Two types of Export-platform FDI with Heterogeneous firms including Communication costs

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Abstract

This study is an extension of Helpman et al. (2004); it is based on a three-country model (two Northern countries and one Southern country) and aims to examine the relationships among the following five organizational regimes: (i) a domestic firm with a plant in a North sells a good domestically, (ii) an export firm with a plant in a Northern country sells a good domestically and exports it to another Northern country, (iii) a horizontal FDI firm has a plant in each of two Northern countries and both sell a good to both the markets, (iv) a platform FDI firm has a plant in a Southern country exports a good to both the Northern markets, and (v) a multi-production-local FDI firm has one plant in a Northern country to serve own and another plant in a Southern country to export a good to another Northern country. Additionally, I discuss the increasingly important issues associated with communication costs. The model shows that all the organizational regimes of firms can coexist in a scenario wherein communication costs are lesser than transportation costs and a pair of high/low transportation costs and low/high wage levels in a Southern country holds. Moreover, I analyze the effect of a reduction in both costs on welfare, under equilibrium where all regimes coexist. A numerical exercise reveals that transportation costs have a larger impact on welfare. This result stems from the fact that a decrease in transportation costs increase the share of firms engaging in foreign activities. However, a decline in communication costs benefits only high productive firms.

Keywords: Export-Platform FDI, Heterogeneous firms, Communication costs,

Welfare analysis

JEL Classification: F12, F23, L22

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1 Introduction

According to the United Nations Conference on Trade and Development (UNCTAD) statistic, foreign direct investment (FDI) by multinational enterprises (MNEs) has witnessed a rapid expansion. The statistic shows that the worldwide flow of FDI during 1990–1994 was about 202 billion per year; however, during 2012–2016, FDI was about 1 trillion and 580 billion per year. The global FDI flow witnessed a 7.5 times growth compared to 20 years ago. The rapid growth in FDI has been triggered by MNE investments. The number of theoretical explanations for this growth has increased over the years. They show that MNEs construct plants in a host country for supplying products to the host markets (horizontal FDI) or for exporting them back to their home market (vertical FDI). (Markusen and Venables, 1998, 2000; Brainard, 1997; Ethier and Markusen, 1996; Qiu and Tao, 2001). Studies show that this scenario has led to the growth of FDI.

Moreover, due to the development of information and communications technology (ICT), firms can relocate their production affiliates or plants from their headquarters (HQ) more easily. Additionally, during the last two decades, there has been a rapid increase in the number of bilateral trade agreements (BTAs) and free trade agreements (FTAs). The development of ICT and a surge in the number of BTAs and FTAs have contributed toward increasing the complexities in the behaviors of MNEs. Feinberg and Keane (2006) show that only 12% of the firms in an industry engage in horizontal FDI, whereas only 19% of the firms pursue vertical FDI. An important example of such complex FDI is the export-platform FDI [1]. To see if export-platform FDI is an important phenomenon, I introduce some studies. Using U.S. data, Hanson, Mataloni, and Slaughter (2005) report that although the average share of exports sales in plants has remained about one third, there has been a substantial increase in Mexico and Canada after the formation of NAFTA. In addition, Ito (2013) reveals that the ratio of exports to third countries over the total sales of U.S. affiliates in some European countries is more than 50%. For Japanese data, Spinelli et al. (2018) show that Japanese firms conducting export-platform FDI tend to export their goods in plants to third countries. Hence, export-platform FDI play an important role in the modern economy.

In one of the scenarios under export-platform FDI, an MNE invests in a host country and exports its products to a third-country market. It does not serve its own or host country markets. The first study on the aforementioned export-platform FDI is conducted by Motta and Norman (1996). They consider three identical countries and a single stage of production. Costs of production are identical among countries, but there is variance in trading costs. Suppose two of three countries sign an FTA. In this case, the country outside the FTA would establish a plant inside the FTA bloc and export to countries inside the bloc. In this model, owing to identical costs, neither of the countries inside the bloc choose export-platform FDI as a strategy. Yeaple

[1] For example, in Japan, Toyota exports their products from plants in Mexico to U.S. and has the production center in Indonesia for exporting their products to Asian countries.

(2003) also analyses the export-platform FDI under a general equilibrium model. It assumes a three-country model with two identical Northern countries (West (W) and East (E)) and one Southern (S) country. There are two stages of production: production of intermediate goods and assembly of these goods. Country S gets a cost advantage in both stages. This study shows the condition of wage levels in W or E and the transportation costs of intermediates goods that firms choose under the export-platform FDI. Muàzovà and Neary (2011), using the supermodularity concept, develop a general model to show how a firm will choose to serve goods to foreign markets by exports or export-platform FDIs. Additionally, it also reveals the number of foreign plants a firm will tend to establish.

There are several studies on different types of export-platform FDIs. Ekholm et al. (2007) set up a partial equilibrium model with a three-country model, similar to Yeaple (2003). Production comprises one stage, and if firms have multiple plants, they incur additional fixed or marginal costs. The key assumption of this model is lower costs (wage levels) in S. If this assumption is true, then firms in W and/or E will have incentives to establish their plants in S. This study examines the conditions under which the export-platform FDI is adopted by MNEs. The study considers the following three types of export-platform FDIs: (i) home-country export-platform FDI (a firm exports back to home country), (ii) third-country export-platform FDI (a firm exports to another Norther country), and (iii) global export-platform FDI (a firm exports to both Norther countries). Ito (2013) uses a model comprising two regions, with two countries in each region. Production processes involve producing and assembling intermediate goods. This assumption allows us to consider the new export-platform FDIs: (1) horizontal export-platform FDI [2] and (2) vertical export-platform FDI [3].

Besides the aforementioned literature on the export-platform FDI model, little work has been done on productivity heterogeneity. Since the study by Melitz (2003) and Helpman et al. (2004), firm heterogeneity with respect to productivity has assumed significance as a tool for tracing and explaining differences between firms' foreign activities within an intra-industry. To the best of my knowledge, Grossman et al. (2006) is the only study that deals with export-platform FDI with heterogeneous firms. This study is motivated by the fact that various supply modes of firms coexist within the same industry (Feinberg and Keane 2006). By considering intermediate trade similar to Yeaple (2003), they show the taxonomy of various firms" organizational forms.

This study considers two types of export-platform FDI. One of export-platform FDI types is called platform FDI. [4] Firms engaged in platform FDI establish only one plant in the Southern country, and, subsequently, export goods to both Northern countries. Another export-platform FDI type is multi-production-local FDI. Firms using this FDI own a single plant in their home

[2] A firm has plants of intermediate goods and assembly in one country in each region and exports to another country in the same region.

[3] A firm has both plants of component and assembly in a country and exports final goods to another country in a same region and intermediate goods to a country in a different region. A plant of assembly in a country in the different region exports to another country within the region.

[4] This is a same regime of global-platform FDI in Ekholm et al. (2007).

country and another plant in the Southern country for exporting produce to another Northern country.[5] To the best of my best knowledge, there is no literature that analyzes the two types of export-platform with the other three modes of firms' foreign activities—domestic, export, and horizontal FDI—and firm heterogeneity with respect to productivity.

Based on the above discussions, in this study, I link export-platform FDI with firms' heterogeneity and try to show the relationships among all five firms' regimes. I construct a three-country model and examine the market structure to show the coexistence of all organizational forms; this analysis aspect has not been analyzed in existing literature.

In an equilibrium where all five organizational forms coexist within an industry, how are firms arrayed with respect to firms' productivity levels? Recent empirical studies show that firms with high productivity levels can invest in a country with a small market size (Cheng and Moore 2010 and Tanaka 2015). Furthermore, Spinelli et al. (2018) reveal that firms conducting export-platform FDIs tend to be most productive firms in the host country. From above empirical facts, firms engaged in platform FDI have higher productivity levels when compared to exporting firms. [6] Concerning the relationships between platform FDI and horizontal FDI, horizontal FDI firms pay larger fixed costs (they are required to establish two affiliates), and thus I conclude that they are more productive than platform-FDI firms. The relationship between horizontal FDI firms and multi-production-local FDI seems complex. In my model, multi-production-local FDI firms do not supply goods to Southern market, that is, the market of the host country is very small. Hence, considering the facts revealed by Cheng and Moore (2010) , multi-production-local FDI firms have higher productivity levels than those of horizontal FDI firms. In addition, considering the fact that firms engaged in multi-production-local FDI tend to appear in developed countries [7], if firms conducting multi-production-local FDI and horizontal FDI coexist, multi-production-local FDI firms have the smaller cost advantages emerging from low wage levels, but they will incur high fixed costs for supplying products [8]. Therefore, if all organizational forms coexist, the model considered in this study would sort heterogeneous firms, that is, arrange domestic, export, platform FDI, horizontal FDI, and multi-production-local FDI firms in ascending order of the productivity levels.

In addition to the above arguments on trade costs, as I claimed, issues associated with communication costs have gained prominence. Due to the development of ICT, people can gain easy access to a mass of information and communicate regardless of their physical distances. According to Helpman (2006), owing to the rapid development of ICT, firms can establish separate production activities geographically. Usually, a headquarter engages in activities such as a management, R&D, and finance; and its plant(s) produce(s) some goods. The plants depend on their headquar-

[5] Ekholm et al. (2007) regards this as third-Platform FDI.

[6] For the theoretical work, see Helpman et al. (2006) and Muràzovà and Neary (2011)

[7] US affiliates of this FDI mainly locate in European countries. In effect, it is worth noting that the FDI occurs mainly among developed countries such as Canada, the EU, Finland, UK, and US (Flanagan, 1999) However, it appears in some Asian countries see data in Ekholm et al. (2007).

