Analyzing Effects of RCEP on Foreign Direct Investment in a Firm Heterogeneity CGE Framework

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1. Introduction

Two of my previous studies have used econometrical method to quantify the effects of ACFTA on FDI, both at country level for China and ASEAN6, and at industry level for China. Both papers have found that ACFTA has encouraged FDI flow to member countries. The positive FDI effect is mainly attributed to the liberalization of goods trade but not services liberalization because the latter is not a main achievement of ACFTA. Consequently, what these papers have not shown is the impact of services liberalization. In this paper, I intend to complement the previous studies by analyzing the FDI impacts of services liberalization as well as other trade and investment facilitation initiatives.

That services liberalization is not the focus of these papers however does not mean that it is unimportant. Quite the contrary, services liberalization has been found that it affects FDI in a direct and significant way (Dee & Hanslow, 2000; Konan & Maskus, 2006). FDI has historically been crucial to the effective delivery of services (Tarr, 2012). According to the estimation of WTO, trade through commercial presence (FDI) represents 50% of total services trade (Fink & Jansen, 2007). FDI being involved in services trade constitutes fully two-thirds of the inward stock of FDI, a figure that continues to increase dynamically (Stephenson, 2014). The large amount of overlap between services trade and FDI indicates that services liberalization could almost be equivalent to FDI liberalization. That services liberalization would have a significant effect on FDI and welfare also relates to the high share of services trade in total trade. Based on trade in value added data, the average services content of exports for G20 economies is 42% in 2009, and is at or above 50% for countries such as the US, UK, India, France and the EU as a whole (OECD, WTO, & UNCTAD, 2013). The importance of services trade suggests that extending the analysis of free trade agreement from trade in goods to services is a great complement to the previous studies.

In this paper, I experiment with RCEP to simulate its potential impacts on FDI. RCEP is an under-negotiating FTA among ASEAN and its 6 dialogue partners (China, Japan, Korean, India, Australia and New Zealand). The guiding principles and objectives for negotiating RCEP state that it will be a high-quality FTA covering trade in goods, trade in services and other issues. The wide coverage and possible deep trade liberalization make RCEP to be an ideal research target.

In order to comprehensively analyze the effects of FTA on FDI, I not only turn from ACFTA to RCEP, but also switch from econometrical modelling to CGE modelling. The CGE model developed in this paper is grounded in the firm heterogeneity theory of Melitz (2003) and Helpman, Melitz, and Yeaple (2004). Helpman et al. (2004) extends the Melitz model from the selection of exporters and non-exporters to the selection of export and FDI as the way of supplying foreign markets. The main finding is that among firms supplying foreign markets, the most productive ones choose FDI and the less productive ones choose export because firms choosing FDI face higher fixed costs than firms choosing export.

The theories of Melitz and Helpman et al. lay foundation for my model. In my model, heterogeneous firms are first categorized into foreign firms and domestic firms, and then within each firm type, they are further classified into exporters and non-exporters. According to the theory of Helpman et al. (2004), foreign firms face high entry costs to invest and operate in host region. Only the most productive firms in home region can become the foreign firms in host region. The foreign firms should be more productive than domestic firms of the host region. That explains the high productivity of multinationals and positive spillovers of FDI. Within foreign firms, the same as domestic firms, some can only supply the local market while the more productive ones can supply the export market. Based on this theoretical foundation, I develop a CGE model that integrates FDI to the Firm Heterogeneity model (FHFDI model).

The FHFDI model is built on Zhai (2008). While keeping most of the assumptions and structural features of the Zhai model, the FHFDI model innovates in several ways. The most important is to separate foreign firms from each economy. The reason for separating foreign firms is because they are the main carriers of FDI. The production activities of foreign firms directly relate to FDI demand. Through the activities of foreign firms, we could observe the effects of RCEP on FDI, such as the market expansion and plant rationalization effect identified in previous studies. [1] Trade liberalization lowers trade costs and productivity thresholds for foreign firms to enter the partner's market. More firms can export and the export volume of existing varieties would increase too. The market expansion of foreign firms drives up FDI demand in member countries.

[1] The market expansion effect refers to FDI increase in member countries as a result of market expansion to partner countries of firms using FDI and the plant rationalization effect refers to FDI decrease due to trade substitution and imports competition.

On the other hand, increased imports intensify competition, together with trade substitution, which would weed out the least productive foreign firms, resulting in FDI decrease.

Another extension from the Zhai model is in terms of the treatment of services barriers. The Zhai model did not differentiate services barriers from tariff barriers and treat the two types of barriers as tax equivalents that raise trade costs. The FHFDI model treats services barriers differently from tariff barriers. While tariffs raise trading costs, services barriers not only raise costs to imports, but also generate rents to incumbent firms. The treatment of services restraints follows the way 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). This way of dealing with services barriers is closer to the real economy.

A third extension of the FHFDI model is to add a capital allocation block. This block determines capital allocation among sectors, regions and firms by following a hierarchal structure. When capital moves across regions, it becomes FDI. Therefore, this section is important in presenting results about the FDI effects of RCEP. Finally, the FHFDI model is calibrated to a Social Accounting Matrix (SAM) built on GTAP 8 Data Base and two FDI databases. The two FDI databases include a global FDI stock database and a global foreign affiliate sales database. Both are the lasted developments in FDI data collection and computation (Fukui & Lakatos, 2012; Lakatos, Walmsley, & Chappuis, 2011). With the two FDI databases, I construct a SAM table with foreign firms being separated from the economy.

The FHFDI model has three regions (China, its RCEP partners (PTN) and rest of the world (ROW)). China is the country of interest. Simulation results show that China can gain FDI and welfare from RCEP. Comprehensive liberalization on trade in goods and services with a more than 50% reduction in services barriers in China can promote FDI flow to China by US$1.8 billion and increase its welfare by US72 billion. If RCEP can help to improve the business environments in member countries so as to reduce fixed trading costs, the gains in FDI and welfare would be even bigger. Services are found to dominant in total FDI increase, corresponding to the importance of services liberalization to FDI. In addition, the FHFDI model finds the market expansion and plant rationalization effect of RCEP. The market expansion effect is very significant, while the plant rationalization effect has not decreased FDI much.

This paper is organized as follows: the next section reviews the firm heterogeneity model and its application in CGE frameworks. Section 3 presents the model structure and specifications. Section 4 illustrates data and calibration. The FHFDI model is tested in Section 5. This section also reports and discusses simulation results. Section 6 concludes.

2. Literature Review

This section first reviews CGE models about FDI, then reviews the firm heterogeneity model and its application in CGE studies. In a pioneering contribution to the applied CGE literature, Petri (1997) developed a model that included FDI as well as cross-border trade in services. FDI in the Petri model gives rise to affiliates (foreign-owned plants) that differ from domestic firms in the same sector by using inputs ‘imported’ from the parent company as well as domestic factors of production. By assuming that consumer demand is differentiated both by place of production (along Armington lines) and nationality of ownership of plants it becomes possible to model the effects of policies that decrease the costs of foreign firms that are established in a given market. Capital allocation is modelled in an optimizing framework that allocates capital to the highest return activities, but also takes into account investor preferences for a particular mix of investment instruments. In turn, the return to capital relates to profits in different production locations. Petri applied the FDI-CGE model to analyse the economic effects of APEC’s ‘Bogor Declaration’. Barriers to FDI are represented in the model as a ‘tax’ on FDI profits. It is estimated to be one half as high as tariff-equivalents in the tradable primary and manufacturing sectors. Barriers to FDI in services are higher than other sectors, which are based on the estimates by Hoekman as reported and applied in simulations by Brown, Deardorff, Fox, and Stern (1995). Simulation suggests that global welfare gains from achieving the Bogor targets are estimated at around US$260 billion annually.

Building on the initial Petri (1997) paper, working with the ORANI and GTAP family of models, Hanslow (2000) and Dee and Hanslow (2000) integrated FDI into a FTAP model. The main feature of the FTAP model is incorporating increasing returns to scale (IRS) and large-group monopolistic competition in all sectors. The treatment of FDI follows closely Petri (1997). But the FTAP model is different from Petri in terms of commodity substitutions. Petri assumes commodities produced by the same firm from different locations are closer substitutes than those produced in the same location by firms with different nationality. In contrast, the FTAP model treats that products produced in the same market are closer substitute than products produced by the same firm located in different markets. In dealing with capital allocation, the FTAP model assumes that capital moves less readily between sectors in a given region, but more readily across regions in a given sector, which captures the idea that knowledge capital will often be sector-specific (Markusen, 2002).

The FTAP model contains four types of trade barriers. It distinguishes barriers to commercial presence (primarily through FDI) from barriers to other modes of service delivery; and additionally, it distinguishes non-discriminatory barriers to market access from discriminatory restriction on national treatment. These barriers have been modeled as different taxes. The rents generated from barriers are retained by different parties. A key result of their simulation is that the rents associated with services barriers are substantial.

The FTAP model has been used to compare estimates of the gains from eliminating barriers to trade in services with those from eliminating post-Uruguay barriers remaining in the traditional areas of agriculture and manufacturing in Dee and Hanslow (2000). They find the gains in services liberalization are as big as those related to the combined liberalization of the remaining barriers to trade in agriculture and manufactured goods.

Brown and Stern (2001) adapt the Michigan Model to incorporate cross-border services trade and FDI. Firms are taken to be monopolistically competitive. They set a price for the output of each plant with an optimal mark-up of price over marginal cost. Its demand structure follows Dee and Hanslow (2000). The capital installed in each host country is derived from the multinational’s determination of the profit-maximizing output from each plant. In essence, capital allocation is decided by rate of return. They assume capital is perfectly mobile between countries. Barriers to FDI are modelled as a tax on variable capital and labor, that is, increasing variable costs.

The early papers have not considered different productivity levels between domestic firms and MNCs, which has been picked up in later studies. 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. In their model, they use the basic concept of Markusen's knowledge-capital model. When MNCs produce in Russia, they import technology or management expertise, which makes them more productive. The barriers to FDI affect MNCs' profitability and entry. Reduction in the constraints will induce foreign entry that will typically lead to productivity gains. When more varieties are available, buyers can obtain varieties that more closely fit their demands and needs (the Dixit-Stiglitz variety effect). This model has also been used in some other studies (Lakatos & Fukui, 2013; Latorre, Bajo-Rubio, & Gómez-Plana, 2009).

Lejour, Rojas-Romagosa, and Verweij (2008) also incorporates productivity difference, rather than between national firms and foreign affiliates, but between domestic and foreign capital in a CGE model — WorldScan. WorldScan assumes a hybrid firm using both domestic and foreign capital. It adopts one production function for this hybrid firm because of data limitation which restricts the authors to discriminate production functions for domestic and foreign capital. With one production function, the productivity effect of foreign capital has been modeled in a form of externalities. This model has been applied to the Services Directive of the European Commission which aims to open up services markets within the EU. Result shows that the economic gains of liberalizing FDI in other commercial services are modest and only countries with large FDI inflows benefit significantly.

