Analyzing Effects of the Regional Comprehensive Economic Partnership on FDI in a Firm Heterogeneity CGE Framework

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Abstract

The RCEP (Regional Comprehensive Economic Partnership) is a free trade agreement (FTA) that is currently under negotiation among China and 15 Asian countries. It is another mega FTA in the Asia-Pacific region after the Trans-Pacific Partnership (TPP). This paper investigates the potential effect of the RCEP on foreign direct investment (FDI) with a focus on China through a computable general equilibrium (CGE) model. The CGE model is built on the extended theory of firm heterogeneity to FDI, which is able to capture the intensive margin and extensive margin of FDI increase. The RCEP is simulated to impact on FDI through a direct effect of FDI liberalization and an indirect effect of trade liberalization. Simulation results show that the RCEP will encourage FDI to China through its trade effect and the direct FDI effect. While the competition from imports drives out the least productive foreign invested firms, the export expansion of firms using FDI will lead to an increase in foreign investment. In addition, the facilitation of trade in intermediate goods tends to promote vertical FDI. The direct FDI effect from investment liberalization will evidently promote FDI from partners. As for the welfare effect, China will gain US$103~214 billion, accounting for 1.08~2.24% of GDP.

Keywords: RCEP; FDI; firm heterogeneity; CGE

1. Introduction

The Regional Comprehensive Economic Partnership (RCEP) is a proposed sixteen-country Asia-Pacific free trade arrangement being negotiated among ASEAN and its six free trade agreement (FTA) partners, China, Japan, Korea, India, Australia, and New Zealand. The RCEP negotiations were launched in November 2012. Fourteen rounds of negotiations have been finished until August 2016. The guiding principles and objectives for negotiating RCEP point out that it will tackle both tariff barriers and Non-tariff barriers (NTBs), liberalizing trade in goods and services based on members' commitments under WTO and ASEAN+1 FTAs. The aim is to achieve a modern, comprehensive, high-quality and mutually beneficial economic partnership agreement. This free trade pact would affect over half of the global population in countries that make up 30% of global economic output and trade. As such it is expected to bring big economic effects to member countries.

FTAs usually have a clear stimulative effect on trade among members, but how foreign direct investment (FDI) response to trade liberalization is less clear-cut. Most FTAs, including RCEP, regulate facilitation measures for foreign investment, either in an investment chapter or in services trade provisions. The lift of FDI restrictions on market access and operation is supposed to directly facilitate foreign investment. Aside from this direct FDI impact, FTAs could also affect foreign investment through trade effect. Export-platform FDI would benefit from trade liberalization arrangements, just like exporters. In addition, firms that invest vertically in a few countries to carry out different production tasks, or vertical FDI, would also benefit from FTAs due to the reduction in trade costs of components and parts transferred intensively inside firms. Horizontal FDI, with an aim of exploring foreign markets, however, may be substituted by trade after FTA. For one reason, trade cost is reduced by FTA, and some firms will switch from FDI to export to supply foreign market. For another reason, increased imports intensify competition, which may squeeze out the less productive foreign firms, generating substitution of trade for FDI. Given the co-existence of positive and negative effects of FTA on FDI, it is an open question about the response of FDI to FTAs.

To answer this question, we could adopt numerical simulation techniques to estimate the FDI effect of future FTAs such as RCEP. The computable general equilibrium (CGE) model is one of the popular numerical simulation tools to assess the effects of trade liberalization arrangements. Petri (1997) pioneers a FDI-CGE model to assess the APEC's 'Bogor Declaration'. Dee and Hanslow (2000) adopt a GTAP model integrated with FDI (or FTAP model) to compare services liberalization with the combined liberalization of the post-Uruguay remaining barriers to trade in agriculture and manufactured goods. Jensen, Rutherford and Tarr (2004, 2007) develop a small open economy CGE model of Russia to assess the impact of FDI liberalization as part of its WTO accession. Lejour, Rojas-Romagosa, and Verweij (2008) build a FDI-CGE model of WorldScan to analyze the Services Directive of the European Commission. These studies have laid a good foundation for adopting CGE to analyze the FDI effect of trade liberalization.

However, the existing FDI-CGE models are less than satisfactory. The way they model the effect of trade liberalization on FDI is relatively simple and less comprehensive. First, most studies focus on FDI restrictions only while ignoring the indirect effect of liberalization of trade barriers on FDI. Second, these studies usually model restrictions on foreign investment as taxes, which increase burden and weaken the competitiveness of foreign firms. The extra tax burden may implicitly restrict the entry of foreign firms, but it is less straightforward in reflecting the entry restriction effect of FDI barriers. The effect of FDI barrier on entry has been taken into account in the model of Jensen, Rutherford and Tarr (2004, 2007). But with a focus on FDI barriers, this model has not paid much attention to the effect of trade barriers on FDI.

In order to give a comprehensive estimation of the effect of FTA on FDI, this paper builds a FDI-CGE model based on the Metiz's firm heterogeneity model and its extension to FDI by Helpman, Melitz, and Yeaple (2004). The firm heterogeneity FDI-CGE model (the FHFDI model) not only can fully capture the intensive margin and extensive margin of trade increase due to trade liberalization, and thus fully captures

FDI effects of FTA related to trade effect, but also can explain the entry of new foreign firms after the removal of FDI restrictions via a transmission mechanism of fixed trading costs and productivity threshold, as well as the exit of foreign firms along with increased competition from imports.

The FHFDI model is built on Zhai (2008), which initially introduces the firm heterogeneity model to a CGE framework. Zhai (2008) innovates in many ways in order to apply the firm heterogeneity model to a CGE study, including the abstraction from the dynamic parts of the Melitz model, using industry-level rather than firm-level equations, as well as the calibration method for key parameters and variables. Developed from the Zhai model, the FHFDI model adds foreign firms and FDI to the CGE framework. Foreign firms are those affiliates of multinationals that sources capital only from the home country. The FHFDI model separates foreign firms from each economy to model the reactions of foreign firms to FDI and trade liberalization. In the model, foreign firms differ from domestic firms in productivity, costs, price, and production, that is, foreign firms have different equations. FDI is owned by foreign owners. Capital owners allocate capital across sectors, regions, and between domestic and foreign firms in chasing for the highest return to capital. The way of how FHFDI dealing with capital allocation draws wisdom from Petri (1997). When FDI being allocated to domestic firms, it forms joint venture. In the FHFDI model, however, we do not different joint ventures from domestic firms.

The FHFDI model is a comparative static model, and like most comparative static models, it includes no treatment of time. The model is calibrated to a Social Accounting Matrix (SAM) built on a GTAP 8 database and two FDI databases. The two FDI databases include a global FDI stock database and a global foreign affiliate sales database. The base year of the global foreign affiliate sales database is 2007, the same as that of the GTAP 8 database, which makes the 8^{th} version of GTAP database the most suitable. The FDI databases are the latest developments in FDI data collection and computation (Fukui & Lakatos, 2012; Lakatos, Walmsley, & Chappuis, 2011).

The model has three regions, China, its RCEP partners (PTN) and the rest of the world

(ROW). China is the country of interest. Simulation results show that the RCEP will bring significant FDI to China, meanwhile, it will improve China's welfare. Simulations start with a trade liberalization on goods, which forms a benchmark for the effect of the RCEP. It turns out that China will receive US$1.6 billion more FDI than without the RCEP. Since services liberalization has been receiving more and more attention in nowadays FTAs, it is assumed to be included in the RCEP as well. After adding services liberalization to simulations, we find that FDI increases in China grow to US$2 billion, and the growth increases along with the depth of services liberalization taken by China. Trade liberalization on goods and services affects FDI via trade effect. When the removal of FDI restrictions is finally added to the simulation scenario, FDI will show the most significant response to the formation of the RCEP. Along with FDI increases, the welfare gains for China will be in the range of US$103~214 billion under different scenarios, accounting for 1.08~2.24% of GDP.

It is important to note that these figures are from the output of simulations based on a model of the economy that is simplified — even if it is state-of-the-art. As such they are not precise predictions but rather good indicators of the rough size of the impact of the RCEP.

The next section reviews the model of Zhai (2008), which our model follows. Then the FHFDI model is presented in section 3. Section 4 depicts data and the calibration of main variables and parameters. Simulation scenarios are shown in section 5. Section 6 presents simulation results and section 7 concludes.

2. The Zhai Model

The FHFDI model builds on the CGE model of Zhai (2008). This section briefly reviews the Zhai model to show the basic structure of the model and to clarify the extensions of FHFDI to the Zhai model.

Zhai (2008) introduces the firm heterogeneity theory of Melitz (2003) to a CGE framework. The aim of this study is to address the problem that traditional CGE models with the Armington assumption are not able to capture the extensive margin of trade, and thereby underestimate the trade and welfare effects of trade opening. Simulation results show that the estimated gains in welfare and exports are more than double that obtained from the Armington CGE model.

The Zhai model is a global CGE model with heterogeneous firms. The model consists of 12 regions, 14 sectors, and 5 production factors. Within the 14 sectors, agriculture and energy sectors produce homogeneous products. Identically, the FHFDI model assumes that firms in the agriculture sector are homogeneous. This assumption could be a closer reflection of reality; meanwhile, it allows agriculture to act as a reference for other sectors with heterogeneous firms. In addition, FHFDI follows other assumptions of the Zhai model. First, we assume there are no fixed entry costs, and thus, all potential firms can produce. But there are fixed trading costs in supplying products to markets. That means not all potential firms are active in a certain market. There is a selection of firms that only those with sufficient high productivity that can cover the market-specific fixed trading costs can supply the market. Changes in fixed trading costs will cause entry and exit of firms. Second, we assume that the total mass of potential firms is fixed, so do not allow free entry and exit to the industry. This assumption indicates that there could be non-zero profits in equilibrium.

Although the FHFDI model borrows many modelling technics from the Zhai model, including some assumptions, parameters, and calibration approaches, FHFDI extends the Zhai model in several ways. First, the FHFDI model introduces FDI to the Zhai model. Zhai (2008) does not seek to incorporate FDI into the firm heterogeneity framework. Although in a later application of the Zhai model, Petri, Plummer, and Zhai (2012) develop an FDI side model to assess the investment effect of trade liberalization, the FDI side model is mainly based on econometric estimations, rather than incorporating FDI into the CGE model. Therefore, the estimated investment effect is more like the result of a partial equilibrium model, and less likely to reflect structural changes in the economy as a result of trade liberalization. In FHFDI, we build FDI into a global CGE model and separate foreign firms from domestic firms in each region and sector. In addition, the model has a capital allocation bloc that allocates assets to different sectors, regions, and firms.

Second, the FHFDI model deals with both border barriers and behind-border barriers. With his focus on the exploration of new techniques, the Zhai model treats trade barriers in a relatively simple way. The Zhai model only simulate with tariffs barriers, and does not consider non-tariff barriers or behind-border barriers. In FHFDI, NTBs are treated as tariff equivalents that raise trade costs. In the services sector, NTBs not only raise trading costs, but also generate rents to incumbent firms.[1] Behind-border barriers such as restrictions to trade and foreign investment are treated as if they are included in fixed trading costs. This extension from tariff barriers to NTBs and behind-border barriers allows us to simulate with a more full range of trade and FDI barriers that are usually tackled in FTAs, which is important for estimating the potential effects of the RCEP in a comprehensive way.

3. The FHFDI Model

This section describes the theoretical structure of the FHFDI model. FHFDI model distinguishes three regions, three factors, five sectors, and two types of firms. The three regions are China, its RCEP partners (PTN), and the rest of the world (ROW). The three factors are land, labor, and capital. Within the three factors, land is a specific factor for agriculture. Labor and capital are used in all sectors and fully employed. Labor can move freely across sectors but cannot move across borders. Capital can move across sectors and borders.

The five sectors consist of an agriculture sector (a), two manufacturing sectors (m1,m2), and two services sectors (s1, s2). Following the Zhai model, firms in agriculture are

[1]This treatment of services restraints follows the approach of Konan and Maskus (2006) in dealing with restraints on foreign ownership in services. Empirical findings show that some elements in prices of banking and telecommunication are caused by the monopoly power from services barriers (Kaleeswaran, McGuire, Nguyen-Hong, & Schuele, 2000; Warren, 2000).

homogeneous, while firms in other sectors are heterogeneous. The manufacturing sector, m1, aggregates machinery and electrical goods (GSC2 NO.41, 42 in GTAP database) which can easily carry on vertically-fragmented production. According to Athukorala and Yamashita (2005), these commodities can gain more efficiency from trade liberalization due to the intensive back-and-forth trade across borders involved in the production. That means sector m1 could be more sensitive to the RCEP than the other sectors. The manufacturing sector m2 aggregates the remaining manufacturing sectors. For the services sectors, s1 aggregates transportation services and s2 takes in all the rest. Services in s2, such as financial, telecommunications, renting, and retail, are more likely to be traded via commercial presence (or FDI) than the transportation sectors; that is, this sector has a closer correlation with FDI. Thus, we expect that the FDI effect of the RCEP could be relatively significant on sector s2.

The two types of firms refer to domestic firms and foreign firms. FHFDI separates foreign affiliates 100% owned by foreigners in each economy. These foreign firms source capital from their home regions, or FDI. FDI liberalization will facilitate the operation of foreign firms, affecting their investment. Domestic firms comprise firms owned by citizens and joint ventures. For simplification, FHFDI treats joint ventures the same as firms 100% owned by citizens. By doing so, joint ventures would not be directly affected by FDI restrictions, and we exclude limits on the participation of foreign equity due to trade and FDI restrictions.[2] Nevertheless, the RCEP would impact on joint ventures through trade liberalization, and in turn, influence foreign investment. According to the SAM table, most of the FDI coming into China flows to joint ventures. Thus, we expect that joint ventures will experience significant changes in FDI after the

[2] In fact, limits on the participation of foreign equity is a standard market access restriction on services trade in a GATS-style framework, and also a standard restriction on foreign investment in a framework where 'commercial presence' is treated as a form of FDI rather than as a mode of supplying services. Thus it is possible to envisage that in practice liberalization of FDI could include removal of restrictions on foreign equity participation i.e. increasing the range of circumstances in which 100% foreign equity participation is permitted. This in turn would imply that the effect of liberalization could include the conversion of some joint ventures into 100% foreign-owned firms. This effect is not captured in this study as our focus is the restriction on the entry of foreign firms, rather than the restriction on foreign equity. This could be a direction for extension in future studies.

formation of RCEP.

In the following sections, we first present how FHFDI models barriers to trade and FDI, and then demonstrate the productivity difference between foreign and domestic firms, as well as the productivity change caused by the RCEP and the resulting changes in the entry and exit of firms to different markets.[3] After that, we show how capital is allocated across borders and sectors. Finally, we depict the special features of FHFDI in each block of demand, production and closure. Appendix B presents all equations of the model.

3.1 Barriers to trade and FDI

FHFDI distinguishes between barriers to trade and FDI barriers. Trade barriers comprise border barriers such as tariff and non-tariff barriers, as well as behind-border barriers such as restrictions to foreign exporters. FDI barriers only refer to the behind-border barriers on foreign investment such as discriminatory treatment of MNCs and investment restrictions. In FHFDI, FDI barriers are modeled as fixed trading costs for foreign firms. Behind-border barriers on trade are modeled as fixed trading costs for exporters. This section details how FHFDI models different types of barriers.

Fixed trading costs are an exogenous variable in FHFDI, which can be calibrated from trade and FDI data. The calibrated fixed trading costs represent the total fixed trading costs faced by firms, including those caused by investment and trade restrictions as well as other costs occurred in distribution and marketing. It is not necessary to isolate the fixed trading costs caused by restrictions in simulation. In simulation, we assume total fixed trading costs will drop if the RCEP tackles behind-border barriers. The SAM table does not contain fixed trading costs. We assume that fixed trading costs are some fixed combination of capital, labor, and intermediate inputs, and thus, payments for fixed trading costs from firms flow to factor owners and intermediate suppliers.

[3] From here on, the exit and entry of firms refers to the exit and entry of firms to different markets, that is, the number of active firms in each market would change from time to time.

For border barriers, the estimation of NTBs is an important issue. Many papers have endeavored to quantify NTBs, not least because NTBs are important in analyzing services trade and FDI.[4] This paper adopts the estimation of Petri et al. (2012), which is in turn drawn from the World Bank estimations for NTBs on goods (Helble, Shepherd, & Wilson, 2007; Looi Kee, Nicita, & Olarreaga, 2009) and estimations for NTBs on services by Wang, Mohan, and Rosen at the Peterson Institute for International Economics. Their estimations are well grounded in trade theory and account for different forms of trade protection. The estimation results coincide with expectation for NTBs that poor countries tend to have more restrictive trade policies but they also face higher trade barriers on their exports.