[8] For example, fixed costs for investigating another market, preparing for some country risks and so on.

ters for gaining knowledge or information for their production activities. [9] However, despite the rapid development of communication devices, the transmission of information is imperfect and incomplete. Therefore, if these two kinds of activities occur in different countries, it would be important for headquarters to ensure that information pertaining to the products has been understood by plant personnel. Antrás et al. (2006) shows that these communication costs increase with an increase in fragmentation.

A few studies have empirically analyzed these communication costs. Giroux (2013) shows that if a new airline reduces the travel time [10] between headquarters and plants, then plants may have 7% higher productivity levels compared to the period before the operation of the airline. Using data of European firms, Dischinger et al. (2014) reveal that plants in the home country earn higher profit than those in the foreign country. This means that the distance between headquarters and plants crucial to a firm's activity. Charnoz et al. (2018), considering the development of the high-speed railway network in France, show the reduction in the travel time of passengers between headquarters and plants. They reveal that the development of French railway increased the concentration of management activities in the headquarters. Additionally, Kalnins and Lafontaine (2013) show that a greater distance between headquarters and plants reduces the longevity of facilities. However, concerning financial issues, Hollander and Verriest (2016) reveal that a greater distance between lenders and borrowers tends restrict loan contracts. This result comes from the notion of Leamer and Storper (2001); as per the authors, the transmission of knowledge by ICT remains incomplete and imperfect. Additionally, face-to-face communications are considered crucial among laborers specializing in different activities in spatially separated headquarters and plants. This is because such contacts facilitate prompt feedback on non-routine activities (Battiston et al. 2017). However, the cost of communication negatively impacts firms' foreign activities; this impact is prominent, despite a decline in communication costs. To the best of my knowledge, only Gokan et al. (2018) analyze the international trade and FDI in relation to communication and transportation costs. This study considers a two-country model. In this model, communication costs are regarded as variable costs.

Although it is known that communication costs significantly contribute toward fragmentation by MNEs, no study compares the effects emerging from a decline in both transportation and communication costs on welfare in a scenario comprising heterogeneous firms. However, it is important to understand which cost exerts a greater impact in today's complex and fragmented economy. This is in line with the explanation that actual firms no longer incur only "traditional" trade costs. Thus, this study examines the effect of reduction in both the aforementioned costs on welfare, under equilibrium where all organizational forms coexist. The results show that, of course, reduction in communication costs is important, but the drop in the traditional trade costs, transportation costs, has a greater positive impact on welfare.

The rest of this paper is organized as follows. Section 2 describes the basic model. Section

[9] This is the notion of Knowledge capital model in Markusen (2002).

[10] This reduction means that the costs of face-to-face communication drops.

3 analyzes the market equilibrium under the situation where all five organizational forms that heterogeneous firms have. In Section 4, I analyze the impact of the reduction in both communication and transportation costs, under the scenario where all organizational types exist. Section 5 provides concluding remarks.

2 A Three-Country Model with Heterogeneous Firms

2.1 The economy

There exist three countries; in other words, there are two symmetric Northern countries—West and East—and another Southern country (South). The latter has one type of labor, and it produces two goods—homogeneous and differentiated. In addition, firms are heterogeneous with respect to productivity levels, and they have two types of facilities—plants and headquarters (HQs).

The consumption of the two goods is different across Northern and Southern countries. West and East consume both differentiated and homogeneous goods, while South consumes only homogeneous goods.

For producing the two types of goods, they only need labor force. Workers in Northern countries know how to produce differentiated and homogeneous goods. In other words, they have information or knowledge to produce both of them. However, laborers in the Southern country only know how to produce homogeneous goods. The number of workers is L_W in West and L_E in East. As Norther countries are symmetric, the number of laborers in both countries is equal, $L_W = L_E = L$. For Southern country, the supply of workers is S. I assume L and S are large enough to produce both goods. Workers in each country are spatially immobile.

A differentiated good is supplied with increasing returns to scale and monopolistic competition, as per the traditional practice, while a homogeneous good is produced under constant returns to scale. If a plant in a Northern or Southern country exports a differentiated good to another Northern country, then it incurs transportation costs. I assume transportation costs are the same globally, that is, transportation costs between West and East, West and South, and East and South are equivalent ($\tau_{WE} = \tau_{WS} = \tau_{ES} = \tau > 1$). Similar to international trade literature, I assume transportation costs are of the iceberg type. 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 the HQ. However, if they are located in different countries, the transmission of knowledge or information from HQs to a plant would be costly. I regard this costly information-transmission activity as communication costs. Similar to transportation costs, communication costs are same in any area, $\gamma_{WE} = \gamma_{WS} = \gamma_{ES} = \gamma > 1$, which are also of the iceberg type. [11] Furthermore, the wage of Northern countries is normalized

[11] Here, I assume communication costs as variable costs. Considering the situation that workers from HQs have

to $w_W = w_E = 1$ and the wage in South country is $w < 1$. These restrictions remain as long as each heterogeneous firm in Northern countries produces homogeneous goods; these goods are also produced in Southern country and not traded.

2.2 Utility

A representative consumer in country i ($i = W, E$) has the quasi-linear utility as follows:

$$u_i = \mu \, ln \, X_i + Z, \tag{1}$$

where X_i is the familiar Dixit-Stiglitz consumption aggregator over products, x_i, which are i's differentiated goods. To have consumers consume both goods, I assume the following: $0 < \mu < w_i = 1$. The consumption aggregator, X_i, is given by: $X_i = \left(\int_{\omega \in \Omega_i} x_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}}$ where Ω_i is the set of varieties from firms in countries i and j, which are available to consumers in country i. I assume $\sigma > 1$, which is the elasticity of substitution between any two varieties. Z represents the consumption of a homogeneous good, which is a numèraire, and the its price is normalized to 1. A consumer's expenditure on differentiated goods thus becomes:

$$\int_{\omega \in \Omega_i} p_i(\omega) x_i(\omega) d\omega = w_i - Z, \tag{2}$$

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

$$x_i(\omega) = \frac{p_i(\omega)^{-\sigma}}{P_i^{1-\sigma}}, \tag{3}$$

where $P_i \equiv (\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$. The parameter P_i is the well-known CES price index. Substituting P_i into the CES aggregates of consumption, I obtain:

$$X_i = \mu P_i^{-1} = \mu (\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega)^{\frac{1}{\sigma-1}} \tag{4}$$

Naturally, the whole consumption of differentiated goods decreases as prices of individual goods rise.

2.3 Production and Profits

Let i be a Northern country where HQs are located, and j be the other Northern country. A firm's location is the location of its HQ. A firm's HQ supplies some services, knowledge, or information to its plant(s). When HQ transmits its intellectual matters to plants in other countries, it incurs communication costs. If a plant exports a differentiated good, it must pay transportation costs.

to visit its plant regularly or non-regularly for face-to-face communication, it seems plausible.

To start producing a variety, first, a firm pays entry costs, f_e, and draws a productivity level φ from a known distribution $G(\varphi)$. After observing this productivity level, the firm decides where to invest and whether to produce a differentiated good at the same time. To construct a plant, fixed costs are different depending on where a firm invests. I consider two versions of fixed cost. Basic fixed costs are F. This cost represents the cost for constructing the first plant in any country. Other fixed costs are G. This additional fixed cost is related with firms' foreign activities. I consider that the foreign activities are three types. First, when a plant in a Northern or Southern country exports to the other Northern country, it is required to pay $G/2$ for investigating in the other market. Second, if a firm decides to invest in an additional plant, it incurs costs, G, for constructing the second plant is. Third, when a firm has a plant in a foreign country, it needs to prepare for the unexpected risks. This additional cost represents $G/2$. I assume the $G \leq F$.[12] The marginal costs for a differentiated good are represented as workers' wages in the country where a plant is located in, and the productivity is: $\frac{w^k}{\varphi}$ where

$$w^k = \begin{cases} 1 & if \;\; k = W \; or \; E, \\ w & if \;\; k = S. \end{cases}$$

Firms' organizational forms are divided into five types—domestic firm ($\equiv$ D), export firms ($\equiv$ X), platform-FDI firms ($\equiv$ P), horizontal FDI firms ($\equiv$ H), and multi-production-local FDI firms ($\equiv$ M)[13]. I explain cost functions of each type of firm in country i.

(i) A domestic firm has one plant and HQ in own country. It supplies a differentiated goods to i's market only and incurs the marginal cost $1/\varphi$ and fixed cost: F. Thus, the cost function of a domestic firm is:

$$C_i^D = \frac{1}{\varphi} x_i^D + F \tag{5}$$

where x_i is the domestic consumption. The subscript represents the place where goods of the i-firm are consumed.

(ii) An export firm's plant and HQ are located in country i and the firm supplies a differentiated good to both Northern countries. When this firm exports the differentiated good to country j, it incurs the transportation cost ($\tau > 1$). The marginal cost of supplying the good domestically is $1/\varphi$ and that of supplying the good in a foreign market is τ/φ. Fixed costs denote a basic cost, F, and an investigating cost, $G/2$; these costs are incurred for producing a good. A cost function for an export firm is:

$$C_i^X = \frac{1}{\varphi} x_i^X + \frac{\tau}{\varphi} x_j^X + (F + \frac{G}{2}), \tag{6}$$

where $i \neq j$, x_j is the consumption of country j.

(iii) A platform FDI firm has one plant in a Southern country and supplies a differentiated

[12] Later, I put an assumption, $G = F$, for simplicity.