Although the recent studies have tried to capture the high productivity of MNCs, none of them has adopted the firm heterogeneity theory. The firm heterogeneity theory differentiates firms by productivity and explains the productivity difference from a perspective of fixed costs, indicating that it can not only capture the high productivity of MNCs, but also provide a theoretical background for it. Because of these advantages of the firm heterogeneity theory, I adopt it in my CGE model.

The firm heterogeneity model is first proposed by Melitz (2003). It is a model of monopolistic competition with heterogeneous firms, which is designed to explain that only the more productive firms are able to export. Opening the economy to trade or increasing the exposure to trade generates a reallocation of market power within the domestic and export markets based on the productivity differences of firms (Akgul, Villoria, & Hertel, 2014). In particular, firms with higher productivity levels are induced to enter the export market; firms with lower productivity levels continue to produce for the domestic market and firms with the lowest productivity levels are forced to exit the industry. These inter-firm reallocations generate a growth in the aggregate industry productivity which then increases the welfare gains of trade. According to Akgul et al. (2014), the main premise of the Melitz model is that aggregate productivity can change even though there is no change in a country's productivity technology.

Developed from the Melitz model, Helpman et al. (2004) builds a firm heterogeneity FDI model. The model is designed to explain the decision of heterogeneous firms to serve foreign markets either through exports or local subsidiary sales (FDI). The main insights of this model are derived from an interaction between productivity differences across firms and fixed costs of serving foreign markets. Exporters face fixed costs of distribution and servicing costs in foreign markets while firms choosing to serve foreign markets via FDI face these distribution and servicing network costs, as well as the costs of forming a subsidiary in a foreign country and the duplicate overhead production costs embodies in the sunk cost of entry the industry in home country. In equilibrium, only the more productive firms choose to serve the foreign markets and the most productive among this group will further choose to serve the overseas market via FDI. This study together with the Melitz model lay the foundation for the FHFDI model.

In application of the firm heterogeneity theory, Zhai (2008) initiatively introduces the Melitz model to a CGE framework. The Zhai model abstracts the Melitz model in several ways to avoid computational difficulties. First, it assumes no entry and exit of firms, characterizing a static equilibrium. In each sector, the total number of registered firms is fixed. But not all registered firms are active. A firm is active in a market only if its productivity is not lower than the productivity threshold to enter the market. When productivity threshold changes, there will be entry or exit of registered firms. Thus, the number of active firms in each market is not fixed. Second, it assumes no sunk costs, but fixed trading costs for firms' domestic sales and exports. The model is calibrated to GTAP 6.2 Data. Simulation results show that the introduction of firm heterogeneity improves the ability of CGE model to capture trade and welfare effects of trade liberalization. Compared with the standard Armington CGE model, the firm heterogeneity model introduces three additional channels through which trade liberalization yields welfare gains. The first is the Dixit-Stiglitz “love-of-variety effect”; the second is the gains in aggregate productivity from intra-industry reallocation and the third is the gains from scale effects as a result of the exit of the least productive firms. Under the scenario of global manufacturing tariff cut, the estimated gains in welfare and exports are more than double that obtained from the Armington CGE model.

The Zhai model has set a good example in applying the firm heterogeneity model in CGE studies. To introduce the firm heterogeneity model to the GTAP Model, Akgul et al. (2014) follows its ways of modelling firm heterogeneity and parsing productivity threshold to enter domestic and export markets. But it differs from the Zhai model by incorporating endogenous firm entry and exit behaviors and fixed sunk costs. The model is built on the monopolistically competitive GTAP model of Swaminathan and Hertel (1996). An initial comparison of model responses to tariff elimination across GTAP models with Armington, Krugman, and Melitz specification do not show significant variation when the policy instrument is the tariff rate.

In addition to specific efforts devoted to the CGE application of the firm heterogeneity model, a series of studies try to present and calibrate Armington model, Krugman’s monopolistic competition model and the firm heterogeneity model in a unified CGE framework. Balistreri and Rutherford (2011) presents the three basic theories in a general equilibrium framework. The main point of this study is to show how to calibrate different models, especially large models. Inspired by this paper, Dixon, Michael, and Maureen (2013) draws out connections between the three models by developing them sequentially as special cases of a common basic model. They derive the Arminton model by imposing strong assumptions on the basic model and relax some of these assumptions to derive the Krugman model and make further relaxations to derive the Melitz model. Solving the Melitz general equilibrium model using GEMPACK software, they find that the Melitz welfare result is close to that which could be obtained from an Armington model with a higher inter-variety substitution parameter.

Based on this study, Oyamada (2014) shows how an Armington-Krugman-Melitz encompassing module can be calibrated. In particular, it finds that the choice of an initial level for the number of registered firms or sunk costs is perfectly neutral, and with one is given, the other one can be calibrated accordingly. It is the same for the initial level for the proportion of registered but inactive firm and fixed trading costs. As a consequence, only one kind of additional information, which is on the shape parameter related to productivity, is required in order to incorporate Melitz-type monopolistic competition and heterogeneous firms into a standard applied general equilibrium model.

The Melitz general equilibrium model has been well developed and integrated to an encompassing module with the Armington model and the Krugman model. But there has no studies that introduce the FDI extension of the Melitz model developed by Helpman et al. (2004) to a CGE framework. The gap is filled by this study. Thus, this study contributes to literature in a way of incorporating the FDI firm heterogeneity model to a CGE framework. By doing so, this study models the high productivity of multinationals in a direct way based on a theoretical background, which could be another contribution to the literature.

3. Model

This section describes the theoretical structure of the FHFDI model. Built on Zhai (2008), the FHFDI model characterizes a monopolistically competitive market with no sunk costs and no free entry and exit of firms.[2] The main departure from the Zhai model is to separate foreign firms from each economy. Foreign firms refer to foreign affiliates owned by foreigners operated in host region. They source capital only from home region, that is, FDI. The production activities of foreign firms directly relates to FDI demand and movements. The separation of foreign firms in the FHFDI model facilitates the examination of FDI movements, and more importantly, it enables to explore the mechanisms of how trade liberalization affects FDI. The FHFDI model takes account of export platform FDI by allowing foreign firms to export. The same as firms in the Melitz model, only more productive foreign firms can export and the less productive ones can only serve the local market of host region.

[2] Adopting this assumption has two reasons. First is to facilitate comparison between the results of the FHFDI model and the Zhai model. The second reason is to simulate a short-term static equilibrium and be consistent with the modelling of capital under an assumption of no capital accumulation.

For domestic firms, less productive firms sell to the local market and more productive ones export to foreign markets. They source capital from both domestic region and foreign regions.[3] That some FDI is used by domestic firms reflects joint ventures in real economy. Until now, the Melitz model is enough to explain the productivity difference between exporters and non-exporters among foreign and domestic firms. The following part illustrates the differences between foreign firms and domestic firms in terms of productivity, which relies on the model of Helpman et al. (2004).

To enter the same market, foreign firms need to be more productive than domestic firms operated in the same region. According to Helpman et al. (2004), firms supplying foreign markets through FDI are the most productive ones in home region because these firms face the highest fixed trading costs. Following the same reasoning, foreign firms in host region are more productive than domestic firms because these firms face higher costs to operate away from home region. The higher costs occurred in producing in the host region determine that foreign firms always face higher trading costs in supplying every market. Thus, foreign firms need to be more productive. In the FHFDI model, the productivity difference is reflected by firm type-specific productivity variables. Originated from here, foreign firms have different industry aggregate price and profits from domestic firms.

In the application of RCEP, the FHFDI model distinguishes three regions, three factors and five sectors. The three regions are China, its RCEP partner (PTN) and 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. But the movement of capital across sectors and borders is not free. The five sectors consist of an agriculture sector, two manufacturing sectors and two services sectors. Agriculture is a reference sector with homogeneous firms. In other sectors, firms are heterogeneous.

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[3] Initially, I assume all FDI is consumed by foreign affiliates. Later when constructing the SAM table, I found in some sectors foreign firms cannot exhaust all FDI from its home region. The excess FDI is allocated to domestic firms, forming joint venture. However, I have not separated joint venture from domestic firms as a third firm type.

The classification of manufacturing and services sectors needs more explanation. The manufacturing industry is split into two sectors, with pro-fragmentation sectors as one group and the remaining sectors as another.[4] As defined in my previous studies, the pro-fragmentation sectors include machinery and electrical goods (GSC2 NO.41, 42 in GTAP database). FTA has a specific vertical fragmentation effect on FDI in these sectors, according to literature. However, the FHFDI model is unable to capture this effect because the model has not separated trade in intermediate goods, an important indicator of production fragmentation. Without this impact, the FDI effects of RCEP on manufacturing sectors might be underestimated. To fix this problem, the pro-fragmentation sectors are isolated to receive an additional positive FDI impact on the top of simulation results. The pro-fragmentation sectors are aggregated to the first manufacturing sector ($m1$). The remaining manufacturing sectors are aggregated to the second sector ($m2$).

The services industry is split into two sectors as well. Sector $s1$ includes air transport, water transport and land transport. Sector $s2$ aggregates the remaining services such as finance, telecommunication, retail trade and business. The split of services is based on an idea that commercial presence is a more important way of delivering services in sector $s2$ than sector $s1$. Based on the close relation between services trade and FDI, and the high proportion of services in FDI stock, I expect that the most significant changes in FDI after RCEP would happen in sector $s2$.

Due to the specification of sectors, markets and firms in the model, a quick summary of the notation that I adopt in this paper is warranted. In the sections that follow F denotes foreign firm while D denotes domestic firm. Country or region is indicated by g, i or j. For variables indicating foreign firms' behaviors, g usually denotes home region, i for host region and j for market. s or c denote a commodity or a sector. In addition, it is important to highlight that the FHFDI model only have industry-level variables and they are distinguished between foreign firms and domestic firms throughout this paper.

[4] Pro-fragmentation sectors are defined in my previous studies as the sectors that can easily participate in international production network. Firms in these sectors can easily split production process to different countries to take advantage of each, with an aim to minimize production costs.

3.1 Demand

Insert Figure 1 here

In each region, the representative consumer receives income from the supply of production factors to and dividends of profits from firms. The details of household incomes are given in Section 3.4.1. 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 equal to the average price of consumer goods. Investment demand and government consumptions 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, the detailed function is presented in Section 3.4.2. In sector $s1$, the transport sector, there is an additional demand from international transportation pool.[5] The demand from 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 1. Each layer of the system follows a CES format. The first layer allocates the aggregate demand in region 1 to commodities sourced from each of the three regions (China, PTN, ROW). Sourcing demand to the origin is a distinguished feature of monopolistically competitive model, which differs from the Armington approach that differentiates commodities 'at border' to imported and domestically produced commodities (Akgul et al., 2014; Swaminathan & Hertel, 1996).[6] The second layer allocates the demand for commodities produced in each region to domestic firms and foreign firms. Each type firm supplies different products with distinct prices. In the final layer, foreign firms are differentiated by ownership.

[5] 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.

