can be rewritten as:

$$\overline{CS}^{OO} + \overline{GR}^{OO} = \frac{\beta\left(N_1q_{1i}^{OO} + N_2q_{2j}^{OO}\right)^2}{2} + \tau\left(N_1q_{1i}^{OO} + N_2q_{2j}^{OO}\right)$$

The effect of the introduction of tariffs on Home welfare is:

$$\Delta\overline{TS}^{OO} \equiv \left.\frac{\partial\overline{CS}^{OO}}{\partial\tau}\right|_{\tau=0} + \left.\frac{\partial\overline{GR}^{OO}}{\partial\tau}\right|_{\tau=0}$$
$$= \left[\frac{(1+N_1+N_2)(1-r) - (N_1+N_2)}{(1+N_1+N_2)(1-r)}\right]\left.\left(N_1q_{1i}^{OO} + N_2q_{2j}^{OO}\right)\right|_{\tau=0} \gtreqless 0$$

The condition that the sign of the change in Home welfare is as follows:

$$\Delta\overline{TS}^{OO} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{1+N_1+N_2} \equiv \overline{r}_{TS}^{OO}$$

**case** $OX$

Firms in groups 1 export their goods using the online marketplace whereas firms in group 2 export their goods directly. Using the inverse demand function (4.31), profit functions of firms $1i$ and $2j$ $(i \in N_1, j \in N_2)$ in case $OX$ are:

$$\pi_{1i}^{OX} = [(1-r)p - \tau - c_1]q_{1i} = \left\{(1-r)\left[\alpha - \beta\left(\sum_{i=1}^{N_1} q_{1i} + \sum_{j=1}^{N_2} q_{2j}\right)\right] - \tau - c_1\right\} q_{1i}$$
$$\pi_{2j}^{OX} = [p - \tau - c_2]q_{2j} = \left[\alpha - \beta\left(\sum_{i=1}^{N_1} q_{1i} + \sum_{j=1}^{N_2} q_{2j}\right) - \tau - c_2\right] q_{2j}$$

Solving the profit maximization problems for each firm, equilibrium quantities for each firm and the equilibrium price in Home are given as:

$$q_{1i}^{OX} = \frac{(1-r)\alpha - (1+N_2 r)\tau - (1+N_2)c_1 + N_2(1-r)c_2}{(1+N_1+N_2)(1-r)\beta}$$
$$q_{2j}^{OX} = \frac{(1-r)\alpha - [1-r(1+N_1)]\,\tau + N_1 c_1 - \frac{(1+N_1+N_2+N_1N_2)(1-r)}{1+N_2}c_2}{(1+N_1+N_2)(1-r)\beta}$$
$$\overline{p}^{OX} = \frac{(1-r)\alpha + [N_1 + (1-r)N_2]\,\tau + N_1 c_1 + N_2(1-r)c_2}{(1+N_1+N_2)(1-r)}$$

We have Home welfare as follows:

$$\overline{CS}^{OX} + \overline{GR}^{OX} = \frac{\beta\left(N_1 q_{1i}^{OX} + N_2 q_{2j}^{OX}\right)^2}{2} + \tau\left(N_1 q_{1i}^{OX} + N_2 q_{2j}^{OX}\right)$$

The effect of the introduction of tariffs on Home welfare becomes:

$$\Delta\overline{TS}^{OX} \equiv \left.\frac{\partial\overline{CS}^{OX}}{\partial\tau}\right|_{\tau=0} + \left.\frac{\partial\overline{GR}^{OX}}{\partial\tau}\right|_{\tau=0}$$
$$= \left[\frac{(1+N_1+N_2)(1-r) - (N_1+N_2)}{(1+N_1+N_2)(1-r)}\right]\left(N_1 q_{1i}^{OX} + N_2 q_{2j}^{OX}\right)\Big|_{\tau=0} \gtreqless 0$$

The condition that the sign of the change in Home welfare is following:

$$\Delta\overline{TS}^{OX} \gtreqless 0 \Leftrightarrow r \lesseqgtr \frac{1}{1+N_1} \equiv \overline{r}_{TS}^{OX}$$

# Chapter 5

# General Conclusion

This dissertation examines the topics of international trade and FDI related to the development of ICTs under the current globalization. Specifically, we consider how a reduction in communication costs for firms engaging FDI affect home welfare (Chapter 2), whether subsidies for FDI improve home welfare (Chapter 3), and how the introduction of a tariff affects an economy with an online marketplace (Chapter 4). In the following, we make brief concluding remarks on the dissertation.