[13] These forms are not by assumptions but by the calculation of any possible profit functions that firms can locate their plant(s).

good from there to both the Northern countries. In this case, a HQ and the plant are spatially separated. It means that the firm incurs the communication cost ($\gamma > 1$) and the transportation cost ($\tau > 1$). This firm has to pay marginal costs, $(\gamma\tau w)/\varphi$, for both domestic and foreign-supplied goods. It also needs to pay a basic fixed cost F, the cost for having a plant in a foreign country, $G/2$, and for investigating, $G/2$.[14] Thus, a cost function for a platform FDI firm becomes:

$$C_i^P = \frac{\gamma\tau w}{\varphi} x_i^P + \frac{\gamma\tau w}{\varphi} x_j^P + (F + G). \tag{7}$$

(iv) A horizontal-FDI firm has two plants. One plant is in country i with its HQ, but another plant is in country j. The plant in its own country produces a differentiated goods domestically, and incurs a marginal cost $1/\varphi$. A plant in country j supplies a differentiated good for j's consumers. In this case, there exists only communication costs ($\gamma > 1$) to produce, and the firm requires the marginal costs γ/φ. Concerning the fixed costs, the firm pays F for constructing the first plant, G for constructing the second plant in country j, and $G/2$ in anticipation of some risks. I obtain the following cost function of a horizontal FDI firm:

$$C_i^H = \frac{1}{\varphi} x_i^H + \frac{\gamma}{\varphi} x_j^H + (F + \frac{3G}{2}). \tag{8}$$

(v) A multi-production local FDI firm has two plants. One plant supplying a differentiated good for the domestic market is located in the same country where its HQ located. Another plant supplying it for j's market is located in the Southern country. In this case, for the domestic market, no communication and transportation costs are incurred, and a firm requires a marginal cost $1/\varphi$. For supplying to market j, communication cost ($\gamma > 1$) and the transportation cost ($\tau > 1$) are incurred. Thus, the marginal costs of the firms are $(\gamma\tau w)/\varphi$. Concerning the fixed costs, F is the basic cost, $G/2$ is incurred to export the goods from the Southern country to country j, $G/2$ is incurred for having an additional plant in the Southern country, and G is incurred for constructing a second plant. A cost function of a multi-production-local firm can be rewritten as:

$$C_i^M = \frac{1}{\varphi} x_i^M + \frac{\gamma\tau w}{\varphi} x_j^M + (F + 2G). \tag{9}$$

The variable and additional fixed costs of each organizational form are summarized in figures in Appendix.

[14] I follow the definition of G from Ekholm et.al (2007) and add costs of export.

2.4 Market equilibrium

Solving a profit maximization problem for each type of firms and using (3) and (5)-(9), profit functions for each organizational form are obtained as follows:

$$\begin{aligned}
\pi_i^D &= \varphi^{\sigma-1}B_i - F, \\
\pi_i^X &= \varphi^{\sigma-1}B_i + \left(\frac{\varphi}{\tau}\right)^{\sigma-1} B_j - (F + \frac{1}{2}G), \\
\pi_i^P &= \left(\frac{\varphi}{\gamma\tau w}\right)^{\sigma-1} B_j + \left(\frac{\varphi}{\gamma\tau w}\right)^{\sigma-1} B_j - (F + G), \\
\pi_i^H &= \varphi^{\sigma-1}B_i + \left(\frac{\varphi}{\gamma}\right)^{\sigma-1} B_j - (F + \frac{3}{2}G), \\
\pi_i^M &= \varphi^{\sigma-1}B_i + \left(\frac{\varphi}{\gamma\tau w}\right)^{\sigma-1} B_j - (F + 2G),
\end{aligned}$$

where $B_i = \frac{1-\alpha}{\alpha^{1-\sigma}}\mu^\sigma L_i X_i^{1-\sigma}$, $B_j = \frac{1-\alpha}{\alpha^{1-\sigma}}\mu^\sigma L_j X_j^{1-\sigma}$, and $\alpha = \frac{\sigma-1}{\sigma} < 1$. The parameters B_i $(i = W, E)$, B_j $(j = W, E)$, and $(j \neq i)$ represent the total demand levels for one type of differentiated good in each Northern country. Assuming the symmetricity between Northern countries, the national demand levels are seen as the same in both Northern countries: $B_i = B_j = B$. Applying the symmetric assumptions, the above profit functions can be rewritten as:

$$\pi_i^D = \varphi^{\sigma-1}B - F, \tag{10}$$

$$\pi_i^X = \varphi^{\sigma-1}(1 + \tau^{1-\sigma})B - (F + \frac{1}{2}G), \tag{11}$$

$$\pi_i^P = 2\varphi^{\sigma-1}(\gamma\tau w)^{1-\sigma}B - (F + G), \tag{12}$$

$$\pi_i^H = \varphi^{\sigma-1}(1 + \gamma^{1-\sigma})B - (F + \frac{3}{2}G), \tag{13}$$

$$\pi_i^M = \varphi^{\sigma-1}(1 + (\gamma\tau w)^{1-\sigma})B - (F + 2G). \tag{14}$$

The use of profit functions enables us to analyze the coexistence of the organizational forms of firms.

3 Organizational forms

In this section, I analyze the market structure of the economy. Particularly, I focus on a scenario wherein all organizational forms of heterogeneous firms coexist. In other words, there exist domestic, export, platform FDI, horizontal FDI, multi-production local FDI firms in an industry.

3.1 Productivity cutoffs

I assume that the economy comprises all organizational forms. The following figure shows the market structure of the economy.

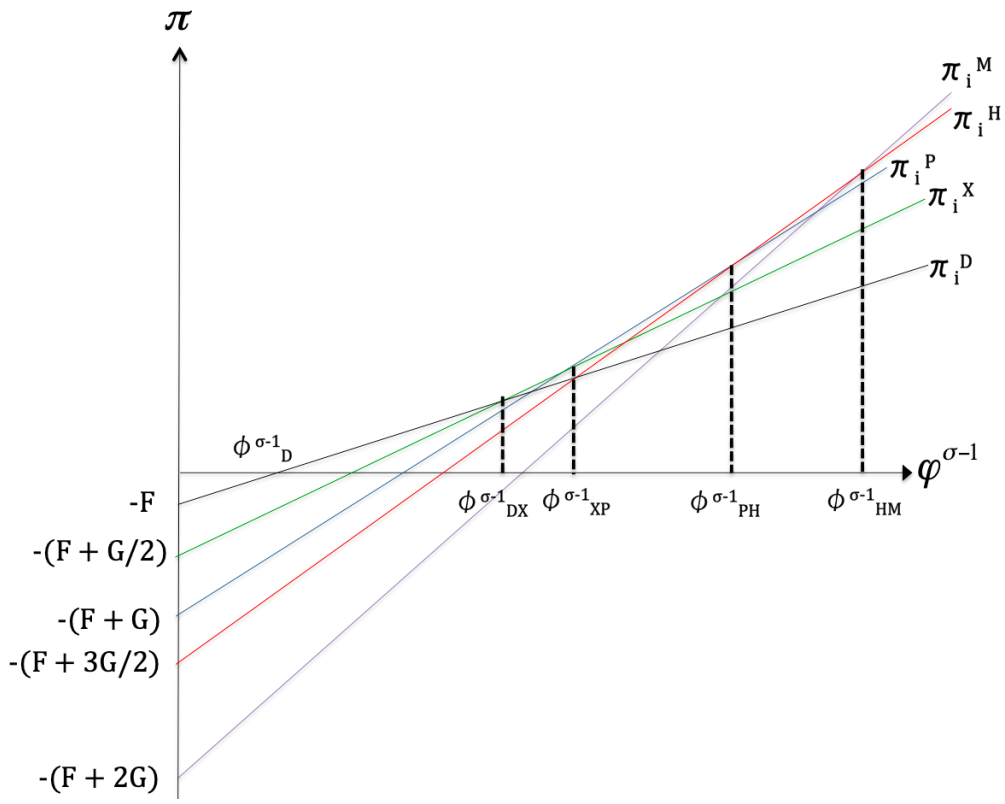

Figure 1: Productivity

I restrict the model parameters for productivity cutoff levels such that $\varphi_D < \varphi_{DX} < \varphi_{XP} < \varphi_{PH} < \varphi_{HM}$. Those are represented as:

$$(\varphi_D)^{\sigma-1} = \frac{F}{B}, \tag{15}$$

$$(\varphi_{DX})^{\sigma-1} = \frac{G}{2\tau^{1-\sigma}B}, \tag{16}$$

$$(\varphi_{XP})^{\sigma-1} = \frac{G}{2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})B}, \tag{17}$$

$$(\varphi_{PH})^{\sigma-1} = \frac{G}{2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})B}, \tag{18}$$

$$(\varphi_{HM})^{\sigma-1} = \frac{G}{2((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})B}. \tag{19}$$

The above relationship of productivity cutoffs implies that only the most productive firms (with $\varphi_{HM} < \varphi$) use multi-production-local FDI, while the second most productive firms (with $\varphi_{PH} < \varphi \leq \varphi_{HM}$) conduct horizontal FDI. Firms' optimal organizational form, with an intermediate level of productivity (with $\varphi_{XP} < \varphi \leq \varphi_{PH}$), is platform-FDI. Firms with $\varphi_{DX} < \varphi \leq \varphi_{XP}$ export and those with $\varphi_D < \varphi \leq \varphi_{DX}$ serve only the domestic market. Finally, the least productive firms (with $\varphi \leq \varphi_D$) do not produce goods or exit from the industry immediately. The figure below shows this sorting pattern of firms.