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

The demand system indicates that in the FHFDI model, varieties are characterized by firm-type product differentiation with national differences.[7]

3.1.1 Demand Determination

In each layer, the preferences of a representative consumer are given by a CES sub-utility function over varieties. For the first layer:

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

Q_j^s is a CES aggregate good of commodity s demanded in region j sourced from different regions, which is analogue to utility (Melitz, 2003). Z_{ij}^s is the demand for variety of commodity s produced in region i and sold in region j, θ_{ij}^s is the Armington preference parameter reflecting consumers' tendency for home or imported products, and σ^s is the constant elasticity of substitution among different varieties ($\sigma^s > 1$).

The demand for variety Z_{ij}^s is determined by consumers' optimal consumption decision. The representative consumer choses Z_{ij}^s that minimizes his expenditure:

$$\min_{Z_{ij}^s} \sum_i PZ_{ij}^s Z_{ij}^s$$

$$s.t.\, Q_j^s = [\sum_i \theta_{ij}^{s\,\frac{1}{\sigma^s}} Z_{ij}^{s\,\frac{\sigma^s-1}{\sigma^s}}]^{\frac{\sigma^s}{\sigma^s-1}}$$

where $PZ_{ij}^s$is the price of variety Z_{ij}^s. The minimization problem yields the CES derived demand for variety Z_{ij}^s as:

$$Z_{ij}^s = \theta_{ij}^s Q_j^s [\frac{PQ_j^s}{PZ_{ij}^s}]^{\sigma^s} \qquad \textbf{Eq.(2)}$$

By substituting the derived demand into the utility function (Eq.(1)) and rearranging we can obtain the dual Dixit-Stiglitz price index for product s in region j:

[7] The sectorial 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 monopolistically competition'. Individual firms believe they are too small to influence the composite price of their group. Thus, allocating demand to individual firms does not give many implications.

$$PQ_j^s = [\sum_i \theta_{ij}^s PZ_{ij}^{s\,1-\sigma^s}]^{\frac{1}{1-\sigma^s}}$$ **Eq.(3)**

PQ_j^s is the price of product s faced by consumers in region j. The sectoral average of PQ_j^s is the price of saving in region j, $PSAV_j$.

As the demand for variety from region i, Z_{ij}^s, has been determined, we can obtain the optimal demand for product s produced by domestic firm in region i sold to region j in the second layer following the same way of determining Z_{ij}^s:

$$QD_{ij}^s = \theta D_{ij}^s Z_{ij}^s [\frac{PZ_{ij}^s}{PD_{ij}^s}]^{\sigma^s}$$ **Eq.(4)**

QD_{ij}^s is total sectoral demand for the variety of commodity s produced by domestic firms in region i sold to region j, θD_{ij}^s is the preference parameter for domestic firm products and PD_{ij}^s is the aggregate price received by domestic firms. Similarly, we can get the optimal demand for the variety of aggregate foreign firm products:

$$QFS_{ij}^s = \theta FS_{ij}^s Z_{ij}^s [\frac{PZ_{ij}^s}{PFS_{ij}^s}]^{\sigma^s}$$ **Eq.(5)**

QFS_{ij}^s is aggregate sectoral demand for the variety of commodity s produced by foreign firms operated in region i sold to region j, θFS_{ij}^s is the preference parameter for foreign firm products and PFS_{ij}^s is the dual price. In the final layer, consumers choose the optimal demand for variety of commodity s produced by foreign firms from different home region.

$$QF_{gij}^s = \theta F_{gij}^s QFS_{ij}^s [\frac{PFS_{ij}^s}{PF_{gij}^s}]^{\sigma^s}$$ **Eq.(6)**

QF_{gij}^s is aggregate sectoral demand for the variety of commodity s produced by foreign firms from home region g operated in region i sold to region j, θF_{gij}^s is the preference parameter for products of foreign firms owned by region g and PF_{gij}^s is the price received by foreign firms from home region g operated in region i sold to region j.

3.1.2 Issues with Behavioral Parameters

In the demand system, there are two types of behavioral parameters. One is preference parameters and another one is substitution elasticity. 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 pattern. The FHFDI model follows the Melitz theory to emphasize the importance of fixed trading costs, but it also captures consumers' preference. 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 taste bias of consumers.

For the elasticity of substitution among varieties, I 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 my 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 elasticity 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. [8] That is because in each sector, firms distinguished from each other in terms of ownership, production region and market. The difference in production region determines national differences of variety. [9]

3.2 Production

In sectors with heterogeneous firms, the total mass of potential firms is fixed. The productivity of firms follows a Pareto distribution, from which firms get their productivity draws before entry an industry. Entry into a market requires paying fixed trading costs that are specific to a destination market. The firm-level heterogeneity means that production is carried out only by firms that are

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[8] Differently, in the Tarr model, the final good sector is completely indifferent between a domestic or foreign variety. That 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.

[9] 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 location is the same as that of commodities produced in the same location by firms with different nationality.

productive enough to afford staying in the market given fixed trading costs. Even in the domestic market, there is a selection of firms because there are fixed trading costs in supplying the domestic market. Therefore, not all potential firms conduct production given the existence of fixed trading costs. Although the number of potential firms is fixed, the number of active firms in each market can vary with the possibility of entry into the market.

Facing the highest fixed trading costs, the most productive firms supply foreign markets through setting up subsidiaries. The subsidiaries of the most productive firms become foreign firms of the host region. The number of foreign firms is determined by the total mass of potential firms in home region and the probability of firms that are productive enough to invest in host region. Hence, in a host region such as China, there are two types of firms, domestic firms and foreign firms. The two type firms can supply all three markets (China, PTN and ROW). In supplying the PTN and ROW markets, domestic firms and foreign firms located in China choose exportation rather than FDI. The case that Chinese firms choose FDI to supply PTN and ROW has been captured by the existence of foreign firms owned by China operated in these markets. The case that foreign firms supply third market through re-investment is not considered in this study.

In supplying the export market, firms face higher fixed trading costs than supplying the local market. Following the Melitz theory, only more productive firms among each firm type can enter the export market. Thus, the number of exporters within each firm type is less than that of active firms in the host market. Trade liberalization alters productivity thresholds to enter each market and firm numbers change accordingly.

The following sub-sections discuss the production structures of foreign firms and domestic firms that characterize the monopolistically competitive industry with firm-level heterogeneity. The derivation of functions for domestic and foreign firms follows a similar way. To save space and clarify new features of this paper relative to literature, the following sections mainly show the functions of foreign firms.

3.2.1 Trade Barriers

Trade barriers consist of tariff barriers and non-tariff barriers (NTBs). In the FHFDI model, tariff barriers exist in agriculture (a) and the two manufacturing sectors ($m1$ and $m2$), while NTBs exist in all sectors. Thus, in the two services sectors, NTBs are the only trade restrictions. In comparison with tariff barriers, NTBs are more difficult to quantify. Many papers have endeavored to quantify NTBs, not least because NTBs are important in analyzing services trade and FDI.[10] This paper adopts the estimation of Petri et al. (2012), which is in turn drawn from the World Bank estimations (Helble, Shepherd, & Wilson, 2007; Looi Kee, Nicita, & Olarreaga, 2009). Their estimation of NTBs is well grounded in trade theory and accounts for different forms of trade protection. The estimation results coincide with expectation that poor countries tend to have more restrictive trade policies but they also face higher trade barriers on their exports.

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

Insert Table 1 here.

In the FHFDI model, NTBs in sector $s2$ are treated differently from those in other sectors. In other sectors, NTBs raise costs to imported goods and services, the same as tariff barriers. In sector $s2$, however, NTBs are modelled as tax equivalences that not only raise costs to imported services, but also generate rents to incumbent firms in the protected market. The inclusion of a rent-creating effect of services barriers is drawn from 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 to gain some monopoly power,

[10] See, for example, Hoekman (1996), Hanslow (2000) and Petri, Plummer, and Zhai (2012).

resulting in a rent-creating distortion in price. However, there is no exact measurement about the rent-creating effect and cost-raising effect of services barriers. Dee and Hanslow (2000) adopts a full rent-creating effect, but at the same time, they admit that in some services sectors, trade restriction raise costs. Konan and Maskus (2006) experiments with different allocation mechanisms of the total price wedge between the distortions of rent-creating and cost-raising.

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

$$v_j^{s2} = \alpha * \frac{\sum_i tn_{ij}^{s2}}{2}, \ \lambda_{ij}^{s2} = tn_{ij}^{s2} - v_j^{s2}, i \neq j \qquad \textbf{Eq.(7)}$$

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 equivalents of NTBs being imposed by 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 rent-creating effect in total price wedge from trade restrictions.

The calculation of 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 aside of j in the FHFDI model. The reason for calculating the rent share based on the average of NTBs is because the rent-creating effect occurs to all firms supply market j, and all the incumbent firms should have the same monopoly power due to trade restriction. Using the average of services barriers as the base of the rent share is the most suitable way I could find. The value of α is set to 10%. The value is chosen based on the tariff equivalents of NTBs and market structures of the three regions. In PTN and ROW, the main markets such as the US and EU are relatively competitive and firms are unlikely to have high monopoly power. 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 of the barriers is equal to a 7.66% price markup on marginal costs, which seems to be a high enough markup from trade restrictions.

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

$$t_{ij}^{s} = tm_{ij}^{s} + tn_{ij}^{s}, s \neq s2,\ t_{ij}^{s2} = \lambda_{ij}^{s2} \qquad \textbf{Eq.(8)}$$

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 $i = j$.

3.2.2. Fixed trading costs

As noted before, fixed trading costs determine firms' self-selection into each market. The fixed trading costs of domestic firms, FD_{ij}^{s}, differentiate themselves in terms of firms' operating region i, market j and sector s. The fixed trading costs of foreign firms, FF_{gij}^{s}, vary with one more index, the home region g. Operated in the same sector same region, fixed trading costs are higher for foreign firms when domestic and foreign firms enter the same market. In addition, fixed trading costs are higher in exportation when $i \neq j$ relative to $i = j$. In the FHFDI model, fixed trading costs of each firm type are exogenous and they are made up of capital, labor and intermediate input costs.

3.2.3 Production Variable Costs

Insert Figure 2 here

Production variable costs are made up of value added costs and intermediate costs, as shown in the production tree of Figure 2. 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 Leontief technology. Land is a specific factor for agriculture sector. In manufacturing and services sectors, firms use labor and capital as primary factors. Labor inputs of foreign firms are sourced from host region. Capital inputs of foreign firms are sourced from home region.