Table 1 presents the estimated tariff equivalences of NTBs by region and sector for 2007. China, as a developing country, adopts relatively high NTBs, especially in the services sectors. Its services barriers are as high as twice those in PTN and more than three times those in ROW. Its agriculture sector is also protected from imports by restrictive NTBs. The NTBs in the manufacturing sectors are relatively low, not only in China, but also in PTN and ROW. PTN has the highest NTBs on agriculture among the three regions. ROW adopts the lowest NTBs in all sectors. Table 1 shows the NTBs before trade liberalization and each region adopts the same NTBs for imports from all sources. After the formation of the RCEP, China and PTN would preferentially reduce trade barriers to each other, but retain high barriers to ROW.

Table 1 Tariff equivalences of NTBs by region and sector (Units: ratio of tariff to imports)

	a	m1	m2	s1	s2
China	0.334	0.167	0.167	0.747	0.766
PTN	0.404	0.155	0.155	0.363	0.376
ROW	0.281	0.129	0.129	0.196	0.205

Note: According to the studies estimating NTBs, the unit of these indices for NTBs is the same as for the tariff, which is the ratio of tariff to trade value. NTBs for sectors $\mathrm{a}, \mathrm{m}1, \mathrm{m}2, s1$ are directly drown from Petri et al. (2012), while NTBs for sector $s2$ are the simple average of its sub-sectors.

[4] See, for example, Hoekman (1996), Hanslow (2000), and Petri et al. (2012).

FHFDI treats border barriers, including tariff and NTBs, as trade costs on commodities across borders.[5] But for sector $s2$, trade barriers not only raise costs in the cross border supply of services, but also generate rents in the protected market. The inclusion of a rent-creating effect of services barriers is drawn from the literature (Dee & Hanslow, 2000; Konan & Maskus, 2006). These studies argue that trade restrictions in some services sectors, including banking and telecommunications, can help existing firms gain some monopoly power, resulting in a rent-creating distortion in price. The rent from services barriers goes to firms' profit, while the tariff revenue from NTBs is modeled to flow to ice-berg costs.

In the FHFDI model, the price distortion from services barriers is allocated between rent-creating (v_j^{s2}) and cost-raising (λ_{ij}^{s2}) such that:

$$v_j^{s2} = \alpha * \frac{\sum_i tn_{ij}^{s2}}{2}\ , \quad \lambda_{ij}^{s2} = tn_{ij}^{s2} - v_j^{s2}, i \neq j \qquad \text{Eq.(1)}$$[6]

where v_j^{s2} represents the rent-creating effect of services barriers which impacts on all firms in sector $s2$ supplying market j, including domestic firms of region j. tn_{ij}^{s2} is the tariff equivalence of NTBs imposed in region j on services $s2$ imported from region i. λ_{ij}^{s2} represents the cost-raising effect of services barriers on imports from region i. $\lambda_{ij}^{s2} = 0$ when $i = j$. α is the percentage share of the rent-creating effect in the total price wedge from trade restrictions. A simulation of NTB reductions in services sector $s2$ will lower v_j^{s2} and λ_{ij}^{s2} accordingly.

As for the value of α, there is no exact measurement of the rent-creating effect and

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5 Tariff data are calibrated from the SAM table of GTAP 8.0 database. As commonly known, the GTAP 8.0 database has a problem with tariff data, particularly for China, which has been fixed in a later version (GTAP 8.1). But it should not cause a problem in this study because what we use is the GTAP SAM table only. By careful comparison, we found the SAM tables of version 8.0 and version 8.1 are exactly the same.

6 The calculation of the rent-creating effect is based on the average of NTBs being imposed by region j on imports from different regions. The average of NTBs is $\frac{\sum_i tn_{ij}^{s2}}{2}$, as there are two other regions besides j in the FHFDI model. The reason for calculating the rent share based on the average of NTBs is because the monopoly power generated from trade restrictions should be the same for all incumbent firms.

cost-raising effect of services barriers. Dee and Hanslow (2000) adopt a full rent-creating effect, but at the same time, they admit that in some services sectors, trade restrictions raise costs. In FHFDI, α is set to 10%. The value is chosen based on the tariff equivalence of NTBs and market structures of the three regions. In PTN and ROW, the main markets, such as the US and EU, are relatively open and firms are unlikely to gain high monopoly power from protection. In China, services sector $s2$ is protected by high trade barriers, which means the monopoly power of existing firms could be high. Given the high services barriers (0.766) in China, a 10% rent-creating effect is equal to a 7.66% price markup on marginal costs, which seems to be a sufficient markup from trade restrictions.

The cost-raising effect of services barriers, λ_{ij}^{s2}, comprises the remaining NTBs after subtracting the rents. It is specific to the services source region and is the trade variable costs in sector $s2$. The trade variable costs in other sectors are equal to the sum of tariff rates and NTBs:

$$t_{ij}^{s} = tm_{ij}^{s} + tn_{ij}^{s}, s \neq s2, and\ \ t_{ij}^{s2} = \lambda_{ij}^{s2} \qquad \text{Eq.(2)}$$

t_{ij}^{s} is the trade variable costs on imported goods or services s from region i to region j and tm_{ij}^{s} is the corresponding tariff rates. $t_{ij}^{s} = 0$ when $i = j$. In sectors other than $s2$, a simulation of tariff and NTBs reduction will lower t_{ij}^{s} through reductions in tm_{ij}^{s} and tn_{ij}^{s}.

3.2 Productivity

Multinationals are usually regarded as more productive than firms supplying the local market. That is because in developing foreign markets via FDI, MNCs usually face high risks, high financial pressure, high costs, etc. To overcome these difficulties, MNCs need to be stronger, more sophisticated and more productive. The advanced management skills and technologies that determine the high level of productivity of

MNCs, which is known as “knowledge capital” can be supplied at relatively low cost to foreign affiliates without reducing the value or productivity of those assets in existing facilities (Markusen, 2002). Therefore, foreign affiliates, or foreign firms in FHFDI, should be at a similar level of productivity as their parent firms. Following this reasoning, foreign firms in FHFDI would be more productive than domestic firms.

The high productivity of MNCs is explained from fixed trading costs in the firm heterogeneity model. Due to the difficulties of investing in foreign markets, the fixed trading costs of MNCs are quite high. According to Helpman et al. (2004), the fixed trading costs comprise the costs faced by exporters, including the costs of customizing products, building distribution channels, and becoming familiar with foreign regulations, as well as the costs of financing and managing foreign branches, avoiding risks, adapting to investment restrictions, etc. Therefore, MNCs face much higher fixed trading costs than exporters, and even greater costs than firms supplying the domestic market. The high costs of MNCs leads to the conclusion of Helpman et al. (2004) that only firms with the highest productivity can supply foreign markets via FDI.

In FHFDI, productivity corresponds to two variables, the productivity threshold and industry aggregate productivity. Industry aggregate productivity is determined by the productivity threshold, and thus, the productivity threshold is the main variable that reflects the high productivity of foreign firms. The productivity threshold is derived from the zero profit condition, that is, the marginal firm that makes zero profits produces at the threshold productivity level.[7] The productivity thresholds of foreign and domestic firms are as follows:

$$\varphi F_{gij}^{s^*} = \frac{\tau_{ij}^s CF_{gij}^s}{(\sigma^s-1)} \left(\frac{P_j^s}{\sigma^s(1+t_{ij}^s)(1+v_j^s)}\right)^{\frac{\sigma^s}{1-\sigma^s}} \left(\frac{FF_{gij}^s}{Q_j^s(1+v_j^s\sigma^s)\theta_{ij}^s \theta FS_{ij}^s \theta F_{gij}^s}\right)^{\frac{1}{\sigma^s-1}} \quad \text{Eq.(3)}$$

$$\varphi D_{ij}^{s^*} = \frac{\tau_{ij}^s CD_{ij}^s}{(\sigma^s-1)} \left(\frac{P_j^s}{\sigma^s(1+t_{ij}^s)(1+v_j^s)}\right)^{\frac{\sigma^s}{1-\sigma^s}} \left(\frac{FD_{ij}^s}{Q_j^s(1+v_j^s\sigma^s)\theta_{ij}^s \theta D_{ij}^s}\right)^{\frac{1}{\sigma^s-1}} \quad \text{Eq.(4)}$$

$\varphi F_{gij}^{s^*}$ is the productivity threshold for foreign firms from region g investing in region

[7] In equilibrium, the industry total profit could be non-zero since we model a monopoly competitive market and we do not allow free entry of firms to the industry.

i and supplying market j in sector s and $\varphi D_{ij}^{s^*}$ is the productivity threshold for domestic firms from region i supplying market j in sector s. The productivity threshold negatively correlates with the aggregate industry price P_j^s and quantity Q_j^s, which means when it is easy to earn revenue in the market the productivity requirement for firms is low. When the cost of supplying the market is high, the requirement for productivity is high. Reflected in the equation, the productivity threshold positively correlates with production variable costs CF_{gij}^s and CD_{ij}^s, trade costs t_{ij}^s, and fixed trading costs FF_{gij}^s and FD_{ij}^s. σ^s is the substitution elasticity, and $\sigma^s > 1$. $\tau_{ij}^s > 1$, which is the iceberg cost of trade. θ_{ij}^s, θFS_{ij}^s, θF_{gij}^s and θD_{ij}^s are consumer demand preference parameters.

When foreign and domestic firms located in the same region i enter the same market j, the productivity threshold for foreign firms is usually higher, $\varphi F_{gij}^{s^*} > \varphi D_{ij}^{s^*}$. That is because foreign firms face higher fixed trading costs, $FF_{gij}^{s^*} > FD_{ij}^{s^*}$, given that all other variables are at a similar level.

The productivity threshold determines the number of active firms. We assume that the total mass of potential firms in region i sector s is fixed to a number of N_i^s, and only a proportion of $1 - \mathrm{G}(\varphi_{ij}^*)$ will survive in market j. $\mathrm{G}(\varphi)$ is the cumulative distribution function for firm productivity which follows a Pareto distribution with a shape parameter γ, such that $\mathrm{G}(\varphi) = 1 - \varphi^{-\gamma}$. Then the number of foreign firms owned by region g, located in region i and supplying market j, MF_{gij}^s, is:

$$MF_{gij}^s = N_g^s \left(1 - G\left(\varphi F_{gij}^{s\ *}\right)\right) \qquad \text{Eq.(5)}$$

Trade liberalization impacts on the number of firms via changes in productivity thresholds. The RCEP will lower the productivity thresholds for exporters by reducing trade cost, t_{ij}^s, and fixed trading costs, and thus, the number of exporters will increase. This is the extensive margin of trade liberalization. When the RCEP tackles investment restrictions for MNCs from partners, the fixed trading costs of foreign firms will decrease, resulting in the reduction of productivity threshold for foreign firms. This will allow more foreign firms to invest in the free trade area.

Different from the increase in the number of exporters and foreign firms, the number of firms supplying domestic market would reduce after the formation of the RCEP. That is because increased imports will drive down revenues, and thus increase the productivity threshold for firms entering the domestic market. As a result, the least productive foreign and domestic firms will be squeezed out of market.

The changes in productivity threshold as a consequence of the formation of RCEP reflect three effects of FTA on FDI. One is the direct FDI promoting effect as the reduction of investment restrictions directly reduces the productivity threshold for foreign firms, releasing new entry of foreign investment. Another one is the negative trade substitution effect. Increased imports push up the productivity threshold for firms supplying domestic markets, driving out the least productive foreign firms. Finally, the trade increase in terms of extensive margin might result in increases in export-platform FDI or market-seeking FDI, which reflects the market expansion effect of the RCEP (Li, Scollay, & Maani, 2016).

3.3 Capital allocation

Capital allocation is an additional and distinguishing block in FDI-CGE models. This section follows the method of Petri (1997) and the FTAP model of Hanslow, Phamduc, and Verikios (2000) to deal with capital allocation. Capital is allocated to the highest return activities. We first introduce the rate of return before illustrating how capital is being allocated.

Drawn from the FTAP model, the rate of return to capital is determined by the rental price of capital and the price of investment (capital price) as expressed in the following equation:

$$R = \frac{WK}{PA} \qquad \text{Eq.(6)}$$

where R is rate of return, WK is rental price of capital and PA is capital price. Rental price, WK, is determined by the market clearance condition for capital. It varies across regions and sectors. Capital price, PA, is specific to the host region and is uniform across industries. Following the assumption of Petri (1997) that each unit of investment provides a return of $1, the inverse of the rate of return is the price of the asset, $1/R$. Asset price is the channel through which the rate of return enters the system of capital allocation.

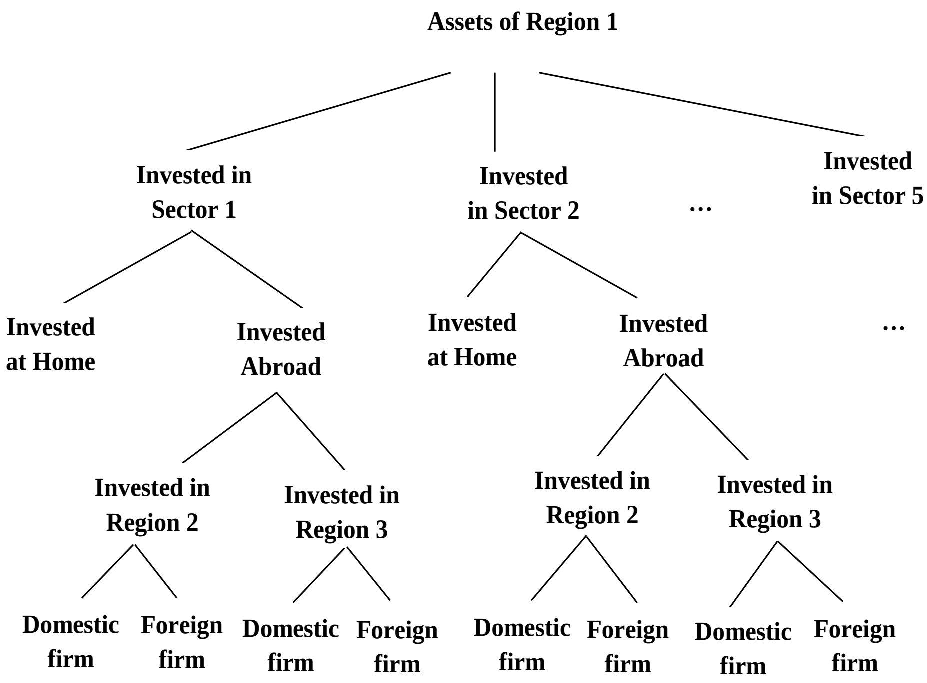

Figure 1 Capital allocation structure.

Following the rule of chasing the highest return activities, capital is allocated to different sectors, regions, and firms according to Figure 1. The top layer determines the allocation of regional assets across production sectors. The choice of sector is relatively early in the nesting structure, so that the implied elasticity guiding the choice of sector, holding only total wealth constant, is relatively low. The relatively low transformation elasticity of capital across sectors captures the idea that knowledge capital will often be sector-specific (Markusen, 2002). The next layer allocates regional assets between domestic and foreign investment (FDI) by sector and then, foreign investments are allocated to specific host regions. This level determines bilateral FDI flow between regions, the change of which reflects the main result we are looking for. Finally, FDI in each host region is allocated between domestic and foreign firms. Each of these branches uses a CET (Constant Elasticity of Transformation)-based allocation function except the final layer. In the final layer, FDI is distributed to domestic firms and foreign firms following a Leontief technology.[8]

In the layers with CET-based allocation functions, the investor is assumed to derive benefits from investments as given by a utility function. The following equations show the utility maximizing problem in the top layer:

$$\max_{AK_g^s} U = \left(\sum_s \alpha a_g^{s\,\frac{1}{\sigma_1^a}} AK_g^{s\,\frac{\sigma_1^a-1}{\sigma_1^a}}\right)^{\frac{\sigma_1^a}{\sigma_1^a-1}}$$

$$S.T \sum_s \left(AK_g^s \frac{1}{RK_g^s}\right) = W_g$$

where AK_g^s is the physical asset allocated to sector s region g and $\frac{1}{RK_g^s}$ is the price of the asset, with RK_g^s as rate of return. $AK_g^s \frac{1}{RK_g^s}$ is the value of the asset. The total value of assets across sectors is the wealth of region g, W_g. The total wealth of each region is exogenous. Thus, total asset value is a constraint, within which the rate of return is contained. In this way, the rate of return enters the system to determine capital allocation. αa_g^s is the share parameter for assets in sector s region g. σ_1^a is the transformation elasticity of assets among sectors. Following the FTAP model, it is set to 1.2. In the next two CET layers of Figure 1, transformation elasticities are set to 1.3 and 1.4 respectively.