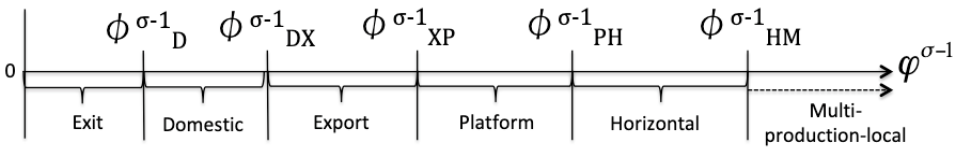

Figure 2: Firm selection

Firms produce for the domestic market when profits of (10) are positive. Solving $\pi_i^D = 0$, we have φ_D. This productivity level is minimum if country i's market is profitable. Firms only supply goods for the domestic market if those profits are $\pi_i^D \leq \pi_i^X$. The intersection of (10) = (11) yields a cutoff level: φ_{DX}. This productivity level is the highest among firms engaging only domestic activity.

Firms export goods from country i to j with the profits level: $\pi_i^X \leq \pi_i^P$. This implies that the highest productivity level of exporting firms is φ_{XP}. The value of φ comes from the calculation: (11) = (12).

For firms choosing the platform FDI, the profits from serving goods from a plant in the Southern country to i and j markets are $\pi_i^P \leq \pi_i^H$. The productivity level φ_{PH} denotes the border of platform FDI and horizontal FDI. The value of that equates (12) = (13) obtains φ_{PH}.

The highest productivity level of horizontal FDI firms, which supply goods domestically from a plant in country i and to country j from a plant in country j, is φ_{HM}. This is because those firms' profits are restricted by the inequality: $\pi_i^H \leq \pi_i^M$. The equation (13) = (14) yields φ_{HM}.

Firms for which $\pi_i^M > \pi_i^H$ conduct multi-production local FDI, producing domestic goods at a plant in country i and exporting goods to country j from a plant in the Southern country. Given that all organizational forms exist in the economy, I consider some conditions and particular regions.

3.2 Conditions and regions of full organizations

In this section, I show the necessary conditions for the full organizations' equilibrium. Considering the positive productivity cutoffs from (15) to (19), all of them must be positive. Hence, one has three inequalities:

$$\gamma < (\frac{2(\tau w)^{1-\sigma}}{1+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \equiv Cl_{XP} \Leftrightarrow (\varphi_{XP})^{\sigma-1} > 0 \tag{20}$$

$$\gamma < (\frac{4(\tau w)^{1-\sigma}-1}{1+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \equiv Cl_{PH} \Leftrightarrow (\varphi_{PH})^{\sigma-1} > 0 \tag{21}$$

$$\tau < \frac{1}{w} \equiv Cl_{HM} \Leftrightarrow (\varphi_{HM})^{\sigma-1} > 0 \tag{22}$$

Next, I consider the orders of productivity cutoff levels. They need to satisfy the inequality: $\varphi_D < \varphi_{DX} < \varphi_{XP} < \varphi_{PH} < \varphi_{HM}$. From these relationships of cutoffs, four conditional expressions can

be obtained:

$$F \leq \frac{G}{2}\tau^{\sigma-1} \equiv EC_D \Leftrightarrow (\varphi_D)^{\sigma-1} \leq (\varphi_{DX})^{\sigma-1} \tag{23}$$

$$\gamma \geq (\frac{2(\tau w)^{1-\sigma}}{1+2\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \equiv EC_X \Leftrightarrow (\varphi_{DX})^{\sigma-1} \leq (\varphi_{XP})^{\sigma-1} \tag{24}$$

$$\gamma \leq (\frac{4(\tau w)^{1-\sigma}-1}{2+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \equiv EC_P \Leftrightarrow (\varphi_{XP})^{\sigma-1} \leq (\varphi_{PH})^{\sigma-1} \tag{25}$$

$$\gamma \geq (3(\tau w)^{1-\sigma}-2)^{\frac{1}{\sigma-1}} \equiv EC_H \Leftrightarrow (\varphi_{PH})^{\sigma-1} \leq (\varphi_{HM})^{\sigma-1} \tag{26}$$

The first inequality means that the basic cost of constructing the first plant, F, cannot be too high or the added cost of foreign activities, G, cannot be too low. If the condition (23) breaks, all firms that can produce a good would select the export strategy over the domestic strategy. The second inequality stands for the condition that exporting firms exist under choices of export and platform-FDI forms. The right-hand side of the inequality is decreasing in τ and w. Namely, given γ and w, τ is not too low. If τ is too low, communication cost from choosing platform FDI is a more preferable for firms because The third inequality is the conditional expression for exists of platform FDI over horizontal FDI. The right-hand side is also decreasing in τ and w. Contrary to the second inequality, τ is not too high. With too high τ, the revenue of platform FDI becomes smaller than that of horizontal FDI, and the productivity levels become ($\varphi > \varphi_{DX}$). The final inequality is the expression in which horizontal FDI firms exist in relation to the multi-production local FDI. Similar to the other inequalities, the right-hand side is decreasing in τ and w. Similar to the second inequality, τ is not too low. If τ is too low, then conducting a multi-production local FDI would be more profitable among all the following productivity levels: ($\varphi > \varphi_{XP}$).

In addition to the restrictions of productivity cutoff levels, under equilibrium, all types of profit functions, (10) – (14), do not have dominant relationships. Corresponding to the orders of fixed costs (FC) of each type of firm—$FC_D < FC_X < FC_P < FC_H < FC_M$—revenues ($R$) of each strategy has relationships such that $R_D < R_X < R_P < R_H < R_M$. This order of revenues leads to three new restrictions with respect to γ and τ:

$$\gamma < \tau \Leftrightarrow R_X < R_H \tag{27}$$

$$\gamma < \frac{1}{w} \Leftrightarrow R_X < R_M \tag{28}$$

$$\gamma\tau w > 1 \Leftrightarrow R_P < R_M \tag{29}$$

Note that other relationships $R_X < R_P$, $R_P < R_H$, and $R_H < R_M$ are the same conditions as (20) – (22).

Based on the above ten conditional expressions, indeed, in order to describe the economy where all organizational forms exist, we need seven expressions from (22) to (29). Considering all conditional expressions, all organizational forms appear in the area surrounded by (24), (25),

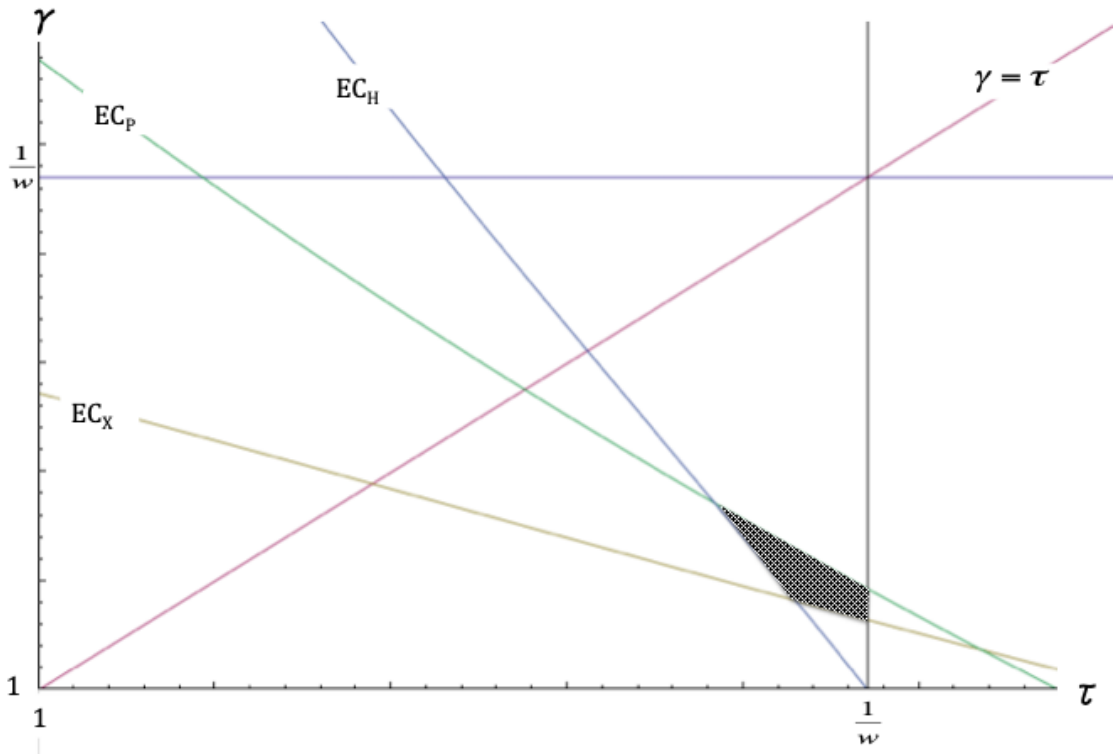

Figure 3: Equilibrium

and (26). (For details, see the Appendix). The shaded area in Figure 1 is the equilibrium. In the equilibrium below, firms' sorted pattern is the same as I claimed in Section 3.

From Figure 1, I explain characteristics of the equilibrium. First, the equilibrium exists under low communication costs. Considering the situation that communication costs are higher than the EC_P line, marginal costs of platform FDI are found costlier and those revenues are lower than that of the export firms. Hence, communication costs must be comparatively low. However, when communication costs are smaller than the EC_H line, marginal costs of horizontal FDI firms becomes smaller, but the effect of reduction on the marginal costs of multi-production local FDI and platform FDI firms increases. Therefore, communication costs are not too low. Concerning transportation costs, if transportation costs are larger than the EC_P line, export firms dominate platform FDI firms. This can be attributed to a further increase in the marginal costs of platform FDI. When transportation costs decline, marginal costs of export, platform FDI, and multi-production local FDI firms fall. In brief, horizontal FDI firms are intending to the three other organizations.