Capital inputs of domestic firms are sourced from three regions. Since foreign firms cannot exhaust all FDI from the home region, the excess FDI flow to domestic firms. Thus, in the production tree of domestic firms, capital input is first discomposed into domestic capital and FDI following a CES technology, and then FDI input is discomposed into different sources following a Leontief technology. [11]

For the layers with CES aggregation, firms minimize its cost according to the following cost minimization problem:

$$\min_{x_{gij}^{fs}} \sum_{f} w_{gi}^{fs}\, x_{gij}^{fs}$$

$$s.t. XF_{gij}^{s} = \omega_{gij}^{s} [\sum_{f} \delta_{gij}^{fs\,\frac{1}{\sigma'}} x_{gij}^{fs\,\frac{\sigma'-1}{\sigma'}}]^{\frac{\sigma'}{\sigma'-1}}$$

where w_{gi}^{fs} is the price of input f employed by foreign firms from home region g operated in region i industry s. Even though the input price is indexed by sector and regions, it does not necessarily change with all indexes. For instance, wage of labor is only specific to production region and it does not change across firm types and sectors. That is because I assume labor can freely move across sectors and firms but cannot move across borders. Returns to capital vary with all indexes.

x_{gij}^{fs} is the demand for input f of foreign firms from home region g operated in region i sector s sold to region j. Different from input prices, input demand varies across all indexes. ω_{gij}^{s} is a scale parameter of the production function and δ_{gij}^{fs} is a share parameter of input f. σ' is the CET transformation elasticity among inputs.

XF_{gij}^{s} is the industry output of foreign firms from home region g operated in region i industry s sold to region j. However, it is not the final industry output, but more like an aggregate of inputs. The final output for consumption equals demand, QF_{gij}^{s}. The relation between XF_{gij}^{s} and QF_{gij}^{s}

[11] Leontief technology is chosen to allocate FDI to different sources because of zero FDI values. 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.

without considering the quantity loss in international transportation (iceberg cost) is represented in the following equation:

$$QF_{gij}^{s} = \widetilde{\varphi F_{gij}^{s}} XF_{gij}^{s} \qquad \textbf{Eq.(9)}$$

$\widetilde{\varphi F_{gij}^{s}}$ is the industry average productivity of foreign firms in sector s from home region g operated in region i sold to region j. In the agriculture sector with homogeneous firms, $\widetilde{\varphi F_{gij}^{s}} = 1$, and output equals demand. In sectors with heterogeneous firms, $\widetilde{\varphi F_{gij}^{s}} > 1$, suggesting the final output is more than the aggregate of inputs.

The cost minimization problem yields the optimal demand for each input:

$$x_{gij}^{fs} = \frac{1}{\omega_{gij}^{s}} \frac{XF_{gij}^{s} {\delta_{gij}^{fs}}^{\sigma'} {w_{gij}^{fs}}^{-\sigma'}}{[\sum_f {\delta_{gij}^{fs}}^{\sigma'} {w_{gij}^{fs}}^{1-\sigma'}]^{\frac{\sigma'}{\sigma'-1}}} \qquad \textbf{Eq.(10)}$$

Bringing Eq.(13) to the cost function, we can get the due cost, CF_{gij}^{s}:

$$CF_{gij}^{s} = \frac{1}{\omega_{gij}^{s}} [\sum_f \delta_{gij}^{fs} {w_{gi}^{fs}}^{1-\sigma'}]^{\frac{1}{1-\sigma'}} \qquad \textbf{Eq.(11)}$$

CF_{gij}^{s} is the unit cost of XF_{gij}^{s} and $CF_{gij}^{s}/\widetilde{\varphi F_{gij}^{s}}$ is the unit cost of QF_{gij}^{s}. When the relation between demand and output is adjusted by iceberg costs and firm numbers, the unit cost of demand will be adjusted accordingly, which is illustrated in the next section.

3.2.4 Productivity Draw

Firms are assumed to draw their productivity level, φ, from a Pareto distribution with the lower bound $\varphi_{min} = 1$, and shape parameter γ. The cumulative distribution function of the Pareto distribution, $G(\varphi)$, and the density function, $g(\varphi)$ are:

$$G(\varphi) = 1 - \varphi^{-\gamma}, \; g(\varphi) = \gamma\varphi^{-\gamma-1} \qquad \textbf{Eq.(12)}$$

The shape parameter γ is specific to sector. It is an inverse measure of the firm heterogeneity. If it is high, it means that the firms are more homogeneous. It is also assumed that $\gamma > \sigma - 1$, with σ as the elastisity of substitution among varieties in a sector. This assumption is important in aggregation and it ensures that the size of distribution of firms has a finite mean (Zhai, 2008). The number of foreign firms in sector s from home region g operated in region i sold to region j, MF_{gij}^{s}, is:

$$MF_{gij}^{s} = N_{g}^{s}\left(1 - G\left(\varphi f_{gij}^{s\ *}\right)\right) \qquad \text{Eq.(13)}$$

N_{g}^{s} is the total mass of potential firms in home region g sector s, which is an exogenous variable and $\varphi f_{gij}^{s\ *}$ is the productivity threshold for foreign firms owned by region g operated in sector s region i to enter the market j. $1 - G\left(\varphi f_{gij}^{s\ *}\right)$ is the probability that foreign firms owned by region g operated in sector s region i can enter the market j, or the probability of foreign firms that are at a higher or at least the same productivity level as the productivity threshold. Since the total mass of potential firms is fixed, the number of foreign firms is totally dependent on productivity threshold.

With the assumption that each firm corresponds to one variety, the number of foreign firms represents the number of varieties produced by foreign firms. Adjusted by the Dixit-Stiglitz variety effect and iceberg cost, the relation between XF_{gij}^{s} and QF_{gij}^{s} becomes:

$$XF_{gij}^{s} = \frac{\tau_{ij}^{s} QF_{gij}^{s}}{\widetilde{\varphi F_{gij}^{s}}} MF_{gij}^{s\ \ 1/_{1-\sigma^{s}}} \qquad \textbf{Eq.(14)}$$

where τ_{ij}^{s} is the iceberg cost whereby only a fraction $1/\tau_{ij}^{s}$ arrives after shipping one unit of good from region i to region j ($\tau_{ij}^{s} = 1$ for $i = j$). The unit cost of QF_{gij}^{s} becomes $\frac{\tau_{ij}^{s} CF_{gij}^{s}}{\widetilde{\varphi F_{gij}^{s}}} MF_{gij}^{s\ \ 1/_{1-\sigma^{s}}}$.

3.2.5. Markup Pricing

The model assumes “large-group monopolistic competition”. Under this assumption, individual firms believe they are too small to influence the composite price of their group (Tarr, 2012). The optimal pricing rule for a monopolistic competition industry is to charge a constant markup over marginal cost which is referred to as the mark-up pricing rule given by:

$$PF_{gij}^{s} = (1 + v_{j}^{s}) \frac{\sigma^{s}}{\sigma^{s} - 1} \frac{(1 + t_{ij}^{s}) \tau_{ij}^{s} CF_{gij}^{s}}{\widetilde{\varphi F_{gij}^{s}}} MF_{gij}^{s\ \ 1/_{1-\sigma^{s}}} \qquad \textbf{Eq.(15)}$$

where PF_{gij}^{s} is the industry aggregate price of product s produced by foreign firms from home region g operated in region i sold to region$j$. $(1+v_j^s)$ is the price wedge from the rent-creating effect of NTBs in sector $s2$. $\frac{\sigma^s}{\sigma^s-1}$ is the mark-up drawn from optimal pricing rule; $(1+t_{ij}^s)$ is the trade variable costs on goods s being shipped from region i to region j and $\frac{\tau_{ij}^s CF_{gij}^s}{\widetilde{\varphi F_{gij}^s}} MF_{gij}^{s}{}^{1/1-\sigma^s}$ is the unit cost of QF_{gij}^s. Trade liberalization between i and j can pull down PF_{gij}^s through reducing trade variable costs and rents, and increasing the number of firms in market j.

For the agriculture sector (a) with homogeneous firms, the markup is zero and productivity is fixed and normalized to one. Their producer prices are simply equal to marginal costs:

$$PF_{gij}^{a} = (1+t_{ij}^{a})\tau_{ij}^{a} CF_{gij}^{a} \qquad \textbf{Eq.(16)}$$

3.2.6 Firm Profits (Productivity Threshold)[12]

Each foreign firm with productivity φf_{gij}^s makes the following profit from selling product s on the $i-j$ link:

$$\pi f_{gij}^{s} = \frac{pf_{gij}^s qf_{gij}^s}{1+t_{ij}^s} - cf_{gij}^s \frac{\tau_{ij}^s qf_{gij}^s}{\varphi f_{gij}^s} - FF_{gij}^s \qquad \textbf{Eq.(17)}$$

where the first component, $\frac{pf_{gij}^s qf_{gij}^s}{1+t_{ij}^s}$, gives the total revenue, the second component, $cf_{gij}^s \frac{\tau_{ij}^s qf_{gij}^s}{\varphi f_{gij}^s}$, gives the total variable cost and FF_{gij}^s is the fixed trading cost of selling on the $i-j$ link. Before deriving the productivity threshold, we substitute price and demand quantity in Eq.(20) by the optimal price and optimal demand as shown in the following two equations:

$$pf_{gij}^{s} = (1+v_j^s)\frac{\sigma^s}{\sigma^s-1}\frac{(1+t_{ij}^s)\tau_{ij}^s cf_{gij}^s}{\varphi f_{gij}^s} \qquad \textbf{Eq.(18)}$$

$$qf_{gij}^{s} = \theta_{ij}^{s}\theta FS_{ij}^{s}\theta F_{gij}^{s} Q_j^s [\frac{PQ_j^s}{pf_{gij}^s}]^{\sigma^s} \qquad \textbf{Eq.(19)}$$

[12] The lower case letters in this section are used to represent the variables for individual firms rather than industry aggregate variables.

For individual firms, price and demand are not adjusted by the Dixit-Stiglitz variety effect. The price equation (Eq.21) is drawn from (Eq.18). The demand function (Eq.22) is drawn from the optimal demand functions (Eq.5, 8, 9) in section 3.1.1. The unit cost faced by each firm is the same as the industry unit cost, $cf_{gij}^{s} = CF_{gij}^{s}$. After substitution, we obtain the maximized profit for each firm as follows:

$$\pi f_{gij}^{s} = \theta_{ij}^{s}\theta fs_{ij}^{s}\theta f_{gij}^{s}(1 + v_{j}^{s}\sigma^{s})(\frac{\tau_{ij}^{s}CF_{gij}^{s}}{(\sigma^{s}-1)\varphi f_{gij}^{s}})^{1-\sigma^{s}}(\frac{PQ_{j}^{s}}{(1+v_{j}^{s})(1+t_{ij}^{s})\sigma^{s}})^{\sigma^{s}}Q_{j}^{s} - FF_{gij}^{s} \qquad \textbf{Eq.(20)}$$

Foreign firms from region g in industry s are active on the $i - j$ link as long as the variable profit can cover the fixed trading costs. The marginal firm that makes zero profits produces at the threshold productivity level. Thus, the zero-cutoff level of productivity for foreign firms from region g supplying on the $i - j$ link is where:

$$\pi f_{gij}^{s}\left(\varphi F_{gij}^{s\ *}\right) = 0$$

Solving it, we get the productivity threshold for foreign firms from region g supplying on the $i - j$ link:

$$\varphi F_{gij}^{s^*} = \frac{\tau_{ij}^{s}CF_{gij}^{s}}{(\sigma^{s}-1)}(\frac{P_{j}^{s}}{\sigma^{s}(1+t_{ij}^{s})(1+v_{j}^{s})})^{\frac{\sigma^{s}}{1-\sigma^{s}}}(\frac{FF_{gij}^{s}}{Q_{j}^{s}(1+v_{j}^{s}\sigma^{s})\theta_{ij}^{s}\theta FS_{ij}^{s}\theta F_{gij}^{s}})^{\frac{1}{\sigma^{s}-1}} \qquad \textbf{Eq.(21)}$$

Any foreign firms from region g has a productivity level below $\varphi F_{gij}^{s^*}$ cannot afford to produce and supply on the $i - j$ link, and therefore exits. On the other hands, any firm that has a productivity level above $\varphi F_{gij}^{s^*}$ stays in the market. This is one of the most important functions in the FHFDI model. It reflects the main feature of the firm heterogeneity model. The productivity threshold is higher with higher costs, including fixed trading costs, production variable costs and trade costs. It is lower with higher price and demand, or revenue. It determines the probability of firms that can enter a specific market and in turn, determines the number of active firms in the market.