In Chapter 2, we construct a three country model based on firm heterogeneity, as in Melitz (2003) and Helpman *et al.* (2004), with different communication costs between developed countries and developed and less developed countries. We derive the industry equilibrium in which export platform ($EP$) FDI firms that incur communication costs between developed and less developed countries, horizontal ($I$) FDI firms that incur communication costs between developed countries, exporting firms, and domestic firms coexist, and compare the effects of the reduction in communication costs between developed countries and between developed and less developed countries on home welfare. We find the following three key results. First, the reduction in communication costs between the developed and less developed countries consistently has a larger impact on welfare than that between the developed countries if transportation costs are low. Second, the welfare effects of reducing communication costs depend on the relative mass of $EP$-FDI firms to $I$-FDI firms if transportation costs are at an intermediate level. Third, a decrease in communication costs between the developed countries consistently has a larger impact on welfare than that between the developed and less developed countries when transportation costs are high.

In Chapter 3, we construct a model in which exporting and FDI industries coexist using a general oligopolistic equilibrium model developed by Neary (2016) to evaluate the impact of subsidies for FDI on home welfare. Specifically, we examine the welfare effects of small subsidies for fixed cost of FDI, considering different financing sources, labor income taxes, and consumption taxes, for these subsidies. We find that small FDI subsidies financed by labor income taxes have no impact on welfare, whereas those financed by consumption taxes may improve welfare. Small subsidies financed by labor income taxes do not introduce distortions in consumption patterns or firms' production levels, and do not affect the wages and prices of goods. Consequently, small subsidies financed by labor income taxes do not affect welfare. By contrast, small subsidies financed by consumption taxes reduce both demand and supply, leading to a decline in wages. Assuming that the labor coefficient of exporting industries is smaller than that of FDI industries, consumer prices in exporting industries increase, whereas those in FDI industries decrease because of the small subsidies. Welfare improves when consumer prices are low for exporting industries and high for FDI industries, particularly when trade costs are small, fixed costs of FDI are at an intermediate level, and the labor coefficient of exporting industries is sufficiently large.

Chapter 4 introduces an online marketplace operated by an online platform operator and analyses the effects of introducing a tariff on the economy. Specifically, we construct a model in which only foreign manufacturing firms export their goods to the home market, where manufacturing firms do not exist. Foreign firms that use the online marketplace pay the ad valorem sales fees to the online platform operator. We examine the effects of a tariff on he economy in the following three cases: ($O$) where the foreign monopoly firm exports its product through the online marketplace, ($OO$) where both foreign firms export their products via the online marketplace, and ($OX$) where one foreign firm exports its product through the online marketplace and the other foreign firm exports its product directly. Our findings can be summarized as follows. In all cases, the profit of the firm using the online marketplace decreases and home welfare may decrease with the introduction of a tariff. The profit of the online platform operator decreases in case $O$ but may increase in cases $OO$ and $OX$ by a tariff. Furthermore, the profit of the direct exporting firm in case $OX$ may increase with the introduction of a tariff. These results depend on the size of the sales fees, which affects the price elasticity for demand.

Many improvements can be made for future analysis. In Chapter 2, we assume that a less developed country does not consume manufacturing goods. However, it would be more comprehensive and realistic to assume that less developed countries consume manufacturing goods, as examined by Grossman *et al.* (2006). In Chapter 3, the government's strategic FDI policy provides new insights into the welfare analysis. In particular, only the host country that subsidizes foreign FDI industries has different effects on the welfare of the host and source countries. This reflects the real economy, where the governments of each country decide on FDI policy independently to enhance the welfare of their own countries. Chapter 4 examines the effects of introducing a tariff on the economy. Considering the global trend, analyzing the impact of introducing consumption taxes is important because several countries (e.g., the EU, Australia, and Canada) have eliminated the exemption of consumption taxes for imported goods via online platforms. This underscores the significance of investigating this topic to gain insight into the dynamics of e-commerce and international trade.

In conclusion, although this dissertation has delved into several topics of international trade and foreign direct investment concerning ICT development, further studies are imperative to enhance our understanding of these topics within the dynamic landscape of the global economy.

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