3.2.1 Sketch for deriving equilibrium

To ensure that the equilibrium exists, I derive some restrictions. First, I present an intersection of EC_P and EC_H, I_{PH}:

$$
\begin{aligned}
EC_P = EC_H \quad &\Leftrightarrow \quad \frac{4(\tau w)^{1-\sigma} - 1}{2 + \tau^{1-\sigma}} = 3(\tau w)^{1-\sigma} - 2 \\
&\Leftrightarrow \quad \tau^{\sigma-1} = \frac{3(\tau w)^{1-\sigma} + 2w^{1-\sigma} - 2}{3} \equiv I_{PH}
\end{aligned}
$$

is always between the lines, $\gamma = \tau$ and $\tau = \frac{1}{w}$ (See the proof the Appendix.). This implies that if wage levels are low/high, transportation costs have to be large/small [15]. Concerning the intersection EC_P and EC_X, I_{PX},

$$
\begin{aligned}
EC_P = EC_X \quad &\Leftrightarrow \quad \frac{4(\tau w)^{1-\sigma} - 1}{2 + \tau^{1-\sigma}} = \frac{2(\tau w)^{1-\sigma}}{1 + 2\tau^{1-\sigma}} \\
&\Leftrightarrow \quad \tau^{\sigma-1} = 6(\tau w)^{1-\sigma} - 2 \equiv I_{PX}
\end{aligned}
$$

it can move out from the area. Moreover, an intersection of EC_X and EC_XH, I_{XH} is:

$$
\begin{aligned}
EC_X = EC_H \quad &\Leftrightarrow \quad \frac{2(\tau w)^{1-\sigma}}{1 + 2\tau^{1-\sigma}} = 3(\tau w)^{1-\sigma} - 2 \\
&\Leftrightarrow \quad \tau^{\sigma-1} = \frac{6(\tau w)^{1-\sigma} + w^{1-\sigma} - 4}{2} \equiv I_{XH}
\end{aligned}
$$

In order to ensure the coexistence of all organizational forms in one industry, the conditional expressions $I_{PH} \leq I_{PX}$ and $I_{PX} \leq I_{XH}$ need to be satisfied. I can rewrite $I_{PH} \leq I_{PX}$ and $I_{PX} \leq I_{XH}$ as:

$$
\begin{aligned}
I_{PH} \leq I_{PX} \quad &\Leftrightarrow \quad \frac{3(\tau w)^{1-\sigma} + 2w^{1-\sigma} - 2}{3} \leq 6(\tau w)^{1-\sigma} - 2 \\
&\Leftrightarrow \quad \tau_1^{\sigma-1} \leq \frac{15w^{1-\sigma}}{4 + 2w^{1-\sigma}} \qquad (30) \\
I_{PX} \leq I_{XH} \quad &\Leftrightarrow \quad 6(\tau w)^{1-\sigma} - 2 \leq \frac{6(\tau w)^{1-\sigma} + w^{1-\sigma} - 4}{2} \\
&\Leftrightarrow \quad \tau_2^{\sigma-1} \leq 6 \qquad (31)
\end{aligned}
$$

Transportation costs, τ_1, are smaller than τ_2 because another inequality, $I_{PH} \leq I_{XH}$, must hold. Therefore, I have:

$$
\begin{aligned}
&\frac{15w^{1-\sigma}}{4 + 2w^{1-\sigma}} \leq 6 \\
&\Leftrightarrow w^{1-\sigma} \leq 8 \qquad (32)
\end{aligned}
$$

[15] See the later argument, in deed the pair of transportation costs and wage levels of South is bounded.

Remember $\tau^{\sigma-1} \geq 2$ and $w^{1-\sigma} > 2$ (since $\tau < \frac{1}{w}$); combined with (31) and (32), transportation costs and wage levels of the Southern country are seen to have boundaries:

$$2 \leq \tau^{\sigma-1} \leq 6 \tag{33}$$

$$2 < w^{1-\sigma} \leq 8 \tag{34}$$

These conditions mean that if the elasticity substitution is given, both parameters are not allowed to be extremely high/low. Conditional expressions, (33) and (34), also imply that $1 < (\tau w)^{1-\sigma} \leq 4$.[16] As I claimed, the expression for $(\tau w)^{1-\sigma}$ implies that transportation costs and the wage levels tend to move in different directions. With these conditions, communication costs are reduced, and they are kept relatively lower than transportation costs. Summarizing the equilibrium that I have discussed as follows:

Proposition 1. *The equilibrium exists under the situation in which communication costs are kept lower than transportation costs. Additionally, relationships between transportation costs and the wage levels of the South suggest that all organizational forms coexist under the economic circumstances where transportation costs are large/small and the wage levels are low/high.*

3.3 Welfare

As a measure of welfare for the following analysis, I derive the indirect utility function, V_i, for a representative consumer in country i. Using the demand function for differentiated goods, $x_i(\omega)$, and the budget constraint, I obtain:

$$\begin{aligned} W_i &= w_i - \mu(1 - ln\,\mu) + \mu\, ln\, X_i \\ &= w_i - \mu(1 - ln\,\mu) + \frac{\mu}{\sigma - 1} ln(\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega) \end{aligned} \tag{35}$$

Naturally, welfare is increasing in the wage, w_i, and decreasing in the price of one variety. Since the utility function is quasi-linear, the income effect does not exist.

3.4 Technology

To facilitate an analytical solution, I apply Pareto distribution for firm productivity levels, $\varphi = 1/a$. This also means that price levels are distributed as Pareto. Define $V_i(a) = \int_0^a \tilde{a}^{1-\sigma} dG_i(\tilde{a})$; this expression will show up repeatedly. Pareto distribution with shape parameter k and support $[b, \infty]$, then $V_i(a)$ and $G_i(a)$ are given by:

[16] since $\tau < \frac{1}{w}$ and $\sigma > 1$.

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

Since I consider the symmetric Northern countries, both countries have the same productivity distribution, that is, $V_i(a) = V_j(a) = V(a)$ and $G_i(a) = G_j(a) = G(a)$.

3.5 Equilibrium consumption of differentiated goods

The price levels follow Pareto distribution and are same in both Northern countries, $G(a)$. Define the CES aggregate: $\mu^{1-\sigma} X_i^{\sigma-1} = X_i^i + X_i^j$. The partial aggregate, X_i^i, denotes the amount of goods produced by firms whose HQs are in country i. Similarly, another partial aggregate, X_i^j, is the amount of goods produced by firms whose HQs are in country j. Using the price levels from (1)–(2), I can rewrite these two partial aggregates as:

$$
\begin{aligned}
X_i^i &= N \int_0^{a_{HM}} \left[\frac{a}{\alpha}\right]^{1-\sigma} dG(a) + N \int_{a_{HM}}^{a_{PH}} \left[\frac{a}{\alpha}\right]^{1-\sigma} dG(a) ... \\
&... \quad + N \int_{a_{PH}}^{a_{XP}} \left[\frac{(a\tau\gamma w)}{\alpha}\right]^{1-\sigma} dG(a) + N \int_{a_{XP}}^{a_D} \left[\frac{a}{\alpha}\right]^{1-\sigma} dG(a) \qquad (36) \\
X_i^j &= N \int_{a_0}^{a_{HM}} \left[\frac{(a\tau\gamma w)}{\alpha}\right]^{1-\sigma} dG(a) + N \int_{a_{HM}}^{a_{PH}} \left[\frac{(a\gamma)}{\alpha}\right]^{1-\sigma} dG(a) ... \\
&... \quad + N \int_{a_{PH}}^{a_{XP}} \left[\frac{(a\tau\gamma w)}{\alpha}\right]^{1-\sigma} dG(a) + N \int_{a_{XP}}^{a_{DX}} \left[\frac{(a\tau)}{\alpha}\right]^{1-\sigma} dG(a) \qquad (37)
\end{aligned}
$$

where N is the number of consumption varieties in country i. The first term of two aggregates (36) and (37) denotes the number of goods supplied by multi-production-local FDI firms. Firms belonging to country j incur transportation and communication costs. However, their marginal costs are lower than county i's firms because plants of j firm are in the Southern country. The second terms are the number of varieties supplied by horizontal FDI firms. Country j firms incur only the communication costs, and marginal costs are equal in both countries. The third terms denote the amount of goods produced by platform FDI firms. Since both countries' plants are located in South, those prices incur both costs and they produce at lower marginal costs. The last term of (36) denotes the number of varieties produced by domestic and export firms. However, the fourth term of (37) denotes the aggregate of goods supplied by export firms in country j.