The formation of RCEP will lower the productivity threshold for firms located in member countries to enter partners' markets. The main reason is the reduction in trade costs. Specifically, t_{ij}^{s} will be reduced by RCEP and the reduction of t_{ij}^{s} results in lower $\varphi F_{gij}^{s^*}$. On the contrary, we are not sure about the results from the reduction of v_j^s. In addition, trade liberalization will lead to lower productivity threshold through reducing production variable costs since the price of intermediate goods will goes down along with the formation of RCEP.

With the Pareto distribution, the average productivities for foreign firms from region g supplying on the $i-j$ link can be expressed as:

$$\widetilde{\varphi F_{gij}^s} = \varphi F_{gij}^{s^*}\left(\frac{\gamma^s}{\gamma^s-\sigma^s+1}\right)^{1/(\sigma^s-1)} \qquad \textbf{Eq.(22)}$$

The average productivity enters the industry aggregate demand and price functions (Eq.17, 18).

3.2.7 Industry Profits

With the assumption of no entry and exit of firms, the industry profits for each firm type could be non-zero. The function of industry profit follows the format of individual firms' profit equation, with substitution of firm level variables with industry aggregate variables.

$$\Pi F_{gij}^s = \frac{PF_{gij}^s QF_{gij}^s}{1+t_{ij}^s} - CF_{gij}^s XF_{gij}^s - MF_{gij}^s FF_{gij}^s \qquad \textbf{Eq.(23)}$$

where ΠF_{gij}^s is the total industry profits of foreign firms from home region g supplying on the $i-j$ link. The same as the profit function for individual firms, the first component in Eq.(26) is the total industry revenue; the second component is the total industry variable cost and the third component is the total industry fixed trading cost.

Following the way of Zhai (2008), I calibrate the fixed trading costs, FF_{gij}^s, which could be expressed as:

$$FF_{gij}^s = \frac{PF_{gij}^s QF_{gij}^s}{\left(1+v_j^s\right)\left(1+t_{ij}^s\right)}\frac{1}{\sigma^s}\frac{1}{MF_{gij}^s}\frac{\gamma^s-\sigma^s+1}{\gamma^s}(1+v_j^s\sigma^s) \qquad \textbf{Eq.(24)}$$

Bringing Equations (14, 15 & 24) into Eq.(23), the total industry profits can be simplified to:

$$\Pi F_{gij}^s = \frac{PF_{gij}^s QF_{gij}^s}{\left(1+v_j^s\right)\left(1+t_{ij}^s\right)}\frac{1}{\sigma^s}\frac{\sigma^s-1}{\gamma^s}(1+v_j^s\sigma^s) \qquad \textbf{Eq.(25)}$$

3.3 Capital allocation

Capital allocation is an additional and distinguished block in FDI-CGE models. This section follows the way 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 rate of return before illustrating how capital being allocated.

3.3.1 Rate of Return

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

$$R = \frac{WK}{PA} \qquad \textbf{Eq.(26)}$$

where R is rate of return, WK is rental price of capital and PA is capital price. Rental price is determined by the market clearance condition of capital. It varies across regions and sectors. Capital price is specific to the host region and is uniform across industries. It is equal to the price of capital creation, which can be expressed as:

$$PA_j = \frac{EINV_j}{\sum_s QINV_j^s}, EINV_j = \sum_s PQ_j^s QINV_j^s \qquad \textbf{Eq.(27)}$$

where PA_j is the price of investment in region j, $EINV_j$ is the expenditure on investment of region j and $QINV_j^s$ is investment demand for product s in region j.

With rental price and investment price, rate of return can be derived. Following the assumption of Petri (1997) that each unit of investment provides a return of $1, the inverse of rate of return is the price of asset, $1/R$. Asset price is the channel through which rate of return enters the system of capital allocation and the details are given in the following section.

3.3.2. Capital Allocation Tree

Insert Figure 3 here

Following the rule of chasing the highest return activities, capital is allocated to different sectors, regions and firms according to Figure 3. 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 choice of sector, holding only total wealth constant, are relatively low. The relatively low transformation elasticity of capital across sectors captures the idea that FDI knowledge capital will often be sector-specific (Markusen, 2002). The next layer allocates regional assets between domestic and foreign investment (FDI) by sector. Then, foreign investments are allocated to specific host regions. This level determines bilateral FDI flow between regions, which reflects the result that the model looks for. Finally, FDI in each host region is allocated between domestic firm and foreign affiliate. Each of these branches uses a CET-based allocation function except the final layer. In the final layer, FDI is distributed to domestic firms and foreign firms following a Leontief technology. [13]

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 asset with RK_g^s as rate of return. $AK_g^s \frac{1}{RK_g^s}$ is the value of 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, there is a constraint of the total asset value, in which rate of return is contained. Through this way, rate of return enters the system to determine capital allocation. αa_g^s is the share parameter for asset 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. The following transformation elasticity of asset is all set to the corresponding value in the FTAP model.

[13] The reason for adopting 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.

Solving the utility maximization problem, we get the optimal capital supply in each sector:

$$AK_g^s = \frac{\alpha a_g^s {RK_g^s}^{\sigma_1^a} W_g}{\sum_c \alpha a_g^c {RK_g^c}^{\sigma_1^a - 1}} \qquad \textbf{Eq.(28)}^{14}$$

Eq.(28) shows that the supply of asset, AK_g^s**,** positively correlates with its rate of return, RK_g^s, which reflects the rule of capital allocation that capital chases high rate of return. The capital allocation rule is even clearer in the other layers. In the second layer where sectoral assets are distributed to domestic and foreign markets, the optimal supplies are:

$$AD_g^s = \alpha D_g^s AK_g^s [\frac{RD_g^s}{RK_g^s}]^{\sigma_2^a}, AF_g^s = \alpha F_g^s AK_g^s [\frac{RF_g^s}{RK_g^s}]^{\sigma_2^a} \qquad \textbf{Eq.(29)}$$

where AD_g^s and AF_g^s are the assets of sector s region g being allocated to domestic market and foreign markets respectively, αD_g^s and αF_g^s are the preference shares of domestic and foreign markets and RD_g^s and RF_g^s are the corresponding rates of return. σ_2^a is the transformation elasticity of assets among domestic and foreign markets, which is set to 1.3.

In the third layer, AF_g^s is allocated to different foreign markets and the optimal supply of assets from region g to region i in sector s is:

$$AFDI_{gi}^s = \alpha FDI_{gi}^s AF_g^s [\frac{RFDI_{gi}^s}{RF_g^s}]^{\sigma_3^a}, g \neq i \qquad \textbf{Eq.(30)}$$

where $AFDI_{gi}^s$ is the FDI invested by home region g to host region i, $RFDI_{gi}^s$ is the rate of return and αFDI_{gi}^s is the preference share of region i. $AFDI_{gi}^s$ is an important variable to the model result since it reflects bilateral FDI flow. Trade liberalization under RCEP would change its value and its changes represent the FDI impact of RCEP. σ_3^a is the transformation elasticity of assets among different host regions, which is set to 1.4.

In the final layer, $AFDI_{gi}^s$ is distributed to domestic firms and foreign firms in region i by following a Leontief function:

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[14] The function of AK_g^s looks different from the conventional optimization results of CET aggregation problems. That is because W_g is not a physical asset and does not have a price. In the other layers with price in total asset value, the optimal supply of asset is expressed in a similar way as the optimal demand in section 3.1.1.

$$AFDID_{gi}^{s} = \alpha N_{gi}^{s} AFDI_{gi}^{s}, AFDIF_{gi}^{s} = \alpha F_{gi}^{s} AFDI_{gi}^{s}, g \neq i \qquad \textbf{Eq.(31)}$$

where $AFDID_{gi}^{s}$ is the FDI being used by domestic firms and $AFDIF_{gi}^{s}$ is the FDI being used by foreign firms, while αN_{gi}^{s} and αF_{gi}^{s} are the corresponding shares. In some cases, αN_{gi}^{s} equals to zero, but αF_{gi}^{s} is always higher than zero.

3.4 Household Income and Closure

3.4.1 Household Income

In each region, household is the factor owner and collects income from supplying factors to firms. Factor income in this model is different from conventional models. In conventional model, factor income is equal to the production costs of value added. In the FHFDI model, factor income contains factor-attributed fixed trading costs and profits (hereafter, FP) on top of value added costs. That is, factor income is equal to the sum of factor-attributed FP and production variable costs. “Factor-attributed” means the share of factor input in total costs and profits given that factor is not the only input. Intermediate inputs are important complements to factors in fixed trading costs and value added costs. The distribution of costs and profits between factor and intermediates is according to the shares of each in total inputs. The household income is expressed as:

$$\begin{aligned} YH_j = {} & WLAN_j LAN_j + WL_j L_j + \sum_{s} QDK_j^s WDK_j^s \\ & + \sum_{s} \sum_{g} [QFDID_{jg}^{s} WFDID_{jg}^{s} + QFDIF_{jg}^{s} WFDIF_{jg}^{s}] \\ & + \sum_{ss} \sum_{i} [(SDK_{ji}^{ss} + SDL_{ji}^{ss})(FD_{ji}^{ss} + \Pi D_{ji}^{ss})] \qquad \textbf{Eq.(32)} \\ & + \sum_{ss} \sum_{i} \sum_{g} [SFL_{gji}^{ss}(FF_{gji}^{ss} + \Pi F_{gji}^{ss})] \\ & + \sum_{ss} \sum_{i} \sum_{g} [SFK_{jgi}^{ss}(FF_{jgi}^{ss} + \Pi F_{jgi}^{ss})] \end{aligned}$$

where YH_j is the household income in region j. The first component is the income from land endowments of region j. The second is the income from labor inputs in value added costs of domestic and foreign firms in region j. The third one is the income from domestic capital inputs in value added costs of domestic firms. The next summation represents the income from FDI owned by region j invested in the value added of firms located in foreign regions. These are the total factor income from value added costs.