3.4 Demand, Production and Closure

3.4.1 Demand

In each region, the representative consumer receives income from the supply of

[8] The reason for adopting a Leontief function in the final layer is because of data issues. In some cases, there is no FDI being distributed to domestic firms. The existence of zero values makes it difficult to adopt a CET format.

production factors to and profit dividends from firms. In sectors with heterogeneous firms, factors are used for fixed trading costs in addition to value-added costs. Thus, the income from supplying factors equals the total of value-added costs and fixed trading costs attributed to factors. Except for income from factors, households receive transferred profits from firms. Domestic firms transfer all profits to the local households, while foreign firms split profits between home and host households. The split of profits for foreign firms' is based on an assumption that foreign firms distribute part of firm equity to employees (labor) who are citizens of the host region, and thus, part of foreign firms' profits are allocated to households of the host region. The split of profits between host and home households is done according to the shares of labor and capital in total factor inputs. Hence, households collect domestic firms' profits, profits of inward foreign firms attributed to local labor and profits of outward foreign firms attributed to capital inputs.

Consumers allocate their disposable income among the consumer goods and saving using the extended linear expenditure system (ELES), which is derived from maximizing a Stone-Geary utility function. The consumption/saving decision is completely static. Following the Zhai model, saving enters the utility function as a "good" and its price is set to be equal to the average price of consumer goods. Investment demand and government consumption are exogenous, the values of which are fixed to their initial values in the SAM table. In each sector a composite good is used for household consumption, investment, government consumption and intermediate input. In sector $s1$, the transport sector, there is an additional demand from an international transportation pool.[9] The demand from the international transportation pool is exogenous in this model.

In each region, the composite good for consumption is aggregated by following the demand system in Figure 2. Each layer of the system follows a Constant Elasticity Substitution (CES) format. In the top layer,

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[9] International transportation pool is a term from the GTAP model, which represents a sector that supplies international transportation services that account for the transportation costs in import price. The supply of these services is provided by individual regional economies, which export them to the global transport sector.

$$Q_j^s = [\sum_i \theta_{ij}^{s\frac{1}{\sigma^s}} Z_{ij}^{s\frac{\sigma^s - 1}{\sigma^s}}]^{\frac{\sigma^s}{\sigma^s - 1}} \qquad \text{Eq.(7)}$$

Q_j^s is the demand in region j for commodity s, which is an aggregate of commodities sourced from each of the three regions (China, Partner, ROW). Z_{ij}^s is the demand of region j for commodities produced in region i. θ_{ij}^s is the Armington preference parameter reflecting the preference of consumers for home and imported products, and σ^s is the constant elasticity of substitution among different products ($\sigma^s > 1$). Sourcing demand to the origin is a distinguishing feature of monopolistically competitive models, which differs from the Armington approach that differentiates commodities 'at the border' into imported and domestically produced commodities (Akgul, Villoria, & Hertel, 2014; Swaminathan & Hertel, 1996).[10]

The second layer allocates the demand for commodities produced in each region to domestic firms and foreign firms. Each type of firm supplies different products with distinct prices. In the final layer, foreign firms are differentiated by ownership. The demand system indicates that in the FHFDI model, varieties are characterized by firm-type product differentiation with national differences.[11]

From the demand system we can see that foreign firms export to other regions at the same time of supplying the local market. Thus, trade liberalization between member countries will facilitate the export of foreign firms. Export expansion correlates with production expansion and increased demand for foreign investment. The FDI increase as a result of export expansion reflects the positive market expansion effect of FTA on FDI, which is captured by the FHFDI model (Li et al., 2016).

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[10] Sourcing imports reflects the assumption of a monopolistically competitive model that products are different.

[11] The sectoral demand for each firm type has not been allocated to individual firms. Within each firm type, individual firms face the same price under the assumption of 'large-group monopolistic competition'. Individual firms believe they are too small to influence the composite price of their group. Thus, allocating demand to individual firms does not have many implications.

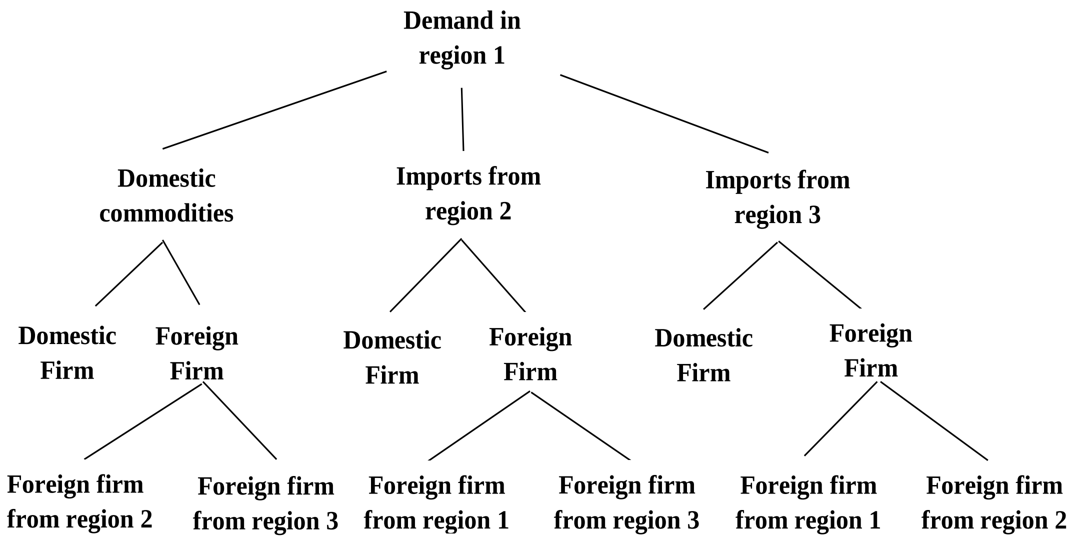

Figure 2 Sectoral demand system in a region.

In the demand system, there are two types of behavioral parameters. One is the preference parameters θ and the other is the substitution elasticity σ^s. For the preference parameters, the Melitz model sets them to 1 to isolate the effect of fixed costs in trade determination, which is different from the assumption of the Armington model that the taste bias of consumers is an important determinant of trade patterns. The FHFDI model follows the Melitz theory to emphasize the importance of fixed trading costs, but it also captures consumer preferences. The preference parameters are calibrated from the real data, which are not equal to 1, but less than 1. That is, the trade data show that there is a taste bias of consumers.

For the elasticity of substitution among varieties, we choose the same elasticity for all layers in the demand system. That is to facilitate the model calibration. Choosing the same elasticity for all layers is not new to our model. In his modeling of foreign firms, Tarr (2012) has set the same elasticity of substitution for varieties from different sources and varieties from different firms. Tarr states that when the elasticities of substitution are equal at all levels, the CES function reduces to strictly firm-level product differentiation. In the FHFDI model, firm-level product differentiation has incorporated national differences.[12] That is because in each sector, firms are distinguished from each

12 Differently, in the Tarr model, the final good sector is completely indifferent between a domestic or foreign variety. This is drawn from the assumption that foreign varieties have identical cost structures and the demand for all foreign varieties is identical, which implies that foreign firms are indifferent to each other. Similarly, domestic firms are indifferent too. Firm-level product difference substitutes national difference.

other by ownership, production region and market, and the differentiation of production region is identical to the differentiation of the nationality of variety.[13]

3.4.2 Production

In the FHFDI model, the aggregation of factors and intermediates follows the production tree of Figure 3. The top level output is a CES aggregate of value added and intermediate inputs. The top level unit cost is dual to the CES aggregation function and it defines the marginal cost of sectoral output. In the second layer, value added is a CES aggregate of primary inputs while aggregate intermediate demand is split into each commodity according to the Leontief technology. Land is a specific factor for the agriculture sector. In manufacturing and services sectors, firms use labor and capital as primary factors. Labor inputs for foreign firms are sourced from the host region. Capital inputs for foreign firms are sourced from the home region. Capital inputs of domestic firms are sourced from both home and foreign regions due to the existence of joint ventures. Capital input is first decomposed into domestic capital and FDI following a CES technology, and then the FDI input of domestic firms is decomposed into different sources following a Leontief technology.[14]

Total sectoral output is made up of the sectoral output of foreign firms and the sectoral output of domestic firms. The sectoral output of foreign firms is determined by the industrial aggregate productivity of foreign firms and the aggregates of factor and intermediate inputs, while domestic firms follow a similar way. As mentioned in Section 3.2, industrial aggregate productivity is a function of the productivity threshold as follows:

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13 By choosing the same elasticity of substitution for all layers, the FHFDI model avoids the contrast between the Petri model (Petri, 1997) and the FTAP model in terms of commodity substitution. The elasticity of substitution among commodities produced by the same firm from different locations is the same as that of commodities produced in the same location by firms with different nationality.

14 Leontief technology is chosen to allocate FDI being used by domestic firms to different sources because of zero FDI data. According to the SAM table, FDI from some sources are exhausted by foreign firms and no FDI is left for domestic firms. The existence of zero values makes it hard to adopt a CET technology. Adopting the Leontief technology infers that the cells with zero values in the SAM table will be always zero.

$$\widetilde{\varphi F_{gij}^{s}} = \varphi F_{gij}^{s*} (\frac{\gamma^s}{\gamma^s - \sigma^s + 1})^{1/(\sigma^s - 1)} \qquad \text{Eq.(8)}$$

The intermediate inputs are sources from domestic commodities and imports, and thus, trade liberalization will reduce the costs of intermediate goods. For the pro-fragmentation sector m1, which relies more heavily on imported intermediate goods (43% of total intermediate inputs are imported), the formation of RCEP tends to reduce its production costs remarkably. The gain in efficiency in sector m1 will further promote production fragmentation among RCEP member countries, which will lead to more vertical FDI. This is the vertical fragmentation effect of FTA on FDI as stated in Li et al. (2016).

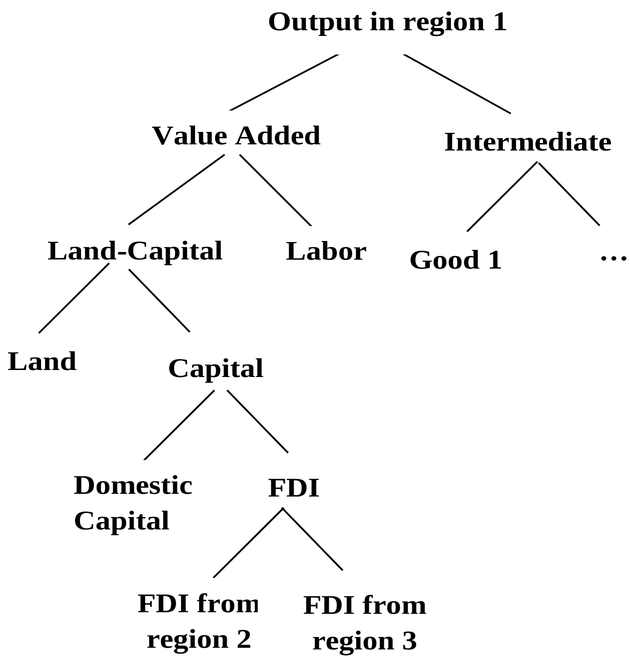

Figure 3 Production tree in a sector.

3.4.3 Closure

The closure of FHFDI comprises the market clearance of commodities and factors, government balance, current-account balance, and investment-saving balance, etc. The market clearance of commodities is specific to domestic and foreign firms. That is, there is a market clearance for commodities produced by domestic firms and a market clearance for foreign firms. The market clearances for two firms follow a similar structure, and here we use foreign firms as an example:

$$XF_{gij}^{s} = \begin{cases} \\ \dfrac{\tau_{ij}^{s} QF_{gij}^{s}}{\widetilde{\varphi F_{gij}^{s}}} MF_{gij}^{s}{}^{1/_{1-\sigma^{s}}}, s \neq a \end{cases} \qquad \text{Eq.(9)}$$

where XF_{gij}^{s} is the aggregate of factors and intermediates following the production tree, and the indices represent that this variable is for foreign firms from home region g operating in region i and sold to region j in sector s. For the agriculture sector, $s = a$, XF_{gij}^{s} is the output of foreign firms, but for sectors with a productivity of more than 1, the output of foreign firms equals $XF_{gij}^{s} * \widetilde{\varphi F_{gij}^{s}}$, and $\widetilde{\varphi F_{gij}^{s}}$ is the industrial average productivity of foreign firms. τ_{ij}^{s} is the iceberg cost. $\tau_{ij}^{s} > 1, i \neq j$, suggesting that if one unit is demanded in the import market, exporters need to ship τ_{ij}^{s} units. $\tau_{ij}^{s} = 0$, for $i = j$. QF_{gij}^{s} is the demand in region j for commodity s being produced by foreign firms from home region g operating in region i.

In sectors with heterogeneous firms, demand is adjusted by the Dixit-Stiglitz variety effect by following Zhai (2008). The variety effect is reflected by $MF_{gij}^{s}{}^{1/_{1-\sigma^{s}}}$, where MF_{gij}^{s} is the number of active foreign firms operating in the $\mathrm{g} - \mathrm{i} - j$ link, or the number of varieties provided by foreign firms.

In factor markets, the market clearance constraints for capital are stricter than labor and land markets. For labor and land, there is one equilibrium constraint for each market. But in capital markets, there are three equilibrium constraints, including the equilibrium for domestic capital, the equilibrium for FDI used by foreign firms and the equilibrium for FDI used by domestic firms.

Besides market clearance, FHFDI has four additional closure rules — net government balance, international transportation services balance, current-account balance, and investment-savings. In each region, the income of government comes from tariffs, which is collected from imported goods on the basis of their pre-tax value.[15] In the net

[15] In order to simplify the process of deriving the price equations and other equations relating to price, all other taxes other than tariffs are not taken into account in this study.

government balance, the net of government income less government expenditure is government saving or deficit.

The international transportation services balance requires that the total demand for international transport services in the global market equals the total supply of services from all regions. In FHFDI, the demand for international transport services is reflected by the iceberg-cost of trade. The supply of transportation services from each region is exogenous. For each region, the supply may not be equal to the demand from its imports, and the difference between supply and demand generates foreign savings from the international transportation pool. Based on the model structure, the current-account balance has three components, namely, trade balance of domestic firms' products, trade balance of foreign firms' products and international capital transaction balance.

4. Data and Calibration

The model is calibrated to the GTAP 8.0 global database.[16] The GTAP SAM table is augmented with the global data of FDI stock (home-host-sector) and foreign affiliate sales (home-host-sector) (Fukui & Lakatos, 2012; Lakatos et al., 2011). The FDI stock data enable us to split capital endowments into domestic and foreign investment, while the foreign affiliate sales data are used for the separation of foreign firms in demand and production. The detailed documentation about the construction of the SAM table is presented in the Appendix.

Table 2 reports some major parameters used in the model, most of which are drawn from Zhai (2008). In a monopoly competitive market, the markup ratios on optimal price are set equal to 25% for the manufacturing sector $m1$, 20% for the manufacturing sector $m2$, and 30% for services sectors. Given that markup ratio is equal to $\frac{\sigma}{\sigma-1}$, the elasticity of substitution among varieties, σ, is 5.0 for $m1$, 6.0 for $m2$, and 4.3 for $s1$ and $s2$. With the markup ratios and substitution elasticity, the shape parameters of the

[16] As documented on the GTAP website, the GTAP 8.0 database has some problems with tariff rates, particularly for China. The tariff rate has been fixed in a later version 8.1. However, using the GTAP 8.0 database is unlikely to cause a problem here because this study uses the GTAP SAM table only, and there is no difference between the two versions.

Pareto distribution of productivity can be calibrated based on the assumption of Zhai (2008) that the profit ratio (expressed in the shape parameter) in the total markup is estimated to be 64.5%.

The last column of Table 2 displays substitution elasticities between inputs in production. They are drawn from the value added elasticity of the GTAP model. In each sector of our model, the same substitution elasticity is applied in all layers of the production tree and the same elasticity is applied in the production activity of domestic and foreign firms.

Table 2 Major parameters in the model

Sectors	Markup Ratio	Elasticity of Substitution	Shape Parameter	Elasticity of Substitution between inputs
a				0.50
m1	25%	5.0	6.2	1.26
m2	20%	6.0	7.75	1.26
s1	30%	4.3	5.17	1.68
s2	30%	4.3	5.17	1.35

Source: Zhai (2008) and the GTAP model.

With data and key parameters, we are ready to calibrate the model. Before calibrating the most important part of the model, the productivity thresholds, we need the mass of potential firms and shares of active firms in each market. We assume the mass of potential firms, N, is proportional to sectoral output. Based on China's data of firm number and output of manufacturing and services industries, we set the ratio for the mass of potential firms to output to 0.1 in the two manufacturing sectors and 0.3 in the two services sectors.

Next, we calibrate the shares of active firms in each market based on three assumptions. First, the extensive margin takes account of 60% of the difference in export values across regions. Second, 60% of potential firms produce and sell in the domestic market. Third, 10% of potential firms invest abroad, and produce and sell in the host market. The first two assumptions follow the Zhai model and the third one is proposed by the author.