Applying Pareto distribution for (36) and (37) and using the productivity cutoff levels: (15)–(19) and the CES aggregator , I have:

$$X_i^i = N\frac{k}{\alpha}\Lambda_i\,\mu^{\frac{\sigma(k-\sigma+1)}{\sigma-1}}L_i^{\frac{k-\sigma+1}{\sigma-1}}X_i^{-(k-\sigma+1)}, \tag{38}$$

$$X_i^j = N\frac{k}{\alpha}\Lambda_j\,\mu^{\frac{\sigma(k-\sigma+1)}{\sigma-1}}L_i^{\frac{k-\sigma+1}{\sigma-1}}X_i^{-(k-\sigma+1)}. \tag{39}$$

The terms Λ_i and Λ_j are explicitly given by:

$$\begin{aligned}
\Lambda_i \;=\;& \frac{\sigma-1}{k-\sigma+1}(\frac{\alpha}{b})^k(1-\alpha)^{\frac{k}{\sigma-1}} \\
& \Bigg[(\frac{2((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}... \\
& ...+\left\{(\frac{2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+((\gamma\tau w)^{1-\sigma})\left\{(\frac{2(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+\left\{(\frac{2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+\left\{(\frac{2\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}+(\frac{1}{F})^{\frac{k-\sigma+1}{\sigma-1}}\right\}\Bigg]
\end{aligned} \tag{40}$$

$$\begin{aligned}
\Lambda_j \;=\;& \frac{\sigma-1}{k-\sigma+1}(\frac{\alpha}{b})^k(1-\alpha)^{\frac{k}{\sigma-1}} \\
& \Bigg[(\gamma\tau w)^{1-\sigma}\left\{(\frac{2((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+\gamma^{1-\sigma}\left\{(\frac{2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+(\gamma\tau w)^{1-\sigma}\left\{(\frac{2(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}... \\
& ...+\tau^{1-\sigma}\left\{(\frac{2\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}-(\frac{2(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})}{G})^{\frac{k-\sigma+1}{\sigma-1}}\right\}\Bigg]
\end{aligned} \tag{41}$$

In other words, Λ_i and Λ_j are same as the ex ante profits. A potential entrant firm in the sector of country i expects sales in countries i and j; this is because the market demand levels are equal, $B_i = B_j = B$, in this analysis. Substituting back (40) and (41) into the CES aggregate $X_i^{\sigma-1} = X_i^i + X_i^j$, it can be rewritten as:

$$X_i = (N\frac{k}{\alpha})^{\frac{1}{k}}(\Lambda_i+\Lambda_j)^{\frac{1}{k}}\,\mu^{\frac{\sigma k-\sigma+1}{k(\sigma-1)}}L_i^{\frac{k-\sigma+1}{k(\sigma-1)}} \tag{42}$$

The CES aggregate holds love of varieties effect because (42) increases in N. In addition, there exists the market size effect since X_i is increasing in L_i (the exponent of L_i in (42) is $\frac{k-\sigma+1}{k(\sigma-1)} > 0$, since $k > \sigma - 1$ and $\sigma > 1$).

Closing the model fully, I need to endogenize the number of varieties, N, in country i with a free-entry condition for the country's sector. However, the quasi-linear utility function leads to a

result in which the endogenized number of varieties is fixed. This is because of the lack of income effect. Hence, total expenditures for the differentiated goods are fixed. For simplicity, I use the exogenous number of varieties for the following analysis.

3.6 Impact of both costs on Welfare

I compare the impact of communication costs on indirect utility with that of transportation costs. In other words, I show which cost has a bigger effect on welfare. To this end, I derive indirect utility, which has only parameters and a fixed number of varieties, N, by substituting (42) into (35):

$$W_i = w_i + \mu(\frac{\mu(\sigma k - \sigma + 1)}{k(\sigma-1)^2} + 1) ln\mu - \mu + \frac{\mu}{k(\sigma-1)} ln(N\frac{k}{\alpha}) + \frac{\mu}{k(\sigma-1)} ln(\Lambda_i + \Lambda_j) + \frac{\mu(k-\sigma+1)}{k(\sigma-1)^2} lnL_i \tag{43}$$

First, I investigate the welfare improvement when communication and transportation costs decrease. Concerning the reduction in communication costs, differentiating welfare by $\gamma^{1-\sigma}$ (since $\sigma > 1$, increase of $\gamma^{1-\sigma}$ means γ decreases), one has:

$$\begin{aligned} \frac{\partial W_i}{\partial \gamma^{1-\sigma}} &= \frac{\mu}{k(\sigma-1)} \frac{\partial ln(\Lambda_i + \Lambda_j)}{\partial(\Lambda_i + \Lambda_j)} \frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} \\ &= \frac{\mu}{k(\sigma-1)} \frac{1}{(\Lambda_i + \Lambda_j)} \frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} \end{aligned} \tag{44}$$

A change in welfare only depends on the variation in ex-ante profits when communication costs decrease. In specific, I have:

$$\begin{aligned} \frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} &= \Phi(\tau w)^{1-\sigma} \{ \underbrace{2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta}}_{+} + \underbrace{((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta}}_{+} ... \\ &\quad ... \underbrace{-2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta}}_{-} \} \\ &\quad + \Phi \{ \underbrace{(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta}}_{+} \underbrace{-((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta}}_{-} \} \end{aligned} \tag{45}$$

where $\eta = \frac{k-\sigma+1}{\sigma-1}$ and $\Phi = (\frac{2}{G})^{\eta}(\frac{k}{\sigma-1})$. The first term denotes the movement of ex-ante profits of platform-FDI and multiple-production-local FDI firms. The second term denotes the variation in the ex-ante profits of horizontal FDI firms. Naturally, a decrease in communication costs increases the ex-ante profits. Therefore, I have the inequality: $\frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} \geq 0$ (In details, see Appendix).

Similarly, the effect of a decrease in transportation costs on welfare is as follows:

$$\begin{aligned}\frac{\partial W_i}{\partial \tau^{1-\sigma}} &= \frac{\mu}{k(\sigma-1)}\frac{\partial ln(\Lambda_i+\Lambda_j)}{\partial(\Lambda_i+\Lambda_j)}\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \tau^{1-\sigma}} \\ &= \frac{\mu}{k(\sigma-1)}\frac{1}{(\Lambda_i+\Lambda_j)}\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \tau^{1-\sigma}} \end{aligned} \tag{46}$$

Also, a change in ex-ante profits by transportation costs has a positive effect on welfare. That effect is:

$$\begin{aligned}\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \tau^{1-\sigma}} &= \Phi(\gamma w)^{1-\sigma}\{\underbrace{2(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta}}_{+}+\underbrace{((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}}_{+}... \\ &\quad ...\underbrace{-2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})^{\eta}}_{-}\} \\ &\quad +\Phi\{\underbrace{(\tau^{1-\sigma})^{\eta}}_{+}\underbrace{-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta}}_{-}\} \end{aligned} \tag{47}$$

Similar to the case of communication costs, the first term implies how the share of ex-ante profits by platform FDI and multi-production-local FDI firms increase. The second term is different from (45). It represents an increase in ex-ante profits by export firms. Repeatedly, since reduction of costs benefits welfare, I have: $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \tau^{1-\sigma}} \geq 0$ (For details, see Appendix).

Next, I analyze which cost has a larger impact on welfare. The comparison between the transportation costs and communication costs is shown by:

$$\begin{aligned}\Delta W|_{\tau-\gamma} \equiv \frac{1}{\Phi}\left[\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \tau^{1-\sigma}}-\frac{\partial(\Lambda_i+\Lambda_j)}{\partial \gamma^{1-\sigma}}\right] &= \{\underbrace{(\gamma w)^{1-\sigma}-(\tau w)^{1-\sigma}}_{+}\}\{\underbrace{2(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta}}_{+}... \\ &\quad ...+\underbrace{((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}}_{+}\underbrace{-2(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})^{\eta}}_{-}\} \\ &\quad +\{\underbrace{(\tau^{1-\sigma})^{\eta}-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta}}_{+}\} \\ &\quad -\{\underbrace{(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})^{\eta}-((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}}_{+}\} \end{aligned} \tag{48}$$

Concerning the formula in the first brace, $\{(\gamma w)^{1-\sigma}-(\tau w)^{1-\sigma}\} > 0$ holds (since $\gamma < \tau$ and $\sigma > 1$). The formula in the second brace is positive; this finding is based on the decrease in communication and transportation costs. The difference between two costs denotes the variation in the ex-ante profits of export and horizontal FDI firms, that is, the second- and third terms. It is ambiguous which cost has a larger impact on welfare.[17] However, a numerical exercise gives a solution in the following figure.

[17]For details, see Appendix

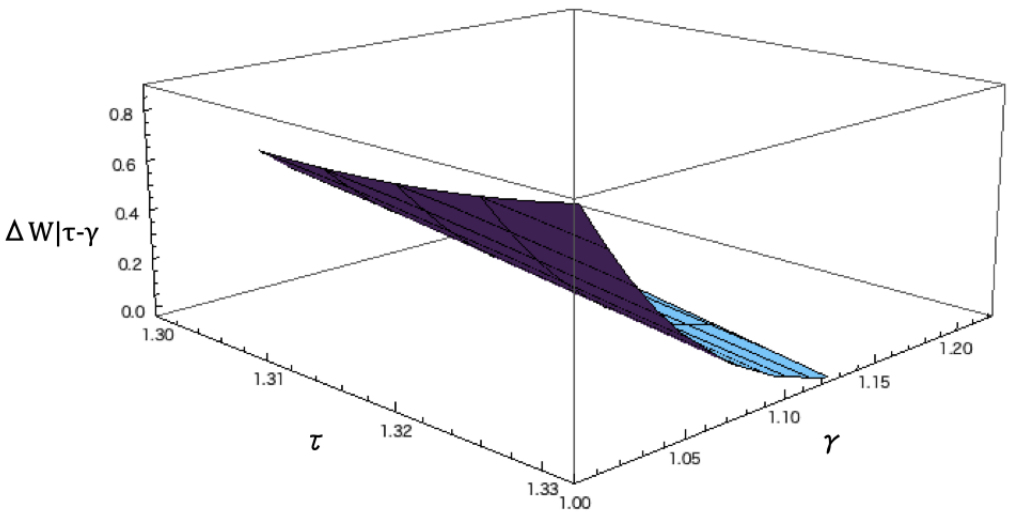

Figure 4: Comparison between both costs: $w = 0.75$, $\sigma = 3.8$, $k = 7$

This figure shows that if the equilibrium in which all organizational forms are present exists, then a reduction in transportation costs will have a larger impact on welfare than communication costs, regardless of the wage levels of the Southern country, w, and the elasticity of substitution, σ, that is:

$$\frac{\partial(\Lambda_i + \Lambda_j)}{\partial \tau^{1-\sigma}} > \frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}}.$$

This result largely depends on the restriction, $\gamma < \tau$, which is a necessary condition for the coexistence of all modes of firms. Platform FDI and multi-production-local FDI firms have the marginal costs $\frac{\gamma \tau w}{\varphi}$. Then, marginal costs of both the modes would decrease with a decrease in both communication and transportation costs. With $\gamma < \tau$, the marginal costs become lower when transportation costs decrease. Therefore, the ex-ante profits of the two organizational forms become higher with a decline in transportation costs. The differences between the impact on welfare by the two types of costs emerge from export and horizontal FDI firms. These forms of firms have different marginal costs, τ and γ, and both τ and γ are independent. Hence, it is unclear which cost has a larger impact on marginal costs.