The next three components represent factor income from fixed trading costs and profits. Since FP exist only in sectors with heterogeneous firms, the factor income is summed over sector index ss, rather than s. The first is the income from FP of domestic firms being distributed to labor and domestic capital. SDL_{ji}^{ss} and SDK_{ji}^{ss} are the shares of labor and domestic capital in the total inputs of labor, domestic capital and intermediate goods of domestic firms. The second is the income from FP of foreign firms operated in region j being distributed to labor since foreign firms source labor inputs from local region. SFL_{gji}^{ss} is the share of labor in total inputs of foreign firms. The last one is the income from FP of foreign firms owned by region j being distributed to FDI since foreign firms source capital input from home region. SFK_{jgi}^{ss} is the share of FDI in total inputs of foreign firms. The detailed functions of these shares will be given in the calibration section 5.4.

3.4.2 Goods Market Clearance

Equilibrium in the good markets requires that output equals demand. For sectors with heterogeneous firms, the market clearance is represented by Eq.(14). For the agriculture sector with homogeneous firms, the market clearance is expressed as:

$$XF_{gij}^{a} = \tau_{ij}^{a} QF_{gij}^{a} \qquad \textbf{Eq.(33)}$$

where XF_{gij}^{a} is the output of foreign firms from home region g operated in region i and sold to region j in sector a, τ_{ij}^{a} is the iceberg cost and QF_{gij}^{a} is the demand for commodity a in region j.

Another thing needs to note in goods market is the distribution of aggregate demand. The aggregate demand, as represented by Eq.(1), is allocated to intermediate inputs, household demand, government demand, investment demand and international transportation demand, as shown by the following equation:

$$Q_j^s = \sum_c \sum_i INTCD_{ji}^{sc} + \left[\sum_{ss} \sum_i SDI_{ji}^{sss}\left(FD_{ji}^{ss} + \Pi D_{ji}^{ss}\right)\right]/PQ_j^s + \sum_g \sum_c \sum_i INTCF_{gji}^{sc} + \left[\sum_{ss} \sum_i SFI_{gji}^{sss}\left(FF_{gji}^{ss} + \Pi F_{gji}^{ss}\right)\right]/PQ_j^s + +QH_j^s + \overline{QG_j^s} + \overline{QINV_j^s} + \overline{TS1_J} \quad \text{Eq.(34)}$$ [15]

where $INTCD_{ji}^{sc}$ is the intermediate demand for commodity s of domestic firms in sectors c operated on the $j - i$ link. The first component is the intermediate inputs in value added of domestic firms. The second term represents intermediate inputs in FP of domestic firms. SDI_{ji}^{sss} is the share of intermediate good s in total inputs of domestic firms excluding FDI inputs. The same as the shares of labor and capital, the function of SDI_{ji}^{sss} is given in the calibration section 5.4. Since costs and profits are in value terms, the FP being distributed to intermediate goods are divided by price PQ_j^s to get the demand quantity of intermediate good s. Similarly, $INTCF_{gji}^{sc}$ is the intermediate demand for commodity s of foreign firms in sectors c from home region g operated on the $j - i$ link. The third component is the intermediate inputs in value added of foreign firms operated in region j. The following component represents the intermediate inputs in FP of foreign firms operated in region j. SFI_{gji}^{sss} is the share of intermediate good s in total inputs of foreign firms. The remaining components represent household demand, QH_j^s, government demand, QG_j^s, investment demand, $QINV_j^s$, and international transportation demand, $TS1_j$.

3.4.3 Factor Market Clearance

Equilibrium in the factor markets requires that endowments equal demand. The capital market has more strict equilibrium constraints. That is, it requires not only the clearance of total capital, but also the clearance of capital in three sub-markets:

$$AD_g^s = QDK_g^s * PA_g, \; AFDID_{gi}^s = QFDID_{gi}^s * PA_i, \; AFDIF_{gi}^s = QFDIF_{gi}^s * PA_i, g \neq i \quad \textbf{Eq.(35)}$$

The first equation represents the constraint that asset being supplied to the domestic market of sector s region g should be equal to the demand for domestic capital. QDK_g^s is the physical domestic capital demanded by domestic firms. Multiplying by capital price in the production

[15] The variables with a bar on top are exogenous.

region, PA_g, the demand for physical capital turns to asset demand. The second equation represents the constraint that FDI supplied from region g to domestic firms in region i should be equal to the demand for FDI from domestic firms. The last represents the constraint that FDI supplied from region g to foreign firms owned by region g operated in region i should be equal to the demand for FDI from corresponding foreign firms.

3.4.4 Additional Closures

There are 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 tariff, which is collected from imported goods on the base of their pre-tax value.[16] In the net 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 to the total supply of services from all regions. In the FHFDI model, the demand for international transport services is reflected by the iceberg-cost of trade and the supply of services from each region is the international transportation demand in Eq.(34), $TS1_j$. For each region, the supply of international transport services may be not equal to the demand for services from its imports of goods. The difference between supply and demand generates foreign savings from the international transportation pool.[17]

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. The two trade balances are:

$$FSAVD_{ij} = \sum_s [\frac{PD_{ij}^s QD_{ij}^s}{1 + t_{ij}^s} - \frac{PD_{ji}^s QD_{ji}^s}{1 + t_{ji}^s}], i \neq j \qquad \text{Eq.(36)}$$

[16] For a simplification, all other taxes aside of tariff are not taken into account in this study. Thus, the results from this study are more like experiment results than prediction.

[17] Because of the similarity in the calculation of iceberg cost and tariff income, and the calculation of government demand and international transportation services demand, I integrated the international transportation services balance into the net government balance, and thus the government saving includes saving from the international transportation services pool.

$$FSAVF_{ij} = \sum_s [\sum_g \frac{PF^s_{gij} QF^s_{gij}}{1+t^s_{ij}} - \sum_h \frac{PF^s_{hji} QF^s_{hji}}{1+t^s_{ji}}], i \neq j, g \neq i, h \neq j$$

where $FSAVD_{ij}$ is the foreign saving from region i to region j by trading commodities produced by domestic firms in each region and $FSAVF_{ij}$ is the foreign saving from region i to region j by trading commodities produced by foreign firms in each region.

The international capital transaction balance captures the movement of FDI and profits of foreign firms across regions, which is expressed as:

$$FSAVK_{ij} = \sum_s [WFDID^s_{ij} QFDID^s_{ij} + WFDIF^s_{ij} QFDIF^s_{ij} - WFDID^s_{ji} QFDID^s_{ji} - WFDIF^s_{ji} QFDIF^s_{ji}] + \sum_g \sum_{ss} [SFK^{ss}_{ijg} (FF^{ss}_{ijg} + \Pi F^{ss}_{ijg})] - \sum_g \sum_{ss} [SFK^{ss}_{jig} (FF^{ss}_{jig} + \Pi F^{ss}_{jig})]$$ **Eq.(37)**

where $FSAVK_{ij}$ is the foreign saving from the capital account from region i to region j. The first summation represents the net FDI income of region i, which equals to the income from outward investment less the payment to inward FDI. The second summation represents the income from outward investment in fixed trading costs and inward transfer of profits. The third summation is the payment to inward investment in fixed trading costs and outward transfer of profits. The investment-savings equilibrium requires that domestic investment equals the sum of household saving, government saving and foreign savings.

4 Data and Calibration

The model is calibrated to the GTAP 8.0 global database. 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 is used to split the capital account of the GTAP SAM table into three capital accounts, including one domestic capital account and two FDI accounts with FDI being differentiated by home region. The foreign affiliate sales data is used to split the outputs in each sector into the outputs of domestic firms and foreign firms.

Using input-output ratios of the GTAP data, the inputs of intermediates and factors can be derived for the production activity accounts of domestic and foreign firms. The input-output ratios for foreign firms have been adjusted to reflect the fact that multinationals from developed countries usually outsource labor-intensive tasks, while FDI from developing countries is usually very low. Thus, the capital-output ratio of foreign firms is assumed to be lower while the labor-output ratio is higher than the counterparts in the GTAP data.

Apart from the extensions in capital and production activity accounts, the GTAP SAM table is further extended in terms of firms' supplying markets. In the FHFDI model, the industrial aggregate output of each firm type is sold to three markets, one domestic market and two export markets. For instance, XD_{ij}^{s} is the output of domestic firms in sector s region i and sold to market j, and j stands for the three regions in the model (China, PTN and ROW). The inputs that used to produce XD_{ij}^{s} are also indexed in supply market j. Thus, we need to split the production activity accounts further into three markets. According to the GTAP SAM table, firms in PTN and ROW have one more export market, which is the intra-regional export market. However, the FHFDI model does not differentiate domestic market from intra-regional export market. To be consistent with the model, I removed intra-regional trade from the PTN and ROW SAM tables. The detailed documentation about the construction of my SAM table is presented in Appendix A.

Table 2 reports some major parameters used in the model, most of which are drawn from Zhai (2008). The markup ratios are set equal to 25% for the pro-fragmentation manufacturing sector ($m1$), 20% for the other manufacturing sector ($m2$), and 30% for the services sectors. Given that markup ratio is equal to $\frac{\sigma}{\sigma-1}$, the elasticity of substitution among varieties 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 Pareto distribution of productivity can be calibrated based on the assumption of Zhai (2008) that the profit ratio (expressed in shape parameter) in total markup is estimated to be 64.5%.

The last column of Table 2 displays transformation elasticity between inputs in production. They are drawn from the value added elasticity of the GTAP model. In each sector of my model, the same transformation elasticity is applied in all layers of the production tree and the same elasticity is applied in the production activity of domestic firms and foreign firms.[18]

[18] Without a more reliable source of elasticity of transformation, this is the best way I could find.

Insert Table 2 here

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

Next, I calibrate the shares of active firms in every market based on three assumptions. First, 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, produce and sell in the host market. The first two assumptions follow the Zhai model and the third one is given by author.

With the first assumption, we have the proportions of exporters in the total numbers of active firms within each firm type:

$$\left(\frac{PD_{ij}^{ss}*QD_{ij}^{ss}}{PD_{ii}^{ss}*QD_{ii}^{ss}}\right)^{0.6}=\frac{1-G(\varphi D_{ij}^{ss^*})}{1-G(\varphi D_{ii}^{ss^*})},\ \left(\frac{PF_{gij}^{ss}*QF_{gij}^{ss}}{PF_{gii}^{ss}*QF_{gii}^{ss}}\right)^{0.6}=\frac{1-G(\varphi F_{gij}^{ss^*})}{1-G(\varphi F_{gii}^{ss^*})} \qquad \text{Eq.(38)}$$

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

$$\varphi D_{ij}^{ss*} = 1 - G(\varphi D_{ij}^{ss*})^{-\frac{1}{\gamma^{ss}}}, \varphi F_{gij}^{ss*} = 1 - G(\varphi F_{gij}^{ss*})^{-\frac{1}{\gamma^{ss}}} \quad \textbf{Eq.(39)}$$

Then, the industry aggregate productivity can be derived by following Eq.(22).