With the first assumption, we have:

$$(\frac{PD_{ij}^{ss}*QD_{ij}^{ss}}{PD_{ii}^{ss}*QD_{ii}^{ss}})^{0.6}=\frac{1-G(\varphi D_{ij}^{ss^*})}{1-G(\varphi D_{ii}^{ss^*})},\quad (\frac{PF_{gij}^{ss}*QF_{gij}^{ss}}{PF_{gii}^{ss}*QF_{gii}^{ss}})^{0.6}=\frac{1-G(\varphi F_{gij}^{ss^*})}{1-G(\varphi F_{gii}^{ss^*})} \qquad \text{Eq.(10)}$$

where ss stands for the sectors with heterogeneous firms. With the second and third assumptions, we can get the share of non-exporters within domestic and foreign firms, $1-G\left(\varphi D_{ii}^{ss^*}\right)=0.6$ and $1-G\left(\varphi F_{gii}^{ss^*}\right)=0.1$. $PD_{ij}^{ss}*QD_{ij}^{ss}$ represents exports of commodity ss from region i to region j produced by domestic firms, while $PD_{ii}^{ss}*QD_{ii}^{ss}$represents sales by domestic firms to the domestic market. Both exports and sales data are available from the SAM table. As a result, we can derive the shares of exporters to market j within domestic firms, $1-G(\varphi D_{ij}^{ss^*})$. Similarly, $PF_{gij}^{ss}*QF_{gij}^{ss}$ and $PF_{gii}^{ss}*QF_{gii}^{ss}$ represents sales of foreign firms in export market j and local market i, and we can derive the share of exporters to market j, $1-G(\varphi F_{gij}^{ss^*})$.

Since $G(\varphi)=1-\varphi^{-\gamma}$, the productivity thresholds can be derived from the share of exporters within each firm type by following:

$$\varphi D_{ij}^{ss^*}=[1-G(\varphi D_{ij}^{ss^*})]^{-\frac{1}{\gamma^{ss}}},\ \varphi F_{gij}^{ss^*}=[1-G\left(\varphi F_{gij}^{ss^*}\right)]^{-\frac{1}{\gamma^{ss}}} \qquad \text{Eq.(11)}$$

After calibrating the productivity threshold, we can calibrate the fixed trading costs of individual firms, FF_{gij}^{ss}, with given firm numbers. The calibration of fixed trading costs of foreign firms follows:

$$PF_{gij}^{ss}*QF_{gij}^{ss}=\left(1+v_j^{ss}\right)(1+t_{ij}^{ss})\sigma^{ss}\frac{\gamma^{ss}}{\gamma^{ss}-\sigma^{ss}+1}\frac{1}{1+v_j^{ss}\sigma^{ss}}MF_{gij}^{ss}FF_{gij}^{ss} \qquad \text{Eq.(12)}$$

The industry profits, ΠF_{gij}^{s}, are calibrated as:

$$\Pi F_{gij}^{s}=\frac{PF_{gij}^{s}QF_{gij}^{s}}{\left(1+v_j^{s}\right)\left(1+t_{ij}^{s}\right)}\frac{1}{\sigma^{s}}\frac{\sigma^{s}-1}{\gamma^{s}}(1+v_j^{s}\sigma^{s}) \qquad \text{Eq.(13)}$$

Although we calibrate fixed trading costs and profits, the SAM table has no corresponding data for these variables. Following the approach of Hosoe, Gasawa, and

Hashimoto (2010), the input cells in production activity accounts of the SAM table are presumed to contain fixed costs and profits. We subtracted from these input cells the amount of the fixed costs and profits in order to meet the constraint that total revenue equals the sum of total costs and profits. Fixed trading costs are subtracted from both factor and intermediate inputs according to their share in total inputs. Profits are subtracted only from factor inputs (labor and capital) because profits will be collected by factor owners, or households.

Last but not least, we need to calibrate the marginal budget and minimal consumption parameters in the household demand function since FHFDI adopts an extended linear expenditure system in determining demands. To calibrate the marginal budget, we need income elasticity of demand for each good, η_j^s, which can be drawn from the GTAP database of behavioral parameters (Table 3). Saving is regarded as a consumption good, and its income elasticity of demand is assumed to be the average of the five commodities in each region.

Table 3 Income elasticity of demand

	a	m1	m2	s1	s2	Saving
China	0.84	0.91	0.91	0.99	1.25	0.98
PTN	0.77	0.94	0.94	1.04	1.21	0.98
ROW	0.74	0.95	0.95	1.02	1.23	0.98

Note: The parameters are derived from the GTAP table of income elasticity of demand for 10 commodity aggregates by following a simple average approach.

To calibrate the marginal budget on each commodity, we also need the budget share of each commodity, which can be obtained from the SAM table. Then, the marginal budget can be derived as:

$$\beta_j^s = \frac{\eta_j^s SB_j^s}{\sum_c \eta_j^c SB_j^c + \eta_j^{sav} SB_j^{sav}}, \ \beta_j^{sav} = \frac{\eta_j^{sav} SB_j^{sav}}{\sum_c \eta_j^c SB_j^c + \eta_j^{sav} SB_j^{sav}} \qquad \text{Eq.(14)}$$

where β_j^s and β_j^{sav} are the marginal budget on commodity s and saving and SB_j^s and SB_j^{sav} are budget shares.

To calibrate the minimal household consumption on each commodity, we need another parameter, the Frisch parameter. It is defined as minus the reciprocal of the marginal utility of income, or the money flexibility. Following the GTAP model, the Frisch parameter is assumed to be the minus of the average of the substitution elasticity of variety, $Fr = -\sum_s \sigma^s/5$.

Then, we can calculate the minimal consumption as:

$$B_j^s = QH_j^s + \frac{\beta_j^s}{PQ_j^s}\frac{YH_j}{Fr},\ B_j^{sav} = HSAV_j + \frac{\beta_j^{sav}}{PQ_j^{sav}}\frac{YH_j}{Fr} \qquad \text{Eq.(15)}$$

where B_j^s and B_j^{sav} are the minimal consumption of commodity s and saving; QH_j^s and $HSAV_j$ are the consumptions in the base year; PQ_j^{sav} is the price of saving, which is defined as the average of commodity prices, and YH_j is the household income in region j.

5. Simulation

5.1 Model Test

The FHFDI model was rendered in the GAMS language. Programming a complex new model like FHFDI in GAMS is not an easy task, and errors are hard to avoid. We employ a number of strategies to prevent errors and to make them apparent. First is to replicate the initial equilibrium of the SAM table. This test is to check the correctness of the calibration process and to check the existence of a unique equilibrium in the model. The FHFDI model can pass this test by returning the initial equilibrium of the SAM table. Second is the price homogeneity test. It is a property of neoclassical models that agents respond to changes in relative prices, but not to changes in the absolute level of prices. In this test, we shock the numeraire, that is, the wage of labor, by 10%, and simulation shows that all prices and flows increased by 10% while real variables remain unchanged.

The third test examines the global balance of the database. In this test, we checked two types of balances. First is that the total output of commodities produced by each firm type (domestic firms or foreign firms) must equal the total demand. Second is that the value of outputs for each industry must equal total production costs. This test and the price homogeneity test were performed each time the model's equations or data were changed, in order to make sure that the model can always fulfil the two conditions.

5.2 Simulation Scenarios

The participants in the RCEP comprise ASEAN and its 6 dialogue partners. With the 6 dialogue partners, ASEAN has formed 5 Free Trade Agreements (FTAs), including the ASEAN-China FTA, the ASEAN-Japan FTA, the ASEAN-Korea FTA, the ASEAN-Australia-New Zealand FTA, and the ASEAN-India FTA. These FTAs have cut tariffs to a low level, and Fukunaga and Isono (2013) state that the RCEP should eliminate 95% of tariffs, otherwise it will have no effect on most of its member countries. Because our study aggregates to five commodities, it is unable to determine the 5% of products that will maintain non-zero tariffs after the formation of the RCEP. Alternatively, we assume that the RCEP will reduce tariffs on all commodities by 95%, as shown in Table 4.

For example, PTN has high tariffs on agriculture against China, at 29.6%. The RCEP will reduce it to 1.5%, which liberalizes trade significantly. In the two manufacturing sectors, PTN adopts relatively low tariff barriers against China, at 2.1% and 6.7% respectively. The tariffs will be reduced to less than 1% by the RCEP. In China, agriculture and manufacturing sector $m1$ have less than 10% tariffs against PTN before the RCEP, which is simulated to be reduced to less than 1%. Manufacturing sector $m2$ is protected by a 19% tariff against PTN. In simulation, it will be reduced to 1%.

Compared with tariff barriers, we are less certain about the possible achievements of the RCEP in NTBs. Based on NTBs in China and PTN, as shown by Table 1, we set out two scenarios to simulate the possible achievements of RCEP in NTBs:

- NTBs in China and PTN are reduced to the same target level of the average of NTBs in Japan and Korea.

- Except for sectors $s1$ and $s2$ in China, NTBs in China and PTN are reduced to the target level. Sectors $s1$ and $s2$ in China are reduced by the same margin as the corresponding sectors in PTN.

The average of NTBs in Japan and Korea has been chosen as the potential achievement of the RCEP because it represents the middle level of NTBs among RCEP member countries. With this target, the NTB reductions in most sectors of China and PTN are less than 20%, which seems to be achievable (Table 4).

However, this target seems too high for the two Chinese services sectors. NTBs in these sectors are 74.7% and 76.6%, much higher than the average of Japan and Korea (16.9% and 18.1%). This would be a big step in services liberalization for China. Thus, aside from this scenario of "big step" services liberalization, we establish another scenario of "small step" liberalization. In the "small step" scenario, China reduces NTBs in services by the same margin as PTN. That is, PTN will reduce NTBs in services by 19.5%, with the average of Japan and Korea as the goal, so China also cuts services barriers by 19.5%, reducing NTBs to 55.3% and 57.1% (Table 4).

Table 4 Simulated reductions of tariffs and NTBs in China and PTN under RCEP (%)

			Tariff Barrier			Non-tariff Barrier				
Exporter	Importer		a	m1	m2	a	m1	m2	s1	s2
CN	PTN	Initial	29.6	2.1	6.7	40.4	15.5	15.5	36.3	37.6
		Simulated	1.5	0. 1	0.3	25	3.2	3.2	16.9	18.1
PTN	CN	Initial	5.5	3.9	19	33.4	16.7	16.7	**74.7**	**76.6**
		Big Step	0.3	0.2	1	25	3.2	3.2	16.9	18.1
		Small Step	0.3	0.2	1	25	3.2	3.2	**55.3**	**57.1**

Data source: Calculation from GTAP Database and estimation of Petri et al. (2012)

Tariffs and NTBs are modelled as border barriers in FHFDI, and so reductions in tariff and NTBs will facilitate trade across borders. Trade facilitation has a positive market expansion effect on FDI by encouraging market-seeking FDI. Since services barriers are included in NTBs, and thus, services liberalization will affect FDI via the market expansion effect, or the trade effect. This treatment of services liberalization is different from literature, as the literature usually treats services liberalization as FDI liberalization, and so services liberalization has an important effect on FDI. In the

FHFDI model, services liberalization is still important given that the majority FDI flow to services sectors, but services liberalization will not directly liberalize FDI. By doing so, we separate services and FDI liberalization.

We simulate FDI liberalization by shocking fixed trading costs of foreign firms. Reductions in fixed trading costs will directly lower the productivity threshold, increasing the number of foreign firms. We experiment with a 50% reduction in fixed trading costs for firms operating in the China-PTN link, including MNCs and exporters. For exporters, the reduction in fixed trading costs also has a direct effect on the productivity threshold and firm number, bringing new varieties to foreign markets.

In total, we have four scenarios to simulate regarding the potential achievements of the RCEP:

- Scenario 1. No services liberalization. Tariff barriers on all goods are reduced by 95% by all RCEP members. NTBs on goods are reduced to the average level of Japan and Korea.
- Scenario 2. Small step services liberalization. Scenario 1 plus a small step reduction in services barriers for China. PTN reduces services barriers to the average level of Japan and Korea.
- Scenario 3. Big step services liberalization. Scenario 1 plus a big step reduction in services barriers for China. Both China and PTN reduce services barriers to the average level of Japan and Korea.
- Scenario 4. Fixed trading costs reduction. Scenario 3 plus a 50% reduction in fixed trading costs for firms operating on the China-PTN link.

From Scenario 1 to 4, the degree of liberalization under the RCEP increases gradually. Scenario 1 simulates liberalization on goods trade only. Scenarios 2 and 3 experiment with small and big steps in services liberalization of China, and Scenario 4 shocks fixed trading costs to simulate FDI liberalization as well as a reduction in behind-border barriers on trade.

6. Results

Simulation results show that the RCEP can generate FDI creation effects for members and FDI diversion effect for non-members. Similarly, the RCEP has trade creation effects and trade diversion effects. Increases in trade and FDI squeeze the domestic market of member countries, forcing the least productive firms to exit. The exit of the least productive firms improves aggregate industry productivity. Not surprisingly, the welfare of member countries will increase but non-members will be slightly hurt by the RCEP.

6.1 FDI Effects

Figure 4 shows the FDI creation and diversion effects of the RCEP. China and its RCEP partners will gain FDI after the RCEP, while ROW will lose FDI. However, FDI loss is much smaller than FDI increases in all scenarios. For instance, in Scenario 1, the total gain for China and PTN is US$3.8 billion, while the loss for ROW is US$178 million. Thus, the RCEP will boost the global economy by encouraging more foreign investment activities in the world.

The FDI effect grows with the degree of trade liberalization. As shown in Figure 4, from Scenario 1 to 4 (SN1~SN4) trade liberalization goes deeper and FDI increases grow bigger in China and PTN. In Scenario 1, China will gain US$1.6 billion in FDI, while in Scenario 4, the FDI gain is US$5.86 billion. Comparing China and PTN, we find that in SN1 and 2, FDI increases in China are less than PTN, but in SN3 and 4, China overtakes PTN, a result that is probably related to the big step services liberalization taken by China. Since services liberalization cannot directly facilitate FDI in FHFDI, the dramatic FDI increase could be explained as that a big step services liberalization significantly improves the efficiency of sector $s2$ in China, which leads to production expansion of firms using FDI as inputs. We will show the mechanisms of different scenarios affecting FDI in the following part.

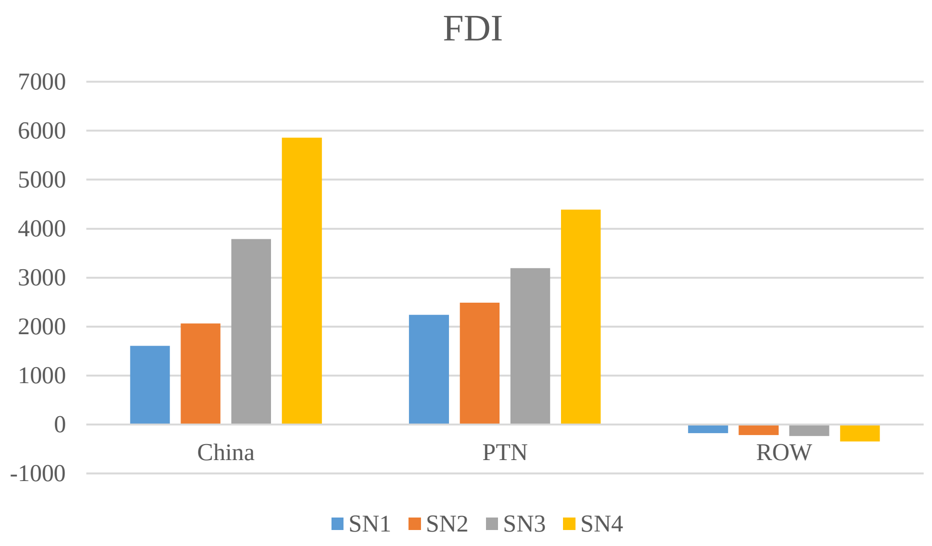

Figure 4 FDI changes, in millions US$

In the first three scenarios, there is no direct FDI liberalization, and all FDI changes should be attributed to the trade effects from the RCEP. Trade liberalization will expand exports to the partner's market on one hand and will increase competition from imports in the domestic market on the other. Sales expansion of exporters will increase FDI used by exporters, while sales contraction in the domestic market will decrease FDI used in supplying the domestic market. By using Scenario 1 as an example, Table 5 and 6 show sales and FDI changes for firms located in China by firm owner and market.

The RCEP shows a clear trade creation effect as sales of all firms from China to PTN have expanded dramatically. Comparing goods with services sectors, goods sectors increase exports more dramatically.[17] This is because Scenario 1 simulates with liberalization on trade in goods only. The trade creation effect not only exists in the PTN market, but also appears in the ROW market. Exports from China to ROW increase probably because firms in China gain international competitiveness due to the reduction in costs as a result of trade liberalization. The trade expansion in PTN and

[17] The significant export increase in agriculture from China to PTN should correlate with the big reduction in tariff barriers of PTN on agriculture imports (from 29.6% to 1.5%). Although the two manufacturing sectors have not gone through as big a tariff reduction as agriculture, exports in the two sectors show no smaller growth rates than agriculture. This could probably be explained by the fact that manufacturing sectors produce heterogeneous products while agriculture does not, and the capture of extensive margins in manufacturing leads to a relatively significant trade effect.