From a different perspective, lower communication costs have advantages for only productive firms such as platform, horizontal, and multi-production-local FDI firms. Owing to the quasi-linear utility function, the mass of firms is fixed. This implies that the ratio of firms engaged in a foreign activity does not change.

However, lower transportation costs benefit both low and high productive firms. Some of the low productive firms (only doing domestic activity) can start exporting and become more profitable. With Pareto distribution, increasing the number of export firms can exert a larger

effect on welfare. This is because Pareto distribution assumes that the mass of low productive firms is larger than that of high productive firms. In other words, more firms can engage in foreign activities and become profitable when transportation costs decrease.

4 Conclusion

In this study, I tried to fill in the gap between export-platform FDI and heterogeneous firms regarding their productivity levels. Conventional models of export-platform FDI focus on a single type of multi-production-local FDI. Ekholm et al. (2007) introduce three-country oligopolistic model and examine the relationships between multi-production-local FDI and platform FDI firms (definition of this study). It has analyzed the tradeoff between the two types of export-platform FDIs and has showed they do not coexist. However, both types of export-platform FDI coexist, particularly in the Asian region. Introducing heterogeneous firms and communication costs, I revealed some conditions under which both two types of export-platform FDIs coexist with other foreign activities in an industry. The conditions implied that all five organizational forms coexist under the economic situations where transportation costs are large/small and the wage levels are low/high.

Another contribution was that I compared the effect of reduction in both communication and transportation costs on welfare. The result of analysis implied that transportation costs played a more important role than communication costs in a deeply fragmented economy. The larger positive impact of transportation costs on welfare stemmed from the fact that a reduction in those costs increases the share of firms engaged in foreign activities. However, communication costs did not change the ratio of the number of firms engaged in foreign activities. This result was intuitive because only productive firms take advantages of the benefit from a decline in communication costs. However, in the real economy, a large number of firms participate only in domestic or export activity. Hence, a decrease in transportation costs raised those firms' profits.

The final remark reflects the limitation of this model. I assumed the symmetric trade (transportation) costs. If transportation costs are asymmetric, then this assumption will allow us to distinguish the incentive between multi-production-local FDI and platform-FDI more clearly. It will also enable us to analyze other types export-platform FDI. In addition, the assumption of symmetric transportation costs forced us to consider the situation in which all countries signed BTA or FTA or a situation in which they did not sign these agreements. Analyzing the effect of such agreements is also important for gaining a better understanding of the export-platform FDI.

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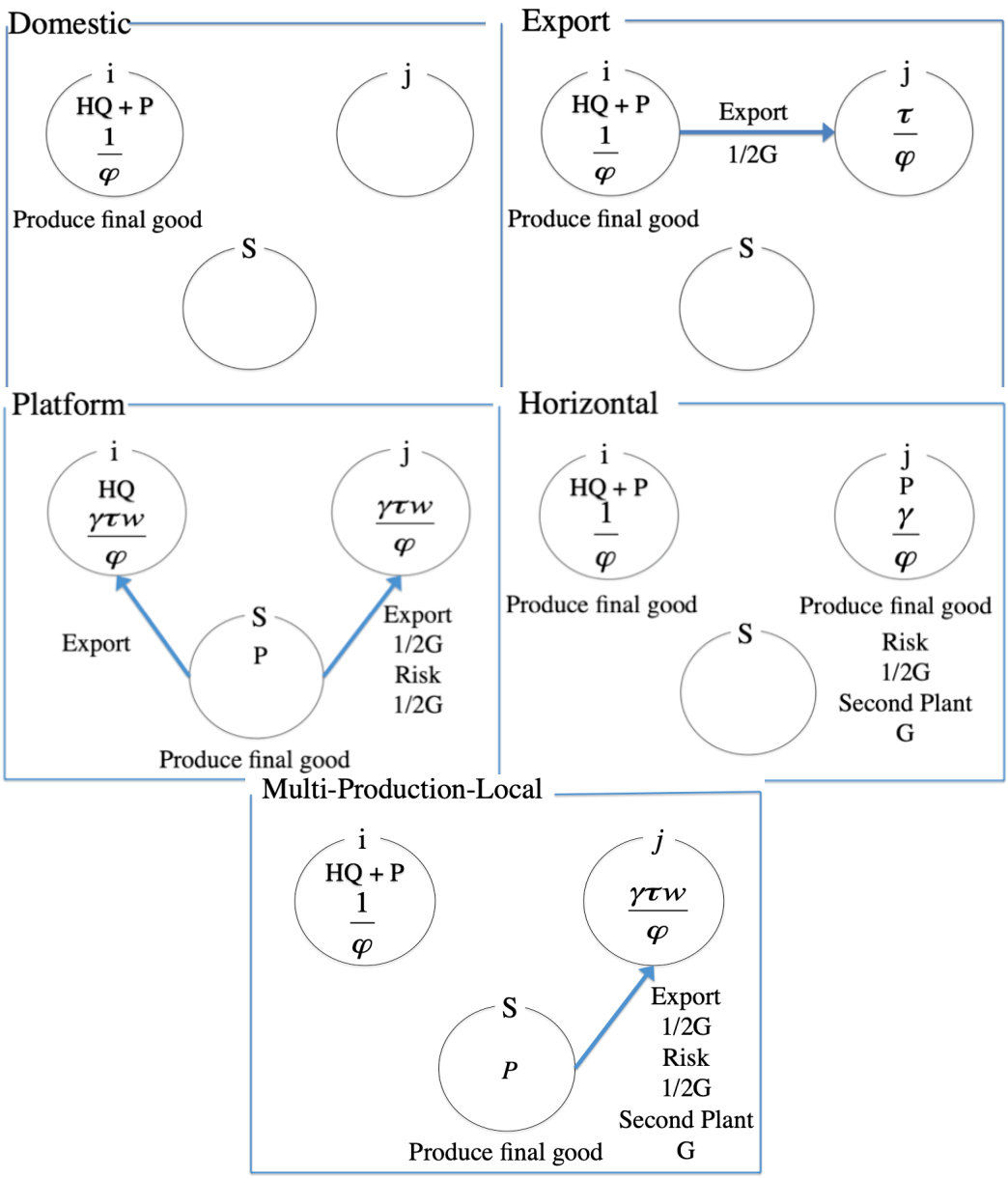
Appendix

Figure of additional fixed costs and variable costs of each regime



Conditions and proofs for the equilibrium

The conditional expressions (22), (27), (23), and (28) are essential.

From (23) and the assumption $G \leq F$, I have: $\tau^{\sigma-1} > 2$.

Considering the restriction (19) with $\tau^{\sigma-1} > 2$, I have: $w^{1-\sigma} > 2$.

Proof: EC_P is dominated by Cl_{XP}

$$EC_P \leq Cl_{XP} \Leftrightarrow 2\tau^{1-\sigma} \leq 1 + \tau^{1-\sigma} \Leftrightarrow \tau^{\sigma-1} \leq 2(\tau w)^{1-\sigma} - 1$$

The above intersection is the same one when I set $\gamma = \tau = Cl_{XP}$ or $\gamma = \tau = EC_P$. From the conditional expression (27), I have $\tau^{\sigma-1} \leq 2(\tau w)^{1-\sigma} - 1$. This implies that EC_P locates below Cl_{XP} within the area, $\gamma < \tau$. Hence, only (25) is a necessary condition over (20) for the economy.

Proof: $(\frac{1}{\tau w})$ **is dominated by** EC_H

From (29), I get $(\frac{1}{\tau w})$.

$$(\frac{1}{\tau w}) \leq (3(\tau w)^{1-\sigma} - 2)^{\frac{1}{\sigma-1}} \Leftrightarrow \tau \leq \frac{1}{w}$$

Together with the condition, $\tau < \frac{1}{w}$, $\gamma = (\frac{1}{\tau})$ located below $\gamma = EC_H$. Thus, I only have to need a condition (26) over (29).

Proof: I_{PH} **exists between** $\gamma = \tau$ **and** $\tau = \frac{1}{w}$

Note that $\tau = \frac{1}{w} \Leftrightarrow \tau^{\sigma-1} = w^{1-\sigma}$. I now show $I_{PH} < w^{1-\sigma}$:

$$\begin{aligned} I_{PH} \quad &: \quad \frac{3(\tau w)^{1-\sigma} + 2w^{1-\sigma} - 2}{3} < w^{1-\sigma} \\ &\Leftrightarrow \quad 3(\tau w)^{1-\sigma} + 2w^{1-\sigma} - 2 < w^{1-\sigma} \\ &\Leftrightarrow \quad \tau^{1-\sigma} < \frac{2w^{\sigma-1} + 1}{3} \end{aligned}$$

Recall that $\tau^{\sigma-1} > 2 \Leftrightarrow \tau^{1-\sigma} < \frac{1}{2}$. If $\frac{2w^{\sigma-1}+1}{3}$ is larger than $\frac{1}{2}$, I_{PH} always locates in the area then I have:

$$\begin{aligned} & \frac{2w^{\sigma-1} + 1}{3} > \frac{1}{2} \\ \Leftrightarrow \quad & 6w^{1-\sigma} + 2 > 3 \\ \Leftrightarrow \quad & w^{1-\sigma} > \frac{1}{6} \end{aligned}$$

Since $w^{1-\sigma} > 1$ holds, I_{PH} always exists within the area surrounded by $\gamma = \tau$ and $\tau = \frac{1}{w}$.