Drawn from the findings of Oyamada (2014), I 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 Eq.(40), which is derived from the demand equations, the price functions, average productivity functions and productivity threshold functions. The fixed costs of domestic firms can be derived following the same way.

$$PF_{gij}^{ss} * QF_{gij}^{ss} = \left(1 + v_j^{ss}\right)(1 + t_{ij}^{ss})\sigma^{ss} \frac{\gamma^{ss}}{\gamma^{ss} - \sigma^{ss} + 1} \frac{1}{1 + v_j^{ss}\sigma^{ss}} MF_{gij}^{ss} ff_{gij}^{ss} \quad \textbf{Eq.(40)}$$

The industry revenue from production activities should equal to the sum of fixed trading costs, production variable costs and profits. But the SAM table does not have accounts reflecting FP. Following the way of Hosoe, Gasawa, and Hashimoto (2010), the inputs cells in production activity accounts of the SAM table are presumed to contain FP. Therefore, to derive the net initial equilibrium values of inputs in variable costs, we must subtract from the input values of the SAM table the amount of the FP supposed to be included in these cells. In the calculation of FP contained in each of these cells, we assume that it is in proportion to the amount of input value in each cell, respectively.

The net initial equilibrium value of inputs (after subtracting FP) is computed as follows, with labor input in foreign firms as an example:

$$LF_{gij}^{ss} = SAMFL_{gij}^{ss} - SFL_{gij}^{ss}(FF_{gij}^{ss} + \Pi F_{gij}^{ss}) \quad \textbf{Eq.(41)}$$

where LF_{gij}^{ss} is the labor input in value added of foreign firms from home region g, operated in host region i, sold in region j in sector ss, $SAMFL_{gij}^{ss}$ is the original labor input drawn from the SAM table and SFL_{gij}^{ss} is the share of labor in total inputs of labor, FDI and intermediate goods. The following equation shows the calculation of SFL_{gij}^{ss} together with the shares of capital and intermediate goods, which have been used in equations (32, 34, 37):

$$SFL_{gij}^{ss} = \frac{SAMFL_{gij}^{ss}}{SAMFL_{gij}^{ss} + SAMFK_{gij}^{ss} + \sum_c SAMFI_{gij}^{css}}, \quad \textbf{Eq.(42)}$$

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

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

For domestic firms,

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

$$SDK_{ij}^{ss} = \frac{SAMDK_{ij}^{ss}}{SAMDL_{ij}^{ss}+SAMDK_{ij}^{ss}+\sum_c SAMDI_{ij}^{css}},$$ **Eq.(43)**

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

where SDI_{ij}^{sss} is the share of intermediate good s in total inputs of labor, domestic capital and intermediate goods in domestic firms located in sector ss, SDK_{ij}^{ss} is the share of domestic capital and SDL_{ij}^{ss} is the share of labor.

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

Insert Table 3 here

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

$$\beta_j^s = \frac{\eta_j^s SB_j^s}{\sum_c \eta_j^c SB_j^c + \eta_j^{sav} SB_j^{sav}},\ \beta_j^{sav} = \frac{\eta_j^{sav} SB_j^{sav}}{\sum_c \eta_j^c SB_j^c + \eta_j^{sav} SB_j^{sav}}$$ **Eq.(44)**

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

To calibrate the minimal consumption on each commodity of household, we need another parameter, 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 substitution elasticity of variety, $Fr = -\sum_s \sigma^s/5$.

Then, we can calculate the minimal consumption as:

$$B_j^s = QH_j^s + \frac{\beta_j^s}{PQ_j^s}\frac{YH_j}{Fr}, B_j^{sav} = HSAV_j + \frac{\beta_j^{sav}}{PQ_j^{sav}}\frac{YH_j}{Fr} \qquad \textbf{Eq.(45)}$$

where B_j^s and B_j^{sav} are minimal consumption on commodity s and saving; QH_j^s and $HSAV_j$ are the consumptions at 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 Model Tests and Results

5.1 Model Tests

Prior to using the FHFDI model to generate results, the model is tested through a way of reproducing the results of Zhai (2008). Since the FHFDI model has extended the Zhai model in several ways, we would not expect exactly the same results from the two models. However, the results should be similar to each other since the FHFDI model follows the Zhai model closely. To make the FHFDI model closer to the Zhai model, I abstract the FHFDI model by removing the rent-creating effect of services barriers. Two scenarios from the Zhai model are experimented with the FHFDI model:

Scenario 1. a 50% worldwide reduction of tariff and NTBs in all sectors.

Scenario 2. a 50% worldwide reduction in fixed exporting costs in manufacturing sectors.

Scenario 1 is not exactly the same as that from the Zhai model. Instead of a 50% worldwide reduction of tariff and NTBs in all sectors, the Zhai model simulates a 50% worldwide reduction of tariff barriers in manufacturing industry only. The reason for adopting a scenario of much bigger trade liberalization is that tariff reduction in manufacturing sectors might be a substantial trade liberalization initiative at the base year of the Zhai model (2001), but it is not at the base year of my model (2007). In 2007, tariff barriers in global manufacturing sectors were already very low, less than 10% in PTN and ROW, and less than 30% in China. A 50% reduction would be a too small policy shock. Under the new scenario, the FHFDI model finds that the global welfare would gain US$832 billion. The welfare gain is bigger than the gain of US$75 billion from the Zhai model, which seems to be reasonable as the simulation scenario defines high-level trade liberalization.

Scenario 2 is exactly the same as that in the Zhai model. Simulation results from the FHFDI model indicate a welfare gain of US$263 billion, which is close to the Zhai result from the same scenario (US$372 billion). The close results from the two models infer that the FHFDI model is able to simulate trade policies and generate reliable results.

5.2 Simulation Scenarios

RCEP comprises ASEAN and its 6 dialogue partners. With the 6 dialogue partners, ASEAN has formed 5 FTAs, including ASEN-China, ASEAN-Japan, ASEAN-Korea, ASEAN-Australia-New Zealand and ASEAN-India. Based on the commitments in these FTAs, Fukunaga and Isono (2013) state that RCEP should reach a 95% tariff elimination, otherwise it will have no effect on most of its member countries. Since it is not easy to identify the 5% of products that will remain high tariffs after RCEP, this paper assumes a 95% tariff reduction on all goods.

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

- NTBs of China and PTN are reduced to a level of the average of NTBs in Japan and Korea from the estimation of the World Bank.
- Except sectors $s1$ and $s2$ of China, NTBs of China and PTN are reduced to a level of the average of NTBs in Japan and Korea. NTBs in sectors $s1$ and $s2$ of 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 RCEP because it represents the middle level of NTBs among RCEP member countries. With this target, the NTBs reductions in most sectors of China and PTN are less than 0.2, which seems to be achievable for RCEP (Table 4).

The reason that sectors $s1$ and $s2$ of China are dealt differently in the two scenarios is because NTBs in these sectors are extraordinarily high relative to other sectors and sectors in PTN (Table 1). In the first scenario, NTBs in sectors $s1$ and $s2$ of China are assumed to be reduced to a level of the average of NTBs in Japan and Korea. Under this scenario, tariff-equivalents of NTBs of China are reduced by RCEP from 0.747 to 0.1685 in sector $s1$ and from 0.766 to 0.181 in sector $s2$. This scenario represents a big step of services liberalization in China, which is termed as "big step" for the convenience of writing in the following part. In the second scenario, sectors $s1$ and $s2$ of China are assumed to be reduced by the same margin as those in PTN. Under this scenario, tariff-equivalents of NTBs of China are reduced by RCEP from 0.747 to 0.553 in sector $s1$ and from 0.766 to 0.571 in sector $s2$. This scenario is termed as "small step" in the following part.

A third scenario I experiment with is a 50% reduction in fixed trading costs for firms operated on the China-PTN link. This scenario is based on a consideration that RCEP might reduce the time and costs occurred in registration, approval and operation for firms from partner countries, which could be simulated as a reduction in fixed trading costs. For domestic firms in China and PTN, only the exporters operated on the China-PTN link face a 50% reduction in fixed trading costs. Firms supplying domestic market and the ROW market face the initial fixed trading costs. Foreign firms owned by China or PTN and operated in each other's market also face a 50% reduction in fixed trading costs, no matter which market they supply.

Therefore, I have three scenarios about the potential achievements of RCEP in trade liberalization to be experimented with:

Scenario 1. Small step. Services barriers of China are reduced by a small margin. Tariff barriers on all goods are reduced by 95%.

Scenario 2. Big step. Services barriers of China are reduced by a big margin. Tariff barriers on all goods are reduced by 95%.

Scenario 3. Scenario 2, plus a 50% reduction in fixed trading costs of firms operated on the China-PTN link.

Table 4 shows the simulated reductions of tariff and NTBs in China and PTN. The target of 95% tariff elimination is reflected by small reductions in most sectors because these sectors have already reached a high level of liberalization before RCEP. The agriculture sector of PTN has a relatively big tariff reduction, which relates to the high protections in this sector. Different from the small tariff reduction margins, NTBs reduction margins in most sectors are more than 10%, with services sectors of PTN almost reaching 20%. Based on the simulation scenarios about RCEP, there are two reductions of NTBs for each of the services sectors in China. One reduction is exactly the same as that in the corresponding sectors in PTN, which represents a small step of services liberalization in China (Scenario 1). Another reduction reflects a big step of services liberalization in China (Scenario 2).

Insert Table 4 here

5.2. The impacts of RCEP on FDI and welfare of China

Simulation results suggest that China can gain FDI and welfare from RCEP under all three scenarios. Figure 4 shows FDI increases in China in the three scenarios. FDI is measured in real value terms, which uses constant price of the base year. In scenario 1, a small step of services liberalization in China with a 95% tariff reduction and NTBs being reduced to the average of Japan and Korea in RCEP member countries, the total FDI in China increases by US$799 million, that is, 2% of China's FDI stock. Among the total FDI increase, services sector $s2$ takes 95.5%, which means services completely dominate FDI increase with comprehensive trade liberalization on goods and services.

Insert Figure 4 here

Scenario 2 differs from scenario 1 only in terms of the step of services liberalization in China. In scenario 2, China is assumed to reduce services barriers substantially from 75% to less than 20%. FDI increase in services sectors reaches US$1.77 billion, which is more than double that in scenario 1. The increase in other sectors grows from US$36 million in scenario 1 to US$75 million in scenario 2. The degree of services liberalization not only correlates to FDI in services, but also influences FDI in goods sectors. One interpretation for the correlation between services liberalization and FDI in other sectors is that services such as finance and telecommunication are key intermediates in the other sectors of the economy. The improvement of efficiency in services benefits the whole economy.