ROW markets corresponds to the FDI increase being used for exports (Table 6).

In the domestic market, however, sales in sectors with heterogeneous firms will drop after trade liberalization as a result of import competition. Manufacturing sectors will lose more than services, again because services in China are still protected by high barriers. Increased imports would also squeeze the agriculture market of local firms, but agriculture sales in the domestic market will not decrease as in other sectors. The main reason would be that unlike sectors with heterogeneous firms, agriculture will not suffer the exit of firms, which tends to intensify the shock to domestic sales. Along with a sales contraction in sectors with heterogeneous firms, in many cases FDI used for supplying the domestic market will decrease.

In Scenario 4, the RCEP is simulated to directly liberalize FDI between member countries by reducing fixed trading costs for MNCs. The direct FDI liberalization does not exist in the first three scenarios. Intuitively, Scenario 4 would encourage more FDI from partner countries, which matches the simulation results. Table 7 shows the Scenario 4 simulation results of FDI changes in China. The direct effect of FDI liberalization is reflected by the different performance of PTN firms from other firms in China's domestic market. Domestic and foreign firms from ROW will reduce investment in some sectors, but PTN firms increase investment in all sectors. As mentioned before, firms would reduce investment in the domestic market due to the competition from imports. Even though PTN firms also face increased competition from imports, the reduced fixed trading costs from FDI liberalization help to lower the productivity threshold for PTN MNCs entering the Chinese market.

As shown in Table 8, the productivity threshold for PTN MNCs supplying the Chinese market will increase in the first three scenarios, but will drop in Scenario 4. In the first three scenarios, the productivity thresholds increase due to a reduction in revenue in the domestic market. The reduction in revenue will also push up productivity thresholds in Scenario 4, but the upward change is overtaken by the downward force from the reduction in fixed trading costs. Hence, in Scenario 4, PTN firms will increase investment in supplying the domestic market, the same as in export markets.

Summing over firms and markets, the last row of Table 7 shows FDI changes by sector in China under Scenario 4. Sector $s2$ dominates the other four sectors by accounting for 85% of total FDI increases.[18] The substantial FDI increase in sector $s2$ reflects the close correlation between services and FDI, and the fact that services take a large share of FDI in China. However, sector $s2$ is not the one with the biggest FDI growth rate. The growth rate of sector $s2$ will be 12%, lower than the 31% growth in sector $\mathrm{m1}$. Sector $\mathrm{m1}$ represents the aggregate of machinery and electrical goods that are easy to carry on vertical fragmentation in production. The remarkable FDI growth reflects the sensitivity of sector $\mathrm{m1}$ to the RCEP. As shown in Table 7, the majority of the FDI increase in sector $\mathrm{m1}$ occurs to ROW foreign firms in China supplying the export markets of PTN and ROW. One explanation is that ROW MNCs actively participate in vertically-integrated production, which is greatly facilitated by the RCEP. Another possible explanation is that ROW firms choose to invest in China to overcome disadvantages in competition with firms inside the free trade area.

The FDI results suggest that the RCEP will encourage FDI to member countries through its trade effect and a direct FDI effect. As for the trade effect, export expansion would increase more FDI to the export sectors, while import competition will drive out the least productive firms supplying the domestic market, resulting in FDI reduction. In addition, the facilitation of trade in intermediate goods tends to promote vertical FDI. The overall effect of trade liberalization, however, is positive. The direct FDI effect from investment liberalization will evidently promote FDI from partners.

[18] The result reflects a problem about China's FDI in the FDI stock database we use. The global FDI stock database is constructed by following econometric methods based on European Commission FDI data. The database shows that FDI has been highly aggregated to services sectors. However, this is a little different from the case in China where manufacturing takes no less FDI than services. Unfortunately, there is no better replacement for the FDI stock database that is compatible with GTAP data.

Table 5 Sales changes of firms located in China by firm owner and market under Scenario 1, in millions US$ ($) and percentage (%)

Firm	**Market**	**a**		**m1**		**m2**		**s1**		**s2**	
		$	%	$	%	$	%	$	%	$	%
China firm	China	61490	6.5	-7352	-1.4	-182616	-8.3	16598	5.6	76570	3.0
China firm	PTN	53607	402.2	87151	329.9	356877	663.3	159	33.9	960	39.9
China firm	ROW	545	5.5	47592	66.3	97295	67.5	1310	40.6	4102	45.1
Foreign firm_PTN	China	26	5.3	-626	-2.4	-131	-10.5	-0.4	-0.8	-27	-4.8
Foreign firm_PTN	PTN	27	396.2	4297	325.6	195	644.7	0.02	25.9	0.2	29.3
Foreign firm_PTN	ROW	0.2	4.3	2338	64.7	51	63.4	0.2	32.1	1	34.0
Foreign firm_ROW	China	297	5.3	-7880	-3.9	-3452	-10.5	-81	-1.6	-2243	-4.8
Foreign firm_ROW	PTN	317	396.2	32688	319.1	5131	644.7	2	24.9	14	29.3
Foreign firm_ROW	ROW	3	4.3	17420	62.2	1362	63.4	18	31.1	60	34.0

Table 6 FDI changes in China by firm and market under Scenario 1, in millions US$

Firm	Market	a	m1	m2	s1	s2
China firm	China	60.6	-4.6	-74.8	0.9	2084.9
China firm	PTN	27.5	9.74	112.8	0.01	11.5
China firm	ROW	0.4	5.40	33.7	0.05	56.3
Foreign firm_PTN	China	0.16	-0.46	-0.17	0.02	0.1
Foreign firm_PTN	PTN	0.07	0.96	0.26	0	0
Foreign firm_PTN	ROW	0	0.53	0.08	0	0
Foreign firm_ROW	China	1.8	-588.8	-4.6	4.7	9.09
Foreign firm_ROW	PTN	0.8	54.3	6.9	0.1	0.05
Foreign firm_ROW	ROW	0.01	-23.1	2.1	1.04	0.25

Table 7 FDI changes in China by firm and market under Scenario 4, in millions US$

Firm	Market	a	m1	m2	s1	s2
China firm	China	157.38	-3.26	-34.61	2.13	4749
China firm	PTN	28.22	18.3	192.04	0.09	175.6
China firm	ROW	0.55	10.99	61.44	0.1	118.5
Foreign firm_PTN	China	0.41	0.155	0.043	0.054	0.238
Foreign firm_PTN	PTN	0.073	1.2	0.3	0.001	0.005
Foreign firm_PTN	ROW	0.001	1.2	0.158	0.002	0.006
Foreign firm_ROW	China	4.73	2.85	-2.1	-2.6	20.7
Foreign firm_ROW	PTN	0.848	279.7	11.8	1.913	0.766
Foreign firm_ROW	ROW	0.017	172.8	3.78	1.745	0.517
Sum		192	484	233	3.47	5065

Table 8 Productivity thresholds from PTN firms investing in and supplying China market under all scenarios

	m1	m2	s1	s2
Basic Scenario	2.167	1.916	2.574	2.344
Scenario 1	2.199	1.956	2.598	2.384
Scenario 2	2.198	1.955	2.597	2.403
Scenario 3	2.188	1.947	2.6	2.441
Scenario 4	1.855	1.706	2.14	2.015

6.2 Effects on Foreign firms

Foreign firms are important in explaining FDI changes as a result of the RCEP even though in some cases foreign firms are dominated by domestic firms in FDI utilization.

In this section, we demonstrate the effect of the RCEP on the production activities of foreign firms, with an aim to reveal factors affecting FDI changes in the black box.

Table 9 illustrates changes in the main variables of foreign firms in China under Scenario 3, that is, China is assumed to undertake a big step services liberalization.[19] The productivity threshold is one of the core variables in the FHFDI model, which selects exporters and non-exporters. Among foreign firms, non-exporters are less productive than exporters. Trade liberalization will raise the productivity threshold for non-exporters but will lower it for exporters, reducing the difference in productivity between the two groups. The industry average productivity will be raised by the FTA because the least productive firms exit. The same changes in productivity occur for domestic firms. This reflects the productivity gain for member countries from the RCEP.

Changes in the productivity threshold directly determine changes in the number of firms. The increased productivity threshold reduces the number of non-exporters, while the drop in the productivity threshold for exportation allows more foreign firms to export. The total number of foreign firms in member countries will be reduced by the RCEP.

In terms of profit, non-exporters will lose and exporters will gain. This is a straightforward indicator showing that the RCEP will benefit exporters and hurt non-exporters. However, the drop in profits does not mean each individual non-exporter will lose after the RCEP. Due to the fact that some firms exit, some surviving competitive firms could earn more profits from economies of scale. Moreover, the drop in profits for non-exporters will not pull down total profits of foreign firms as shown in Table 9.

Following the same track, in China, exporters will expand output while the production of non-exporters owned by ROW parent firms will contract. Different from ROW, PTN owned non-exporters will expand output after the RCEP. Given that the number of non-exporters decreases, the expanded output suggests that surviving firms expand their scale of production to such an extent that total output is greater than the total that was

[19] Here we show changes in foreign firms in China after the RCEP. Simulation results show that China's RCEP partners have very similar changes as China. As a result, the results for China can be used to approximate the results of the RCEP member countries.

produced before the RCEP. FDI inputs of foreign firms change in a way that is exactly the same as outputs. In total, foreign firms increase investment in China after the RCEP.

The price effect meets the expectation for the RCEP in that trade liberalization lowers prices for both domestic commodities and exports. The reduction in prices would increase consumer surplus, benefiting consumers in member countries.

In sum, the mass of foreign firms will gain from the RCEP as reflected by growing profits and expanded output. However, some of the least productive firms will be squeezed out of the Chinese market, and they represent the victims of trade liberalization. The exit of these firms helps to improve aggregate productivity, and so production activities become more efficient. Moreover, the RCEP benefits consumers by reducing prices.

Table 9 Changes in main variables of foreign firms in China under Scenario 3

(1) Productivity Threshold

Owner	Non-Exporter	Exporter	All
PTN	+	-	+
ROW	+	-	+

(2) Firm Number

Owner	Non-Exporter	Exporter	All
PTN	-	+	-
ROW	-	+	-

(3) Profit

Owner	Non-Exporter	Exporter	All
PTN	-	+	+
ROW	-	+	+

(4) Output

Owner	Non-Exporter	Exporter	All
PTN	+	+	+
ROW	-	+	+

(5) Price

Owner	Non-Exporter	Exporter
PTN	-	-
ROW	-	-

(6) FDI Inputs

Owner	Non-Exporter	Exporter	All
PTN	+	+	+
ROW	-	+	+

6.3 Welfare Effect

From the analysis outlined above about FDI and related trade, productivity, and profit changes, it is clear that member countries will gain in welfare while non-members

(ROW) will lose welfare from the RCEP (Figure 5). In all four scenarios, China and its RCEP partners will gain substantially from the RCEP, which is more than the loss of ROW. PTN will gain more than China since PTN is bigger than China in economic size, but the gap between PTN and China is narrowing from Scenario 2 to 4.

In Scenario 1, with no services liberalization, the welfare of China will increase by US$103 billion and PTN by US$196 billion. Under Scenario 2, when China and PTN are assumed to commit the same margin of services liberalization, the gains for China and PTN increase with the level of trade liberalization. The increase in PTN is more evident, suggesting services liberalization in China is important for its RCEP partners. In Scenario 3, however, the gains of PTN have not shown a clear difference from that of Scenario 2. The results indicate that the partners will gain as long as China takes action in services liberalization, but it is relatively unimportant how big the liberalization step is. In contrast, China will gain more by taking a big step services liberalization.

In Scenario 4, China and PTN will gain the most from the RCEP along with the highest level of trade liberalization. The gain for China is US$214 billion and that for PTN is US$291 billion, both of which show clear increases from Scenario 3. The results suggest that removal of behind-border barriers will benefit members greatly. Thus, measures that free foreign trade and FDI from domestic regulations are important in raising welfare, which is worth paying attention to during RCEP negotiations.

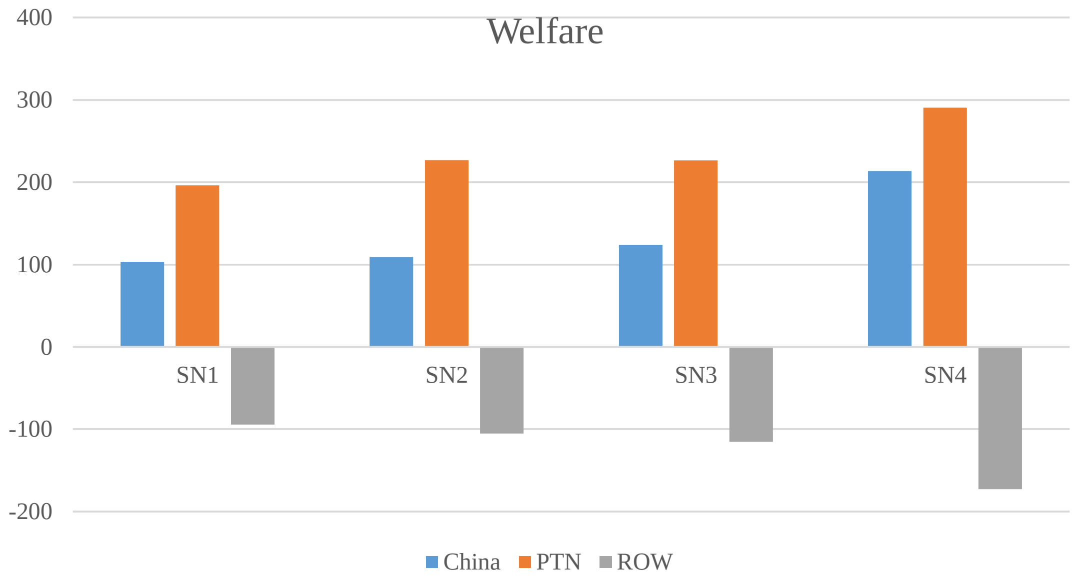

Figure 5 Welfare changes after RCEP, in billions US$

7. Conclusions

This paper investigates the potential influence of the RCEP on FDI through an applied general equilibrium model. Liberalization under the RCEP would presumably be comprised of reductions in both border barriers, such as tariffs and NTBs, as well as behind-border barriers, like discriminative treatment toward trade and investment. The firm heterogeneity theory about trade and FDI which our FHFDI model relies on allows us to simulate reductions in behind-border barriers by shocking fixed trading costs, in addition to reductions in tariffs and NTBs. The removal of investment restrictions directly frees FDI from member countries. Trade liberalization tends to positively impact on FDI by extending markets to partners' and by promoting vertical fragmentation in production processes among members. However, trade liberalization has a negative effect on FDI which is led by increased competition from imports. All these aspects can be captured by the FHFDI model. Thus, we could say that this study explores the effect of FTA on FDI in a relatively comprehensive way.

Simulation results show that the RCEP has a significant FDI creation effect on members. China will receive US$5.86 billion more FDI by joining the RCEP. Its partners will also attract more FDI. That means the creation of a large free trade area increases the attractiveness of members to foreign investment. The increase in FDI not only correlates with the entry of new foreign firms to the liberalized market, but also correlates with growing profits and outputs of foreign firms. Similar as the FDI effect, the RCEP has a trade creation effect on members and can improve their welfare.

The FDI findings suggest that our pursuing of the RCEP is worthwhile. On one hand, the RCEP will increase the attractiveness of members to FDI, suggesting that the economies of member countries will become more active and dynamic. On the other hand, the increase in the productivity thresholds for foreign firms will improve the quality of foreign investment, which coincides with China's FDI policy. The growth in high quality FDI would benefit the host country more through technology spillover and other positive spillovers.

Although the FHFDI model has innovated in several aspects and generated fruitful results, it needs further modifications in future. First, FHFDI is a comparative static model. A comparative static framework restricts the ability of FHFDI to capture capital accumulation over time. In addition, given that capital owners usually make investment decisions based on future expected returns, a dynamic model would be better in modelling FDI movements. Second, FHFDI is a relatively highly aggregated model with 3 regions, 3 factors of production, and 5 sectors. While this aggregation allows us to focus on the important policy issues related to the RCEP, it may not be able to reflect what actually happened in an exact way. Due these limitations, the FDI impacts attributed to the RCEP from FHFDI should be interpreted with caution and not as predictions.