Proofs related to Welfare analysis

Proof : $\frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} > 0$

Recall that

$$\begin{aligned} \frac{\partial(\Lambda_i + \Lambda_j)}{\partial \gamma^{1-\sigma}} \quad = \quad & \Phi(\tau w)^{1-\sigma}\{2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} + ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} ... \\ & ... - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta}\} \\ & + \Phi\{(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} - ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta}\}. \end{aligned}$$

For the fact that the first term is positive, suppose, $2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} < 0$. Then, I have:

$$
\begin{aligned}
& 2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} < 0 \\
\Rightarrow\ & 2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma}) < 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma}) \\
\Rightarrow\ & 2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma} < 1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma} \\
\Rightarrow\ & \gamma^{1-\sigma}(4(\tau w)^{1-\sigma} - 1) < 2 + \tau^{1-\sigma} \\
\Rightarrow\ & \gamma > (\frac{4(\tau w)^{1^{\sigma}} - 1}{2 + \tau^{1-\sigma}})^{\frac{1}{\sigma-1}}
\end{aligned}
$$

This is contradiction for (25). Therefore, $2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0$. In addition to this, $(\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma} > 0$ since $\tau < \frac{1}{w}$. Then, the first term is positive. For the second term, suppose $(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} - ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} < 0$. This can be rewritten as:

$$
\begin{aligned}
& (1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} - ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} < 0 \\
\Rightarrow\ & 1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma} < (\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma} \\
\Rightarrow\ & \gamma^{1-\sigma}(3(\tau w)^{1-\sigma} - 2) > 1 \\
\Rightarrow\ & \gamma < (3(\tau w)^{1-\sigma} - 2)^{\frac{1}{\sigma-1}}
\end{aligned}
$$

This contradicts for the conditional expression (26). Hence, $(1+\gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} - ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} \geq 0$. From these results, $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial\gamma^{1-\sigma}} > 0$ is showed.

Proof : $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial\tau^{1-\sigma}} > 0$

Recall that

$$
\begin{aligned}
\frac{\partial(\Lambda_i + \Lambda_j)}{\partial\tau^{1-\sigma}} &= \Phi(\tau w)^{1-\sigma}\{2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} + ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} ... \\
& ... - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta}\} \\
& + \Phi\{(\tau^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta}\}.
\end{aligned}
$$

The proof that the first term is positive have done in the case of $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial\gamma^{1-\sigma}} > 0$. Therefore, the first term is positive. For that the second term is positive, suppose $(\tau^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} <$

0 I have:

$$
\begin{aligned}
& (\tau^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} < 0 \\
\Rightarrow \quad & \tau^{1-\sigma} < 2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma} \\
\Rightarrow \quad & \gamma^{1-\sigma} > \frac{1 + 2\tau^{1-\sigma}}{2(\tau w)^{1-\sigma}} \\
\Rightarrow \quad & \gamma^{1-\sigma} < (\frac{2(\tau w)^{1-\sigma}}{1 + 2\tau^{1-\sigma}})^{\frac{1}{\sigma-1}}
\end{aligned}
$$

This is contradiction for (24). Hence, I have: $(\tau^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} \geq 0$. From these proofs, I have shown $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial\tau^{1-\sigma}} > 0$.

Calculation : $\frac{\partial(\Lambda_i+\Lambda_j)}{\partial\tau^{1-\sigma}} - \frac{\partial(\Lambda_i+\Lambda_j)}{\partial\gamma^{1-\sigma}}$

Recall that this difference:

$$
\begin{aligned}
\frac{\partial(\Lambda_i + \Lambda_j)}{\partial\tau^{1-\sigma}} - \frac{\partial(\Lambda_i + \Lambda_j)}{\partial\gamma^{1-\sigma}} \quad = \quad & \Phi\{(\gamma w)^{1-\sigma} - (\tau w)^{1-\sigma}\}\{2(2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta}... \\
& ... + ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} - 2(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta}\} \\
& +\Phi\{(\tau^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta}\} \\
& -\Phi\{(1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} - ((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta}\}
\end{aligned}
$$

Remembering that $(\gamma w)^{1-\sigma} > (\tau w)^{1-\sigma}$ since $\gamma < \tau$ and the formula in the second brace is positive, the first term is positive. To prove this difference is positive or not , I need to show the following two formulas are positive or not:

$$
\begin{aligned}
(\tau^{1-\sigma})^{\eta} - (1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0 \\
((\gamma\tau w)^{1-\sigma} - \gamma^{1-\sigma})^{\eta} - (2(\gamma\tau w)^{1-\sigma} - 1 - \tau^{1-\sigma})^{\eta} \leq 0
\end{aligned}
$$

Step 1 : $(\tau^{1-\sigma})^{\eta} - (1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0$

If $(\tau^{1-\sigma})^{\eta} - (1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0$, I have:

$$
\begin{aligned}
& (\tau^{1-\sigma})^{\eta} - (1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0 \\
\Rightarrow \quad & \tau^{1-\sigma} \geq 1 + \gamma^{1-\sigma} - 2(\gamma\tau w)^{1-\sigma} \\
\Rightarrow \quad & \gamma^{1-\sigma}(2(\tau w)^{1-\sigma} - 1) \geq 1 - \tau^{1-\sigma} \\
\Rightarrow \quad & \gamma^{1-\sigma} \geq \frac{1 - \tau^{1-\sigma}}{2(\tau w)^{1-\sigma} - 1} \\
\Rightarrow \quad & \gamma \leq (\frac{2(\tau w)^{1-\sigma} - 1}{1 - \tau^{1-\sigma}})^{\frac{1}{\sigma-1}}
\end{aligned}
$$

If this expression locate above the conditional expression for exist of Platform FDI (25), Step 1 is done. This is because the equilibrium is closed from above by (25). So, I have to have a following

expression:

$$
\begin{aligned}
& (\frac{4(\tau w)^{1-\sigma}-1}{2+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \leq (\frac{2(\tau w)^{1-\sigma}-1}{1-\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} \\
\Rightarrow \quad & \frac{4(\tau w)^{1-\sigma}-1}{2+\tau^{1-\sigma}} \leq \frac{2(\tau w)^{1-\sigma}-1}{1-\tau^{1-\sigma}} \\
\Rightarrow \quad & 1+2\tau^{1-\sigma} \leq 6\tau^{1-\sigma}(\tau w)^{1-\sigma} \\
\Rightarrow \quad & \tau^{\sigma-1} \leq 6(\tau w)^{1-\sigma}-2
\end{aligned}
$$

This conditional expression is always satisfied under the economy where all organizational firms exist. Thus, the expression: $(\tau^{1-\sigma})^{\eta}-(1+\gamma^{1-\sigma}-2(\gamma\tau w)^{1-\sigma})^{\eta} \geq 0$ holds.

Step 2 : $((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta} \leq 0$

Suppose $((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta} > 0$ is satisfied, I have a conditional expression:

$$
\begin{aligned}
& ((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta} > 0 \\
\Rightarrow \quad & 2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma} > (\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma} \\
\Rightarrow \quad & \gamma^{1-\sigma}(1+(\tau w)^{1-\sigma}) < 1+\tau^{1-\sigma} \\
\Rightarrow \quad & \gamma^{1-\sigma} < \frac{1+\tau^{1-\sigma}}{1+(\tau w)^{1-\sigma}} \\
\Rightarrow \quad & \gamma > (\frac{1+(\tau w)^{1-\sigma}}{1+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}}
\end{aligned}
$$

The equilibrium is closed from below by the expression (26). If the expression above is located below (26), the inequality, $((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta}-(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta} > 0$, always holds under the equilibrium. A specific calculation is below:

$$
\begin{aligned}
& (\frac{1+(\tau w)^{1-\sigma}}{1+\tau^{1-\sigma}})^{\frac{1}{\sigma-1}} < (3(\tau w)^{1-\sigma}-2)^{\frac{1}{\sigma-1}} \\
\Rightarrow \quad & \frac{1+(\tau w)^{1-\sigma}}{1+\tau^{1-\sigma}} < 3(\tau w)^{1-\sigma}-2 \\
\Rightarrow \quad & 0 < 3\tau^{1-\sigma}(\tau w)^{1-\sigma}+2(\tau w)^{1-\sigma}-2\tau^{1-\sigma}-3 \\
\Rightarrow \quad & \tau^{\sigma-1} < \frac{3(\tau w)^{1-\sigma}+2w^{1-\sigma}-2}{3}
\end{aligned}
$$

Recall that one of the conditions for having the all types of firms exist in the economy is EC_P : (25) $\geq EC_H$: (26). This holds if $\tau^{\sigma-1} \geq \frac{3(\tau w)^{1-\sigma}+2w^{1-\sigma}-2}{3}$. This is contradiction. Therefore, the inequality : $(2(\gamma\tau w)^{1-\sigma}-1-\tau^{1-\sigma})^{\eta}-((\gamma\tau w)^{1-\sigma}-\gamma^{1-\sigma})^{\eta} \leq 0$ always holds under the equilibrium.