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Appendices

A. The SAM table

The SAM table used for simulation with the FHFDI model is based on the GTAP data. The FHFDI model separates foreign firms and defines market-specific outputs for each firm type. To be consistent with the FHFDI model, we first split the total outputs in the GTAP data into outputs of domestic firms and foreign firms. The outputs of foreign firms are specific to home regions, which are drawn from the three-dimension global foreign affiliate sales database (home-host-sector). Second, the outputs are further allocated into three markets as both foreign and domestic firms can supply all three regions of the world. The allocation of outputs to the three markets is based on the share of each market in total sales drawn from the GTAP data. Therefore, in a region, the production activity accounts are extended from 5 accounts (5 sectors) to 45 accounts (3 firms × 3 markets × 5 sectors).

Based on sectoral input-output ratios in the GTAP data, the inputs of intermediate goods and factors are split across production activity accounts. We adjust the capital-output ratios for foreign firms based on survey data from US majority-owned nonbank foreign affiliates in 2007 (Barefoot & Jr., 2009). The data show that the capital-output ratio of US foreign affiliates is 5% on average, much lower than the GTAP ratio (19%). Because there are no sectoral capital data in the survey, the 5% average ratio is adjusted according to the GTAP sectoral ratios in order to obtain sectoral capital-output ratios for foreign firms. With the sectoral capital-output ratios, the capital inputs of foreign firms in each sector can be calculated. The calculated capital inputs might be higher than the FDI from the home region as given by the global FDI stock database (home-host-sector). In that case, the FDI stock data substitute the calculated capital inputs. The calculated capital becomes real inputs when the calculated capital inputs are lower than the FDI stock data. In this case, the excess FDI that cannot be exhausted by foreign firms is allocated to domestic firms. The labor-output ratio is raised for foreign firms to a level such that the SAM table is balanced.

In terms of supply, we separate sales into three markets in order to be consistent with the production activity accounts. Then, the sales to domestic markets are aggregated with imports from different regions and produced by different firms to compose domestic demand. There are 5 demand accounts and 30 export accounts (2 export markets × 3 regions-owned firms × 5 sectors).

The last adjustment to the GTAP data is for intra-regional trade. Since the FHFDI model does not differentiate between domestic commodities and intra-regional imports, we convert the intra-regional exports to domestic commodities. In sum, the SAM table has 152 accounts for each economy, which are more than three times those in the GTAP data (50 accounts).

B. Equations and Variables

Equation Expression.

Variables are in capital letters. D and F are used to indicate domestic and foreign firms. A parenthesis after a variable or parameter containing letters like i, j, s, c indicates regions and sectors. Regions are denoted with i, j and g. Sector and commodity are denoted with s, ss, c and a, with a for agriculture particularly and ss for sectors with heterogeneous firms. In contexts where two regional indicators are required, the first refers to the origin of a trade flow or investment and the second to the destination (or host). In contexts where three regional indicators are required, the first refers to the home region of foreign firms, the second to the host region, and the third to the destination of a trade flow from foreign firms, i.e.:

$XF(g, i, j, s)$ Output of foreign firms in sector s, sourced capital from home region g, produced in host region i, sold to the market j

In contexts where two commodity indicators are used, the first refers to the producing industry of a commodity and the second to the consuming industry, i.e.:

$INTCF(c, g, i, j, s)$ Intermediate input of commodity c in production of s of foreign firm sourced capital from region g, operating in i and exporting to j

At the end of each function, the perpendicular symbol '⊥' shows the corresponding relationships between variables and equations.

B.1. Capital Allocation

$$A(g) = (\sum_{s} \alpha a(g,s)^{\frac{1}{\sigma 1}} AK(g,s)^{\frac{\sigma 1-1}{\sigma 1}})^{\frac{\sigma 1}{\sigma 1-1}} \quad \perp AK(g,s) \ (1)$$

$$\sum_{s} AK(g,s) * \frac{1}{RK(g,s)} = \overline{W(g)} \quad \perp AK(g,s) \ (2)$$

$$\frac{AK(g,s)}{A(g)} = \alpha a(g,s)\left(\frac{RK(g,s)}{R(g)}\right)^{\sigma 1}, s \neq a \quad \perp AK(g,s) \ (3)$$ [1]

$$AK(g,s) = [\alpha D(g,s)^{\frac{1}{\sigma 2}} AD(g,s)^{\frac{\sigma 2-1}{\sigma 2}} + \alpha F(g,s)^{\frac{1}{\sigma 2}} AF(g,s)^{\frac{\sigma 2-1}{\sigma 2}}]^{\frac{\sigma 2}{\sigma 2-1}} \quad \perp AD(g,s) \ (4)$$

$$\frac{AD(g,s)}{AF(g,s)} = \frac{\alpha d(g,s)}{\alpha f(g,s)}(\frac{RD(g,s)}{RF(g,s)})^{\sigma 2} \quad \perp AF(g,s) \ (5)$$

$$AD(g,s)\frac{1}{RD(g,s)} + AF(g,s)\frac{1}{RF(g,s)} = AK(g,s)\frac{1}{RK(g,s)} \quad \perp RK(g,s) \ (6)$$

$$AF(g,s) = (\sum_{i} \alpha f di(g,i,s)^{\frac{1}{\sigma 3}} AFDI(g,i,s)^{\frac{\sigma 3-1}{\sigma 3}})^{\frac{\sigma 3}{\sigma 3-1}}, g \neq i \quad \perp AFDI(g,i,s) \ (7)$$

$$\frac{AFDI(g,i,s)}{AFDI(g,h,s)} = \frac{\alpha f di(g,i,s)}{\alpha f di(g,h,s)}(\frac{RFDI(g,i,s)}{RFDI(g,h,s)})^{\sigma 3}, g \neq i \neq h \quad \perp AFDI(g,i,s) \ (8)$$

$$\sum_{i} AFDI(g,i,s)\frac{1}{RFDI(g,i,s)} = AF(g,s)\frac{1}{RF(g,s)}, g \neq i \quad \perp RF(g,s) \ (9)$$

$$AFDID(g,i,s) = \alpha N(g,i,s) AFDI(g,i,s), g \neq i \quad \perp AFDID(g,i,s) \ (10)$$

$$AFDIF(g,i,s) = \alpha FA(g,i,s) AFDI(g,i,s), g \neq i \quad \perp AFDIF(g,i,s) \ (11)$$

$$AFDID(g,i,s)\frac{1}{RFDID(g,i,s)} + AFDIF(g,i,s)\frac{1}{RFDIF(g,i,s)} = AFDI(g,i,s)\frac{1}{RFDI(g,i,s)}, g \neq i \quad \perp RFDI(g,i,s) \ (12)$$

[1] This equation sets $s \neq a$ in order to equalize the number of equation with the number of variables. With $s \neq a$, the equation group (3) has 12 equations (3 regions × 4 sectors). Together with the 3 equations in (1), there are 15 equations which correspond to 15 variables of $AK(g,s)$.

$$RFDID(g,i,s) = \frac{WFDID(g,i,s)}{PA(i)}, g \neq i \qquad \perp RFDID(g,i,s) \; (13)$$

$$RFDIF(g,i,s) = \frac{WFDIF(g,i,s)}{PA(i)}, g \neq i \qquad \perp RFDIF(g,i,s) \; (14)$$

$$RD(g,s) = \frac{WDK(g,s)}{PA(g)} \qquad \perp RD(g,i,s) \; (15)$$

$$PA(i) = \frac{EINV(i)}{\sum_s \overline{QINV(j,s)}} \qquad \perp PA(i) \; (16)$$

$$AFDID(g,i,s) = QFDID(g,i,s) * PA(i), g \neq i \qquad \perp AFDID(g,i,s) \; (17)$$

$$AFDIF(g,i,s) = QFDIF(g,i,s) * PA(i), g \neq i \qquad \perp AFDIF(g,i,s) \; (18)$$

$$AD(g,s) = QDK(g,s) * PA(g) \qquad \perp AD(g,s) \; (19)$$

$$QFDID(g,i,s) = \sum_j QFDIDJ(g,i,j,s)\,, g \neq i \qquad \perp QFDID(g,i,s) \; (20)$$

$$QFDIF(g,i,s) = \sum_j QFDIFJ(g,i,j,s)\,, g \neq i \qquad \perp QFDIF(g,i,s) \; (21)$$

$$QDK(i,s) = \sum_j QDKJ(i,j,s) \qquad \perp QDK(i,s) \; (22)$$

B.2. Production

B.2.1. Domestic Firm

$$\Pi D(i,j,ss) = \frac{PD(i,j,ss)QD(i,j,ss)}{(1+t(i,j,ss))} \frac{1+v(i,j,ss)\sigma(ss)}{\sigma(ss)} \frac{\sigma(ss)-1}{\gamma(ss)(1+v(i,j,ss))} \qquad \perp \Pi D(i,j,ss) \; (23)$$

$$\Pi F(g,i,j,ss) = \frac{PF(g,i,j,ss)QF(g,i,j,ss)}{(1+t(i,j,ss))} \frac{1+v(i,j,ss)\sigma(ss)}{\sigma(ss)} \frac{\sigma(ss)-1}{\gamma(ss)(1+v(i,j,ss))} \qquad \perp \Pi F(g,i,j,ss) \; (24)$$

$i \neq g$

$$PD(i,j,ss) = \left(1 + v(j,ss)\right)\frac{\sigma(ss)}{\sigma(ss)-1}\frac{\left(1+t(i,j,ss)\right)\tau(i,j,ss)CD(i,j,ss)}{\widetilde{\varphi D}(i,j,ss)}[\overline{N(\imath,ss)}(1 - G(\varphi D(i,j,ss)^{*}))]^{1/_{1-\sigma(ss)}} \quad \perp XD(i,j,ss) \quad (25)$$ [2]

$$PD(i,j,a) = \left(1+t(i,j,a)\right)\tau(i,j,a)CD(i,j,a) \quad \perp XD(i,j,a) \quad (26)$$

$$\widetilde{\varphi D}(i,j,ss) = \varphi D^{*}(i,j,ss)\left(\frac{\gamma(ss)}{\gamma(ss)-\sigma(ss)+1}\right)^{1/_{\sigma(ss)-1}} \quad \perp \widetilde{\varphi D}(i,j,ss) \quad (27)$$

$$\varphi D^{*}(i,j,ss) = \frac{\tau(i,j,ss)CD(i,j,ss)}{\sigma(ss)-1} * \left(\frac{PQ(j,ss)}{\sigma(ss)\left(1+v(i,j,ss)\right)\left(1+t(i,j,ss)\right)}\right)^{\frac{\sigma(ss)}{1-\sigma(ss)}} * \left(\frac{\overline{FD(\imath,\jmath,ss)}}{Q(j,ss)[1+v(i,j,ss)\sigma(ss)]\theta(i,j,ss)\theta D(i,j,ss)}\right)^{1/_{\sigma(ss)-1}} \quad \perp \varphi D^{*}(i,j,ss) \quad (28)$$

$$XD(i,j,s) = \omega D(i,j,s)\,[\delta 1(i,j,s)^{1/_{\sigma'(s)}} * VAD(i,j,s)^{\sigma'(s)-1/_{\sigma'(s)}} + \delta 2(i,j,s)^{1/_{\sigma'(s)}} * INTD(i,j,s)^{\sigma'(s)-1/_{\sigma'(s)}}]^{\sigma'(s)/_{\sigma'(s)-1}} \quad \perp VAD(i,j,s) \quad (29)$$

$$\frac{PVAD(i,j,s)}{PINTD(i,j,s)} = \left(\frac{\delta 1(i,j,s)}{\delta 2(i,j,s)}\frac{INTD(i,j,s)}{VAD(i,j,s)}\right)^{1/_{\sigma'(s)}} \quad \perp INTD(i,j,s) \quad (30)$$

$$CD(i,j,s) = \frac{1}{\omega D(i,j,s)}\left(\delta 1(i,j,s)PVAD(i,j,s)^{1-\sigma'(s)} + \delta 2(i,j,s)PINTD(i,j,s)^{1-\sigma'(s)}\right)^{1/_{1-\sigma'(s)}} \quad \perp CD(i,j,s) \quad (31)$$

$$INTCD(c,i,j,s) = \alpha cs(c,i,j,s)INTD(i,j,s) \quad \perp INTCD(c,i,j,s) \quad (32)$$

$$PINTD(i,j,s) = \sum_{c}\alpha cs(c,i,j,s)PQ(i,c) \quad \perp PINTD(i,j,s) \quad (33)$$

---

[2] $1 - G(\varphi) = \varphi^{-\gamma}$

$$VAD(i,j,ss)$$

$$= \omega VAD(i,j,ss)[\delta va1(i,j,ss)^{1/\sigma'(ss)} LD(i,j,ss)^{\sigma'(ss)-1/\sigma'(ss)} \qquad \perp LD(i,j,ss) \qquad (34)$$

$$+ \delta va2(i,j,ss)^{1/\sigma'(ss)} * KD(i,j,ss)^{\sigma'(ss)-1/\sigma'(ss)}]^{\sigma'(ss)/\sigma'(ss)-1}$$

$$\frac{WL(i)}{WKD(i,j,ss)} = (\frac{\delta va1(i,j,ss)}{\delta va2(i,j,ss)} \frac{KD(i,j,ss)}{LD(i,j,ss)})^{1/\sigma'(ss)} \qquad \perp KD(i,j,ss) \qquad (35)$$

$$PVAD(i,j,ss) = \frac{1}{\omega VAD(i,j,ss)} [\delta va1(i,j,ss)\big(WL(i)\big)^{1-\sigma'(ss)} \qquad \perp PVAD(i,j,ss) \qquad (36)$$

$$+ \delta va2(i,j,ss) WKD(i,j,ss)^{1-\sigma'(ss)}]^{1/1-\sigma'(ss)}$$

$$VAD(i,j,a)$$

$$= \omega VAD(i,j,a)\Big[\delta va1(i,j,a)^{1/\sigma'(a)} LD(i,j,a)^{\sigma'(a)-1/\sigma'(a)} \qquad \perp LD(i,j,a) \qquad (37)$$

$$+ \delta va2(i,j,a)^{1/\sigma'(a)} * LKD(i,j,a)^{\sigma'(a)-1/\sigma'(a)}\Big]^{\sigma'(a)/\sigma'(a)-1}$$

$$\frac{WL(i)}{PLKD(i,j,a)} = (\frac{\delta va1(i,j,a)}{\delta va2(i,j,a)} \frac{LKD(i,j,a)}{LD(i,j,a)})^{1/\sigma'(a)} \qquad \perp LKD(i,j,a) \qquad (38)$$

$$PVAD(i,j,a) = \frac{1}{\omega VAD(i,j,a)} [\delta va1(i,j,a) WL(i)^{1-\sigma'(a)} \qquad \perp PVAD(i,j,a) \qquad (39)$$

$$+ \delta va2(i,j,a) PLKD(i,j,a)^{1-\sigma'(a)}]^{1/1-\sigma'(a)}$$

$$LKD(i,j,a)$$

$$= \omega LKD(i,j,a)\Big[\delta lk1(i,j,a)^{1/\sigma'(a)} LND(i,j,a)^{\sigma'(a)-1/\sigma'(a)} \qquad \perp LND(i,j,a) \qquad (40)$$

$$+ \delta lk2(i,j,a)^{1/\sigma'(a)} KD(i,j,a)^{\sigma'(a)-1/\sigma'(a)}\Big]^{\sigma'(a)/\sigma'(a)-1}$$

$$\frac{WLAN(i)}{WKD(i,j,a)} = (\frac{\delta lk1(i,j,a)}{\delta lk2(i,j,a)} \frac{KD(i,j,a)}{LND(i,j,a)})^{1/\sigma'(a)} \qquad \perp KD(i,j,a) \qquad (41)$$

$$PLKD(i,j,a) = \frac{1}{\omega LKD(i,j,a)} [\delta lk1(i,j,a) WLAN(i)^{1-\sigma'(a)} \qquad \perp PLKD(i,j,a) \qquad (42)$$

$$+ \delta lk2(i,j,a) WKD(i,j,a)^{1-\sigma'(a)}]^{1/1-\sigma'(a)}$$

$$KD(i,j,s) = \omega KD(i,j,s)\left[\delta k1(i,j,s)^{1/\sigma\prime(s)} QDKJ(i,j,s)^{\sigma\prime(s)-1/\sigma\prime(s)} + \delta k2(i,j,s)^{1/\sigma\prime(s)} QFKD(i,j,s)^{\sigma\prime(s)-1/\sigma\prime(s)}\right]^{\sigma\prime(s)/\sigma\prime(s)-1} \quad \perp QDKJ(i,j,s) \quad (43)$$

$$\frac{WDK(i,s)}{WFKD(i,j,s)} = \left(\frac{\delta k1(i,j,s)}{\delta k2(i,j,s)}\frac{QFKD(i,j,s)}{QDKJ(i,j,s)}\right)^{1/\sigma\prime(s)} \quad \perp QFKD(i,j,s) \quad (44)$$

$$WKD(i,j,s) = \frac{1}{\omega KD(i,j,s)}[\delta k1(i,j,s) WDK(i,s)^{1-\sigma'(s)} + \delta k2(i,j,s) WFKD(i,j,s)^{1-\sigma'(s)}]^{1/1-\sigma\prime(s)} \quad \perp WKD(i,j,s) \quad (45)$$

$$QFDIDJ(g,i,j,s) = \delta fk(g,i,j,s) QFKD(i,j,s), g \neq i \quad \perp QFDIDJ(g,i,j,s) \quad (46)$$

$$WFKD(i,j,s) = \sum_g \delta fk(g,i,j,s) WFDID(g,i,s), g \neq i \quad \perp WFKD(i,j,s) \quad (47)$$

B.2.2. Foreign Firms

$$PF(g,i,j,ss) = \left(1 + v(i,j,ss)\right)\frac{\sigma(ss)}{\sigma(ss)-1}\frac{(1+t(i,j,ss))\tau(i,j,ss)CF(g,i,j,ss)}{\widetilde{\varphi F}(g,i,j,ss)}[\overline{N(g,ss)}(1 - G(\varphi F(g,i,j,ss)^*))]^{1/1-\sigma(ss)} \quad \perp XF(g,i,j,ss) \quad (48)$$

$$PF(g,i,j,a) = \left(1 + t(i,j,a)\right)\tau(i,j,a)CF(g,i,j,a) \quad \perp XF(g,i,j,a) \quad (49)$$

$$\widetilde{\varphi F}(g,i,j,ss) = \varphi F^*(g,i,j,ss)\left(\frac{\gamma(ss)}{\gamma(ss)-\sigma(ss)+1}\right)^{1/\sigma(ss)-1} \quad \perp \widetilde{\varphi F}(g,i,j,ss) \quad (50)$$

$$\varphi F^*(g,i,j,ss) = \frac{\tau(i,j,ss)CF(g,i,j,ss)}{\sigma(ss)-1} * \left(\frac{PQ(j,ss)}{\sigma(ss)\left(1+v(i,j,ss)\right)\left(1+t(i,j,ss)\right)}\right)^{\frac{\sigma(ss)}{1-\sigma(ss)}} * \left(\frac{\overline{FF(g,\iota,\jmath,ss)}}{Q(j,ss)\left(1+v(i,j,ss)\sigma(ss)\right)\theta(i,j,ss)\theta FS(i,j,ss)\theta F(g,i,j,ss)}\right)^{1/\sigma(ss)} \quad \perp \varphi F^*(g,i,j,ss) \quad (51)$$

$$XF(g,i,j,s) = \omega F(g,i,j,s)\,[\delta F1(g,i,j,s)^{1/\sigma'(s)}\,VAF(g,i,j,s)^{\sigma'(s)-1/\sigma'(s)} + \delta F2(g,i,j,s)^{1/\sigma'(s)} * INTF(g,i,j,s)^{\sigma'(s)-1/\sigma'(s)}]^{\sigma'(s)/\sigma'(s)-1} \qquad \perp VAF(g,i,j,s) \quad (52)$$

$$\frac{PVAF(g,i,j,s)}{PINTF(g,i,j,s)} = \left(\frac{\delta F1(g,i,j,s)}{\delta F2(g,i,j,s)}\frac{INTF(g,i,j,s)}{VAF(g,i,j,s)}\right)^{1/\sigma'(s)} \qquad \perp INTF(g,i,j,s) \quad (53)$$

$$CF(g,i,j,s) = \frac{1}{\omega F(g,i,j,s)}\left(\delta F1(g,i,j,s)PVAF(g,i,j,s)^{1-\sigma'(s)} + \delta F2(g,i,j,s)PINTF(g,i,j,s)^{1-\sigma'(s)}\right)^{1/1-\sigma'(s)} \qquad \perp CF(g,i,j,s) \quad (54)$$

$$INTCF(c,g,i,j,s) = \alpha csf(c,g,i,j,s)INTF(g,i,j,s) \qquad \perp INTCF(c,g,i,j,s) \quad (55)$$

$$PINTF(g,i,j,s) = \sum_{c} \alpha csf(c,g,i,j,s)PQ(i,c) \qquad \perp PINTF(g,i,j,s) \quad (56)$$

$$VAF(g,i,j,ss) = \omega VAF(g,i,j,ss)[\delta vaF1(g,i,j,ss)^{1/\sigma'(ss)}LF(g,i,j,ss)^{\sigma'(ss)-1/\sigma'(ss)} + \delta vaF2(g,i,j,ss)^{1/\sigma'(ss)}QFDIFJ(g,i,j,ss)^{\sigma'(ss)-1/\sigma'(ss)}]^{\sigma'(ss)/\sigma'(ss)-1} \qquad \perp LF(g,i,j,ss) \quad (57)$$

$$\frac{WL(i)}{WFDIF(g,i,s)} = \left(\frac{\delta vaF1(g,i,j,ss)}{\delta vaF2(g,i,j,ss)}\frac{QFDIFJ(g,i,j,ss)}{LF(g,i,j,ss)}\right)^{1/\sigma'(ss)} \qquad \perp QFDIFJ(g,i,j,ss) \quad (58)$$

$$PVAF(g,i,j,ss) = \frac{1}{\omega VAF(g,i,j,ss)}[\delta vaF1(g,i,j,ss)WL(i)^{1-\sigma'(ss)} + \delta vaF2(g,i,j,ss) * WFDIF(g,i,ss)^{1-\sigma'(ss)}]^{1/1-\sigma'(ss)} \qquad \perp PVAF(g,i,j,ss) \quad (59)$$

$$VAF(g,i,j,a) = \omega VAF(g,i,j,a)[\delta vaF1(g,i,j,a)^{1/\sigma'(a)}LF(g,i,j,a)^{\sigma'(a)-1/\sigma'(a)} + \delta vaF2(g,i,j,a)^{1/\sigma'(a)}LKF(g,i,j,a)^{\sigma'(a)-1/\sigma'(a)}]^{\sigma'(a)/\sigma'(a)-1} \qquad \perp LF(g,i,j,a) \quad (60)$$

$$\frac{WL(i)}{PLKF(g,i,j,a)} = \left(\frac{\delta vaF1(g,i,j,a)}{\delta vaF2(g,i,j,a)}\frac{LKF(g,i,j,a)}{LF(g,i,j,a)}\right)^{1/\sigma'(a)} \qquad \perp LKF(g,i,j,a) \quad (61)$$

$$PVAF(g,i,j,a) = \frac{1}{\omega VAF(g,i,j,a)}[\delta vaF1(g,i,j,a)WL(i)^{1-\sigma'(a)} + \delta vaF2(g,i,j,a)PLKF(g,i,j,a)^{1-\sigma'(a)}]^{1/1-\sigma'(a)} \quad \perp PVAF(g,i,j,a) \quad (62)$$

$$LKF(g,i,j,a) = \omega LKF(g,i,j,a)\left[\delta lkF1(g,i,j,a)^{1/\sigma'(a)}LNF(g,i,j,a)^{\sigma'(a)-1/\sigma'(a)} + \delta lkF2(g,i,j,a)^{1/\sigma'(a)}QFDIFJ(g,i,j,a)^{\sigma'(a)-1/\sigma'(a)}\right]^{\sigma'(a)/\sigma'(a)-1} \quad \perp LNF(g,i,j,a) \quad (63)$$

$$\frac{WLAN(i)}{WFDIF(g,i,a)} = \left(\frac{\delta lkF1(g,i,j,a)}{\delta lkF2(g,i,j,a)}\frac{QFDIFJ(g,i,j,a)}{LNF(g,i,j,a)}\right)^{1/\sigma'(a)} \quad \perp QFDIFJ(g,i,j,a) \quad (64)$$

$$PLKF(g,i,j,a) = \frac{1}{\omega LKF(g,i,j,a)}[\delta lkF1(g,i,j,a)WLAN(i,a)^{1-\sigma'(a)} + \delta lkF2(g,i,j,a) * WFDIF(g,i,a)^{1-\sigma'(a)}]^{1/1-\sigma'(a)} \quad \perp PLKF(g,i,j,a) \quad (65)$$

B.3. Demand and Government

$$Q(j,s) = \left[\sum_i (\theta(i,j,s)^{1/\sigma(s)}Z(i,j,s)^{(\sigma(s)-1)/\sigma(s)}\right]^{\sigma(s)/(\sigma(s)-1)} \quad \perp Z(i,j,s) \quad (66)$$

$$PQ(j,s) = [\sum_i \theta(i,j,s) * PZ(i,j,s)^{1-\sigma(s)}]^{1/1-\sigma(s)} \quad \perp PQ(j,s) \quad (67)$$

$$\frac{Z(i,j,s)}{Q(j,s)} = \theta(i,j,s)\left(\frac{PQ(j,s)}{PZ(i,j,s)}\right)^{\sigma(s)}, i \neq CN \quad \perp Z(i,j,s) \quad (68)$$ [3]

$$Z(i,j,s) = \left[(\theta D(i,j,s)^{1/\sigma(s)}QD(i,j,s)^{(\sigma(s)-1)/\sigma(s)} + \theta FS(i,j,s)^{1/\sigma(s)}\,QFS(i,j,s)^{(\sigma(s)-1)/\sigma(s)}\right]^{\sigma(s)/(\sigma(s)-1)} \quad \perp QD(i,j,s) \quad (69)$$

$$PZ(i,j,s) = [\theta D(i,j,s) * PD(i,j,s)^{1-\sigma(s)} + \theta FS(i,j,s) * PFS(i,j,s)^{1-\sigma(s)}]^{1/1-\sigma(s)} \quad \perp PZ(i,j,s) \quad (70)$$

$$\frac{QD(i,j,s)}{QFS(i,j,s)} = \frac{\theta D(i,j,s)}{\theta FS(i,j,s)}\left(\frac{PFS(i,j,s)}{PD(i,j,s)}\right)^{\sigma(s)} \quad \perp QFS(i,j,s) \quad (71)$$

[3] This equation sets $i \neq CN$ in order to equalize the number of equations with the number of variables $Z(i,j,s)$.

$$QFS(i,j,s) = \left[\sum_{g} (\theta F(g,i,j,s)^{1/\sigma(s)} QF(g,i,j,s)^{(\sigma(s)-1)/\sigma(s)}\right]^{\sigma(s)/(\sigma(s)-1)} \quad \perp QF(g,i,j,s) \quad (72)$$

$$PFS(i,j,s) = [\sum_{g} \theta F(g,i,j,s) * PF(g,i,j,s)^{1-\sigma(s)} \ ]^{1/1-\sigma(s)} \quad \perp PFS(i,j,s) \quad (73)$$

$$\frac{QF(g,i,j,s)}{QFS(i,j,s)} = \theta F(g,i,j,s)(\frac{PFS(i,j,s)}{PF(g,i,j,s)})^{\sigma(s)}, g \neq i \quad \perp QF(g,i,j,s) \quad (74)$$

$$\begin{aligned} YH(j) = {} & WLN(j)\overline{LN(j)} + WL(j)L(j) + \sum_{s} QDK(j,s)WDK(j,s) \\ & + \sum_{s}\sum_{g} [QFDID(j,g,s)WFDID(j,g,s) \\ & + QFDIF(j,g,s)WFDIF(j,g,s)] \\ & + \sum_{ss}\sum_{i} (SDK(j,i,ss) + SDL(j,i,ss))(FD(j,i,ss) \\ & + \Pi D(j,i,ss)) \\ & + \sum_{ss}\sum_{i}\sum_{g} (SFL(g,j,i,ss))(FF(g,j,i,ss) + \Pi F(g,j,i,ss)) \\ & + \sum_{ss}\sum_{i}\sum_{g} SFK(j,g,i,ss)(FF(j,g,i,ss) + \Pi F(j,g,i,ss)) \end{aligned} \quad \perp YH(j) \quad (75)$$

$$\begin{aligned} PQ(j,s)QH(j,s) = {} & PQ(j,s)b(j,s) \\ & + \beta(j,s)\left[YH(j) - \sum_{c} PQ(j,c)b(j,c) \right. \\ & \left. - PSAV(j)b(j,sav)\right], c \neq s \end{aligned} \quad \perp QH(j,s) \quad (76)$$

$$\mathrm{PSAV(j)} = \frac{\sum_s PQ(j,s)}{5} \quad \perp PSAV(j) \quad (77)$$

$$\begin{aligned} PSAV(j)HSAV(j) & \\ = {} & PSAV(j)b(j,sav) \\ & + \beta(j,sav)\left[YH(j) - \sum_{s} PQ(j,s)b(j,s)\right] \end{aligned} \quad \perp HSAV(j) \quad (78)$$

$$\begin{aligned} YG(j) = {} & \sum_{s}\sum_{i} [(tm(i,j,s) + \tau(i,j,s) - 1) \\ & * \frac{\left(PD(i,j,s)QD(i,j,s) + \sum_g PF(g,i,j,s)QF(g,i,j,s)\right)}{1 + t(i,j,s)}] \end{aligned} \quad \perp YG(j) \quad (79)$$

$$EG(j) = \sum_s PQ(j,s)\overline{QG(j,s)} + PQ(j,s1)\overline{TS1(j)} \qquad \perp EG(j) \quad (80)$$

$$GSAV(j) = YG(j) - EG(j) \qquad \perp GSAV(j) \quad (81)$$

$$EINV(j) = \sum_s PQ(j,s)\overline{QINV(j,s)} \qquad \perp EINV(j) \quad (82)$$

B.4. Closure

$$\begin{aligned} Q(j,s) = {} & \sum_c \sum_i INTCD(s,j,i,c) + \left[\sum_{ss}\sum_i SDI(j,i,ss)\big(FD(j,i,ss) + \Pi D(j,i,ss)\big)\right] \Big/ PQ(j,s) \\ & + \sum_g INTCF(s,g,j,i,c) \\ & + \left[\sum_{ss}\sum_i SFI(g,j,i,ss)\big(FF(g,j,i,ss) + \Pi F(g,j,i,ss)\big)\right] \Big/ PQ(j,s) + QH(j,s) \\ & + \overline{QG(j,s)} + \overline{QINV(j,s)} + \overline{TS1(j)}, \qquad TS1(j) = 0 \; if \; s \neq s1 \end{aligned} \qquad \perp Q(j,s) \quad (83)$$

$$XD(i,j,ss) = [\overline{N(i,ss)}(1 - G(\varphi D(i,j,ss)^*)]^{1/(1-\sigma(ss))} \frac{\tau(i,j,ss)QD(i,j,ss)}{\varphi D\widetilde{(i,j},ss)} \qquad \perp PD(i,j,ss) \quad (84)$$

$$XD(i,j,a) = \tau(i,j,a)QD(i,j,a) \qquad \perp PD(i,j,a) \quad (85)$$

$$XF(g,i,j,ss) = [\overline{N(g,ss)}(1 - G(\varphi F(i,j,ss)^*)]^{1/(1-\sigma(ss))} \frac{\tau(i,j,ss)QF(g,i,j,ss)}{\varphi F\widetilde{(i,j},ss)} \qquad \perp PF(g,i,j,ss) \quad (86)$$

$$XF(g,i,j,a) = \tau(i,j,a)QF(g,i,j,a) \qquad \perp PF(g,i,j,a) \quad (87)$$

$$\sum_j \sum_s \left(LD(i,j,s) + \sum_g LF(g,i,j,s) \right) = \overline{L(i)} \qquad \perp WL(i) \quad (88)$$

$$\sum_j \sum_s \left(LND(i,j,s) + \sum_g LNF(g,i,j,s) \right) = \overline{LN(i)} \qquad \perp WLAN(i) \quad (89)$$

$$FSAVD(i,j) = \sum_s [\frac{PD(i,j,s)QD(i,j,s)}{1 + t(i,j,s)} - \frac{PD(j,i,s)QD(j,i,s)}{1 + t(j,i,s)}], i \neq j \qquad \perp FSAVD(i,j) \quad (90)$$

$$FSAVF(i,j) = \sum_s \left[\sum_g \frac{PF(g,i,j,s)QF(g,i,j,s)}{1 + t(i,j,s)} - \sum_h \frac{PF(h,j,i,s)QF(h,j,i,s)}{1 + t(j,i,s)} \right], i \neq j, g \neq i, h \neq j \qquad \perp FSAVF(i,j) \quad (91)$$

$$FSAVK(i,j) = \sum_{s}(QFDID(i,j,s)WFDID(i,j,s) + QFDIF(i,j,s)WFDIF(i,j,s) - QFDID(j,i,s)WFDID(j,i,s) - QFDIF(j,i,s)WFDIF(j,i,s)) + \sum_{g}\sum_{ss} SFK(i,j,g,ss)(FF(i,j,g,ss) + \Pi F(i,j,g,ss)) - \sum_{g}\sum_{ss} SFK(j,i,g,ss)(FF(j,i,g,ss) + \Pi F(j,i,g,ss)) \quad \perp FSAVK(i,j) \quad (92)$$

$$EINV(j) = PSAV(j)HSAV(j) + GSAV(j) + \sum_{i}(FSAVD(i,j) + FSAVF(i,j) + FSAVK(i,j)) + VBIS(j) \quad \perp VBIS(j) \quad (93)$$

B.5. Variables and Parameters

B.5.1. Variables

B.5.1.1. Capital Allocation Variables

$A(g)$ Assets owned by region g
$AK(g,s)$ Assets owned by region g allocated to sector s
$RK(g,s)$ Rate of return on AK(g,s)
$AD(g,s)$ Assets owned by region g allocated to domestic market sector s
$AF(g,s)$ Assets owned by region g allocated to foreign markets sector s
$RD(g,s)$ Rate of return on $AD(g,s)$
$RF(g,s)$ Rate of return on $AF(g,s)$
$AFDI(g,i,s)$ FDI owned by region g invested in region i sector s
$RFDI(g,i,s)$ Rate of return on $AFDI(g,i,s)$
$AFDID(g,i,s)$ FDI owned by region g invested in region i sector s used by domestic firms of i
$RFDID(g,i,s)$ Rate of return on $AFDID(g,i,s)$
$AFDIF(g,i,s)$FDI owned by region g invested in region i sector s used by foreign firms with parents in g
$RFDIF(g,i,s)$ Rate of return on $AFDIF(g,i,s)$
$PA(g)$ Asset price in region g
$WFDID(g,i,s)$ Rental price of FDI owned by region g invested in region i sector s paid by domestic firms of i
$WFDIF(g,i,s)$ Rental price of FDI owned by region g invested in region i sector s paid by foreign firms with parents in g
$WDK(g,s)$ Rental price of capital owned by region g invested in domestic market sector s paid by domestic firms
$QDK(g,s)$ Demand of domestic firms in region g sector s for domestic capital
$QFDID(g,i,s)$ Demand of domestic firms in region i sector s for FDI from home region g
$QFDIF(g,i,s)$ Demand of foreign firms in region i sector s from FDI from home region g

B.5.1.2. Production Variables

$\Pi D(i,j,ss)$ Sectoral profits of domestic firms in sector with heterogeneous firms ss operating on the $i-j$ link

$PD(i,j,s)$ Sectoral average price for commodity s produced by domestic firms operating on the $i-j$ link

$QD(i,j,s)$ Demand of market j for commodity s produced by domestic firms of region i

$\Pi F(g,i,j,ss)$ Sectoral profit of foreign firms from home region g located in region i and supplying market j (the $g-i-j$ link) in sector ss

$PF(g,i,j,s)$ Sectoral average price for commodity s produced by foreign firms on the $g-i-j$ link

$QF(g,i,j,s)$ Demand of market j for commodity s produced by foreign firms from home region g located in region i

B.5.1.2.1. Domestic firms

$\varphi D^{*}(i,j,ss)$ Productivity threshold for domestic firms in sector ss to operate on the $i-j$ link

$\widetilde{\varphi D}(i,j,ss)$ Average productivity of domestic firms in sector ss operating on the $i-j$ link

$XD(i,j,s)$ Output of domestic firms in sector s on the $i-j$ link

$VAD(i,j,s)$ Value added inputs of domestic firms in sector s on the $i-j$ link

$INTD(i,j,s)$ Composite intermediate inputs of domestic firms in sector s on the $i-j$ link

$PVAD(i,j,s)$ Price of $VAD(i,j,s)$

$PINTD(i,j,s)$ Price of $INTD(i,j,s)$

$CD(i,j,s)$ Marginal cost of $XD(i,j,s)$

$INTCD(c,i,j,s)$ Inputs of intermediate commodity c in the production of commodity s of domestic firms on the $i-j$ link

$LD(i,j,s)$ Labor demand of domestic firms in sector s on the $i-j$ link

$WL(i)$ Wage for labor in region i

$KD(i,j,s)$ Capital demand of domestic firms in sector s on the $i-j$ link

$WKD(i,j,s)$ Rental price of capital paid by domestic firms in sector s on the $i-j$ link

$LKD(i,j,a)$ Demand for land-capital composite of domestic firms in agriculture sector on the $i-j$ link

$PLKD(i,j,a)$ Price of $LKD(i,j,a)$

$LND(i,j,a)$ Land demand of domestic firms in agriculture sector on the $i-j$ link

$WLAN(i)$ Price of land in region i

$QDKJ(i,j,s)$ Demand for domestic capital of domestic firms in sector s on the $i-j$ link

$QFKD(i,j,s)$ Demand for foreign capital of domestic firms in sector s on the $i-j$ link
$QFDIDJ(g,i,j,s)$ Demand for FDI owned by region g of domestic firms in sector s on the $i-j$ link
$WFKD(i,s)$ Rental price of foreign capital paid by domestic firms in region i sector s

B.5.1.2.2. Foreign firms

$\varphi F^*(g,i,j,ss)$ Productivity threshold for foreign firms from home region g to operate on the $i-j$ link sector ss
$\widetilde{\varphi F}(g,i,j,ss)$ Average productivity of foreign firms in sector ss on the $g-i-j$ link
$XF(g,i,j,s)$ Output of foreign firms in sector s on the $g-i-j$ link
$VAF(g,i,j,s)$ Value added of foreign firms in sector s on the $g-i-j$ link
$INTF(g,i,j,s)$ Intermediate composite of foreign firms in sector s on the $g-i-j$ link
$PVAF(g,i,s)$ Price of $VAF(g,i,j,s)$
$PINTF(g,i,s)$ Price of $INTF(g,i,j,s)$
$CF(g,i,s)$ Marginal cost of $XF(g,i,j,s)$
$INTCF(c,g,i,j,s)$ Inputs of intermediate commodity c in the production of commodity s of foreign firms on the $g-i-j$ link
$LF(g,i,j,s)$ Labor demand of foreign firms in sector s on the $g-i-j$ link
$LKF(g,i,j,a)$ Demand for land-capital composite of foreign firms in agriculture sector on the $g-i-j$ link
$PLKF(g,i,a)$ Price of $LKF(g,i,j,a)$
$LNF(g,i,j,a)$ Land demand of foreign firms in agriculture sectors on the $g-i-j$ link
$QFDIFJ(g,i,j,s)$ FDI demand of foreign firms in sector s on the $g-i-j$ link

B.5.1.3. Demand and Government Variables

$Q(j,s)$ Aggregated demand for good s in region j
$PQ(j,s)$ Aggregated price of commodity s in region j
$Z(i,j,s)$ Aggregated demand of region j for good s sourced from region i
$PZ(i,j,s)$ Aggregated price for $Z(i,j,s)$
$QFS(i,j,s)$ Demand of region j for commodity s produced by foreign firms located in region i
$PFS(i,j,s)$ Price of $QFS(i,j,s)$

$YH(j)$ Household income in region j
$QH(j,s)$ Demand of household for commodity s in region j
$PSAV(j)$ Price for household saving in region j
$HSAV(j)$ Saving of household in region j
$YG(j)$ Government income in region j
$EG(j)$ Government expenditure in region j
$GSAV(i)$ Government saving in region j

$EINV(j)$ Investment in region j

B.5.1.4. Closure Variables

$FSAVD(i,j)$ Foreign saving from trade products produced by domestic firms in regions i and j
$FSAVF(i,j)$ Foreign saving from trade products produced by foreign firms of in regions i and j
$FSAVK(i,j)$ Foreign saving from investment between regions i and j
$VBIS(j)$ Virtual variable in the investment-saving equation for region j

B.5.2. Parameters

B.5.2.1. Capital Allocation Parameters

σ1 Transformation elasticity of assets among sectors
$\alpha a(g,s)$ Share of assets being allocated to sector s in total assets of region g
$\alpha D(g,s)$ Share of assets being invested in domestic market in total assets of region g allocated to sector s
$\alpha F(g,s)$ Share of assets being invested abroad in total assets of region g allocated to sector s
σ2 Transformation elasticity of assets between domestic and foreign investment

$\alpha fdi(g,j,s)$ Share of assets being invested in region j in total assets of region g sector s invested abroad
σ3 Transformation elasticity of assets being invested in different host regions
$\alpha N(g,j,s)$ Share of FDI used by domestic firms in FDI from home region g to host region j sector s
$\alpha FA(g,j,s)$ Share of FDI used by foreign firms in FDI from home region g to host region j sector s

B.5.2.2. Production Parameters

γ(ss) Shape parameter of productivity in a Pareto distribution for sector ss with heterogeneous firms
$\sigma'(s)$ Elasticity of substitution among factors in sector s
$t(i,j,s)$ Tariff equivalents of trade barriers in sector s on the $i-j$ link. It equals to the sum of tariff and tax equivalents of NTBs in sectors a, $m1$, $m2$, $s1$, and equals to the cost-raising distortions of services barriers in sector $s2$
$tm(i,j,s)$ Tariff rates imposed by region j on commodity s from region i
$v(i,j,ss)$ Rent-creating distortions of services barriers in sector $s2$ being imposed by region j on imports from region i
$\tau(i,j,s)$ Iceberg trade costs indicating that only a fraction of $1/\tau(i,j,s)$ can arrive when shipping one unit of good s from region i to j ($\tau(i,j,s) = 1\ for\ i = j$).
$\omega D(i,j,s)$ Scale factor for output of domestic firms in sector s on the $i-j$ link

$\delta 1(i,j,s)$ Share of value added in the output of domestic firms in sector s on the $i-j$ link

$\delta 2(i,j,s)$ Share of intermediates in the output of domestic firms in sector s on the $i-j$ link

$\alpha cs(c,i,j,s)$ Leontief share of commodity c in composite intermediate inputs for the production of s of domestic firms on the $i-j$ link

$\omega VAD(i,j,s)$ Scale factor for value added of domestic firms in sector s on the $i-j$ link

$\delta va1(i,j,ss)$ Share of labor in value added of domestic firms in sector ss on the $i-j$ link

$\delta va2(i,j,ss)$ Share of capital in value added of domestic firms in sector ss on the $i-j$ link

$\delta va1(i,j,a)$ Share of labor in value added of domestic firms in agriculture sector on the $i-j$ link

$\delta va2(i,j,a)$ Share of land-capital composite in value added of domestic firms in agriculture sector on the $i-j$ link

$\omega LKD(i,j,a)$ Scale factor for land-capital composite output of domestic firms in agriculture sector on the $i-j$ link

$\delta lk1(i,j,a)$ Share of land in land-capital composite of domestic firms in agriculture sector on the $i-j$ link

$\delta lk2(i,j,a)$ Share of capital in land-capital composite of domestic firms in agriculture sector on the $i-j$ link

$\omega KD(i,j,s)$ Scale factor for capital aggregation of domestic firms in sector s on the $i-j$ link

$\delta k1(i,j,s)$ Share of domestic capital in total capital inputs of domestic firms in sector s on the $i-j$ link

$\delta k2(i,j,s)$ Share of foreign capital in total capital inputs of domestic firms in sector s on the $i-j$ link

$\delta fk(g,i,j,s)$ Share of FDI owned by region g in the aggregate foreign capital inputs of domestic firms in sector s on the $i-j$ link

$\omega F(g,i,j,s)$ Scale factor for the outputs of foreign firms in sector s on the $g-i-j$ link

$\delta F1(g,i,j,s)$ Share of value added in the outputs of foreign firms in sector s on the $g-i-j$ link

$\delta F2(g,i,j,s)$ Share of intermediates in the outputs of foreign firms in sector s on the $g-i-j$ link

$\alpha csf(c,g,i,j,s)$ Leontief share of commodity c in composite intermediate inputs for the production of s of foreign firms on the $g-i-j$ link

$\omega VAF(g,i,j,s)$ Scale factor for value added of foreign firms in sector s on the $g-i-j$ link

$\delta vaF1(g,i,j,ss)$ Share of labor in value added of foreign firms in sector ss on the $g-i-j$ link

$\delta vaF2(g,i,j,ss)$ Share of capital in value added of foreign firms in sector ss on the $g-i-j$ link

$\delta vaF1(g,i,j,a)$ Share of labor in value added of foreign firms in agriculture sector on the $g-i-j$ link
$\delta vaF2(g,i,j,a)$ Share of land-capital composite in value added of foreign firms in agriculture sector on the $g-i-j$ link
$\omega LKF(g,i,j,a)$ Scale factor for land-capital composite of foreign firms in agriculture sector on the $g-i-j$ link
$\delta lkF1(g,i,j,a)$ Share of land in land-capital composite of foreign firms in agriculture sector on the $g-i-j$ link
$\delta lkF2(g,i,j,a)$ Share of capital in land-capital composite of foreign firms in agriculture sector on the $g-i-j$ link

B.5.2.3. Demand and Government Parameters

$\sigma(s)$ Substitution elasticity among goods in sector s

$\theta(i,j,s)$ Share of $Z(i,j,s)$ in aggregated demand $Q(j,s)$
$\theta D(i,j,s)$ Share of domestic firms' products in $Z(i,j,s)$
$\theta FS(i,j,s)$ Share of foreign firms' products in $Z(i,j,s)$
$\theta F(g,i,j,s)$ Share of products produced by foreign firms owned by region g in the composite demand for foreign firms' products

b(j,s) Compulsory demand for commodity s in region j
$\beta(j,s)$ Marginal consumption of commodity s in region j
b(j,sav) Compulsory saving in region j
$\beta(j,sav)$ Marginal consumption of saving in region j

SDL_{ij}^{ss} Share of labor in total inputs of labor, domestic capital and intermediate goods of domestic firms in sector ss on the $i-j$ link

$$SDL_{ij}^{ss}=\frac{SAMDL_{ij}^{ss}}{SAMDL_{ij}^{ss}+SAMDK_{ij}^{ss}+\sum_c SAMDI_{ij}^{css}};$$

$SAMDL_{ij}^{ss}$ Labor inputs of domestic firms in sector ss on the $i-j$ link from the SAM table

$SAMDK_{ij}^{ss}$ Capital inputs of domestic firms in sector ss on the $i-j$ link from the SAM table

$SAMDI_{ij}^{css}$ Intermediate inputs of commodity c of domestic firms in sector ss on the $i-j$ link from the SAM table

SDK_{ij}^{ss} Share of domestic capital in total inputs of labor, domestic capital and intermediate goods of domestic firms in sector ss on the $i-j$ link

$SDK_{ij}^{ss} = \frac{SAMDK_{ij}^{ss}}{SAMDL_{ij}^{ss}+SAMDK_{ij}^{ss}+\sum_c SAMDI_{ij}^{css}}$;

SDI_{ij}^{sss} Share of intermediate good s in total inputs of labor, domestic capital and intermediate goods of domestic firms in sector ss on the $i-j$ link

$SDI_{ij}^{sss} = \frac{SAMDI_{ij}^{sss}}{SAMDL_{ij}^{ss}+SAMDK_{ij}^{ss}+\sum_c SAMDI_{ij}^{css}}$;

SFL_{gij}^{ss} Share of labor in total inputs of foreign firms in sector ss on the $g-i-j$ link,

$SFL_{gij}^{ss} = \frac{SAMFL_{gij}^{ss}}{SAMFL_{gij}^{ss}+SAMFK_{gij}^{ss}+\sum_c SAMFI_{gij}^{css}}$;

$SAMFL_{gij}^{ss}$ Labor inputs of foreign firms in sector ss on the $g-i-j$ link from the SAM table

$SAMFK_{gij}^{ss}$ Capital inputs of foreign firms in sector ss on the $g-i-j$ link from the SAM table

$SAMFI_{gij}^{css}$ Intermediate inputs of commodity c of foreign firms in sector ss on the $g-i-j$ link from the SAM table

SFK_{gij}^{ss} Share of FDI in total inputs of foreign firms in sector ss on the $g-i-j$ link

$SFK_{gij}^{ss} = \frac{SAMFK_{gij}^{ss}}{SAMFL_{gij}^{ss}+SAMFK_{gij}^{ss}+\sum_c SAMFI_{gij}^{css}}$;

SFI_{gij}^{sss} share of intermediate good s in total inputs of foreign firms in sector ss on the $g-i-j$ link

$SFI_{gij}^{sss} = \frac{SAMFI_{gij}^{sss}}{SAMFL_{gij}^{ss}+SAMFK_{gij}^{ss}+\sum_c SAMFI_{gij}^{css}}$;

B.5.3. Exogenous Variables

$W(g)$ Total assets in region g

$N(i,s)$ Total mass of potential firms in region i sector s

$FD(i,j,s)$ Fixed trading costs faced by domestic firms in sector s on the $i-j$ link

$FF(g,i,j,s)$ Fixed trading costs faced by foreign firms in sector s on the $g-i-j$ link

$L(i)$ Labor endowments in region i

$LN(i)$ Land endowments in region i

$QG(i,s)$ Government demand for commodity s in region i

$QINV(i,s)$ Investment demand for commodity s in region i

$TS1(j)$ Demand for transportation services produced in region j from the international transportation pool