The most dramatic FDI increase in China happens in scenario 3, that is scenario 2 plus a 50% reduction in fixed trading costs for firms operated on the China-PTN link. Total FDI increase in China in scenario 3 is US$11.6 billion, with US$11 billion flows to services. FDI in other sectors also increases significantly, reaching US$572 million. The impact of reduction in fixed trading costs is clearly shown in Table 5. Table 5 displays FDI increases in each sector of China from PTN and ROW under scenarios 2 and 3. In general, FDI increases by less than 5% without the reduction in fixed trading costs, and by around 30% with the reduction. The much bigger FDI increase in scenario 3 suggests that FDI is very sensitive to fixed trading costs. Reduction in fixed trading costs allows more firms to export in the free trade area and more foreign firms to invest in member countries as a result of drop in productivity thresholds.

Insert Table 5 here

Comparing FDI increases from PTN and ROW, I find that changes in FDI from the two regions are very similar. But in scenario 3, the FDI changes in China from the two regions show some diverse patterns in sectors $m1$ and $s1$. In sector $m1$, FDI from PTN increases by 29%, but FDI from ROW decreases by 11.8%. That could be explained by the preferential reduction in fixed trading costs for firms from PTN. In sector $s1$, FDI from both of the two regions increases in China, with a bigger increase for FDI from ROW. The big increase of FDI from ROW after the bilateral reduction in fixed trading costs between China and PTN might relates to high returns from the China market as a consequence of market expansion and efficiency improvement.

The FDI increase shown in Figure 4 has not reflected the whole impact of RCEP. As noted before, the vertical fragmentation effect of RCEP on FDI flow to sector $m1$ cannot be captured by the FHFDI model due to no specific treatment to trade in intermediate goods. Based on the results for ACFTA in the previous studies, the vertical fragmentation effect can increase FDI by 26.7% in the pro-fragmentation sectors, $m1$. Assuming that RCEP has a similar vertical fragmentation effect as ACFTA on FDI flow to China, I add US$106 million to the FDI increases in Figure 4.[19] Figure 5 presents the FDI increases in real value terms after adding the extra FDI from the vertical fragmentation effect. It makes the FDI increase in other sectors more significant, but does not change the dominance of services sectors.

Insert Figure 5 here

RCEP not only promotes FDI to China, but also increases its welfare (Figure 6). The scenario of a small step services liberalization of China under RCEP generates a US$46.6 billion welfare gain, which accounts for 0.5% of China's GDP. With a big reduction in services barriers, the welfare gain of China increases to US$72.5 billion. The biggest welfare gain happens in scenario 3 with a 50% reduction in fixed trading costs. In this scenario, China can gain US$124.5 billion, accounting for 1.3% of its GDP. The welfare results are in line with general findings about the welfare effect of trade liberalization on China.

Insert Figure 6 here

Apart from the overall FDI effect of RCEP, the FHFDI model is able to demonstrate the market expansion and plant rationalization effects of FTA on FDI identified in the previous studies. Prior to show these effects on FDI through foreign firms, Table 6 displays total sales of firms located in each region by market in scenario 1 (small step services liberalization in China). Firms in China and PTN increase exports dramatically to each other's market after RCEP, except the agriculture sector. In the manufacturing and services sectors, firms in China increase exports to the PTN market by more than 50%. In sector $m1$, the increase is as high as 90.6%. Firms in PTN also significantly expand exports to the China market, although less dramatic than the export expansion from China to PTN in most sectors. In this sector $m1$, exports from PTN to China increase by 111.5%.

Insert Table 6 here

The different performance of agriculture from other sectors relates to the assumption that firms in agriculture are homogeneous rather than heterogeneous as in other sectors. This assumption leads to export expansion of agriculture only in terms of intensive margin. In other sectors, trade liberalization cause export expansion in terms of both intensive and extensive margin. The

[19] The base year FDI asset of China is US$397.5 million. $397.5 * 0.267 = 106$

capture of extensive margin is an advantage of the firm heterogeneity model (Zhai, 2008). With only an intensive margin of export expansion, the agriculture sector shows less significant exports increase, particularly when accompanied by a downward export price.

Sales to the local markets of China and PTN firms increase slightly in agriculture and services sectors and decrease in manufacturing sectors. The decrease in sales to the local market reflects the intensified competition from increased imports. The increased competition from imports may chase the least productive firms out of the domestic market, resulting in a sales reduction.

Table 7 relates the market expansion to partner regions and sales contraction in local markets to FDI changes. It shows sales, firm number and FDI demand of foreign firms owned by PTN operated in China. Foreign firms owned by ROW perform in an identical way as those owned by PTN.[20] The sales of foreign firms in the three markets follow a similar pattern as the total sales of domestic and foreign firms shown by Table 6. The foreign firms expand exports greatly to the PTN market, but contract sales to the local market of China. Along with the opposite changes in the two markets, the number of foreign firms changes correspondingly. Much more foreign firms operated in China can export back to the home market of PTN after RCEP. [21] In sector $m2$, the number of foreign firms supplying the PTN market increases by more than 400%, which is much higher than the increase in sales (86.1%). In other sectors, firm numbers also increase by around 200%, higher than the 50~60% growth in sales. The much more dramatic increase in firm number than sales suggests that export expansion to the PTN market is largely attributed to extensive margin, or the increase in new varieties. The intensive margin of export expansion after RCEP is less significant, consistent with the findings about agriculture. The export expansion leads to increase in FDI demand. The FDI increases are close to sales increases, 92.3% in sector $m2$ and 55~65% in other sectors. The FDI increase driven by market expansion represents the market expansion effect of RCEP.

Insert Table 7 here

[20] In the scenario of small step services liberalization, RCEP causes changes in the trade variable costs between PTN and China, which affects foreign firms from PTN and ROW located in China in an identical way.

[21] Even though PTN is the home region of foreign firms, to supply the PTN market from China occurs higher fixed trading costs than the costs of only supplying the local market of China. That is, this study rules out the case that foreign affiliates can save fixed trading costs when export back to home region.

In the host market of China, foreign firms owned by PTN reduce sales and firm number. The decreases should be caused by trade substitution or imports competition. Because RCEP lowers trade costs, firms of PTN may switch from FDI to export in supplying the China market. In addition, increased imports of China from PTN drive the least productive foreign firms out of the market. The decreases in sales and firm number leads to reduction in FDI demand, which represents the plant rationalization effect.

However, the reduction in FDI demand is not significant. Table 7 shows that only the two manufacturing sectors present negative FDI changes. The agriculture and services sectors even show small increases in FDI demand. The increases in these sectors could be explained as an enlargement of production scales of surviving foreign firms. The enlargement of production scales drives up FDI demand.[22] The FDI results suggest that the plant rationalization effect has not pulled down FDI dramatically. The finding of insignificant plant rationalization effect of RCEP is consistent with the results of overall positive FDI effects of ACFTA in the previous studies. The substitution from trade to FDI as a result of trade liberalization is not evident, at least in the cases of ACFTA and RCEP.

6 Conclusion

This paper extends the econometric studies about ACFTA in the previous studies to a CGE study about RCEP. The extension has shifted the focus on tariff reduction to services liberalization in analyzing the FDI impacts of FTA. Simulation results about RCEP find that services dominate FDI increase, which indicates services liberalization has more significant positive impact on FDI flow to member countries. The result also infers the importance of services liberalization in free trade agreements.

Apart from the new findings about services liberalization, another contribution of this study is building the FHFDI model. The FHFDI model applies the Melitz model and its extension by Helpman et al. (2004). It is the first time to introduce FDI to a firm heterogeneity CGE framework. The model is built on Zhai (2008) and extends the Zhai model in several ways. The most important extension is to introduce FDI and separate foreign firms from each economy.

[22] The negative changes in sales could be interpreted as the increase in quantity is outweighed by decrease in price.

Through examining the production activities of foreign firms, I find the market expansion and plant rationalization effects of RCEP. The second innovation of the FHFDI model is in the treatment of services barriers. Services barriers are modelled as tax equivalents that raise costs and create rents. That treatment enables the model to simulate the real economy in a better way. The third extension of the Zhai model is to add a capital allocation block. Capitals are allocated among sectors, regions and firms following a rule of chasing the highest return activities. Finally, I construct a SAM table with foreign firms being separated from domestic firms and FDI being separated from domestic capital. Foreign firms and FDI are differentiated by both home and host region.

The FHFDI model has three merits in interpreting FDI effects of FTA. First, it can capture more trade effect of FTA than the Armington model through capturing the extensive margin of export expansion. Considering that trade effect closely relates to the market expansion effect on FDI, the model can capture more FDI effect too. Second, the FHFDI model allows us to shock fixed trading costs, which is another instrumental variable of FTA aside from trade variable costs. Simulation results suggest that FDI is more sensitive to fixed trading costs in comparison with trade variable costs. A 50% reduction in fixed trading costs results in a FDI increase more than 6 times the increase in a scenario without changes in fixed trading costs. Third, the FHFDI model enables to differentiate the productivity difference between foreign firms and domestic firms in a straightforward way.

The FHFDI model is tested through reproducing the results of Zhai (2008). The tests generate similar results as the Zhai model, demonstrating the reliability of the FHFDI model. The reliability has been reinforced by simulation results about the welfare effects of RCEP on China. The welfare effect of RCEP is found to be in line with the general findings about trade liberalization that welfare gains usually take less than 2% of China's GDP. When PTN reduces its services barriers to the average level of Japan and Korea, a small step services liberalization in China with a 95% tariff reduction in all member countries can improve China's welfare by US$47 billion, while a big step services liberalization can generate a welfare gain of US$72 billion, and a deeper trade liberalization that halves fixed trading costs can increase China's welfare by as much as US$125 billion.

Overall, the experimental results about FDI present that RCEP would encourage FDI to China. A big step of services liberalization in China with a 50% reduction in fixed trading costs would promote US$11.7 billion FDI to China, with US$11 billion flow to services. FDI increases in China drop dramatically in scenarios without reduction in fixed trading costs and small step of services liberalization. Therefore, with increasing FDI as an aim of RCEP, member countries should liberalize trade to a deeper extend, particularly services trade. If RCEP can reduce fixed trading costs among member countries, then FDI gains would be even bigger.

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Appendices

Appendix A. The SAM table

In Chapter 5, 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, I 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 region, which are drawn from the three-dimension global foreign affiliate sales database (home-host-sector). Second, the outputs of each firm are further allocated into three markets as each firm 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).

Accordingly, the inputs of intermediate goods and factors in each sector are split into the 9 activity accounts (3 firms × 3 markets) based on sectoral input-output ratios of the GTAP data. The ratios of capital-output and labor-output have been adjusted for foreign firms in order to reflect the fact that multinationals usually outsource labor-intensive work. For foreign firms, the capital-output ratio is lower while the labor-output ratio is higher than their counterparts in the GTAP data. The capital-output ratio is drawn from the survey data of 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. To obtain the sectoral capital-output ratio, I adjusted the 5% by the sectoral ratios of the GTAP data, because there are no sectoral capital inputs in the survey. With capital-output ratios, the capital inputs of foreign firms can be calculated. The calculated capital inputs might be higher than the FDI from home region based on 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. 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 that the SAM table is balanced.

In terms of supply, I separated sales into three markets in order to be consistent with the production activity accounts. Then, the sales to domestic market 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 types of firms × 5 sectors).

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

Appendix B. Figures and Tables

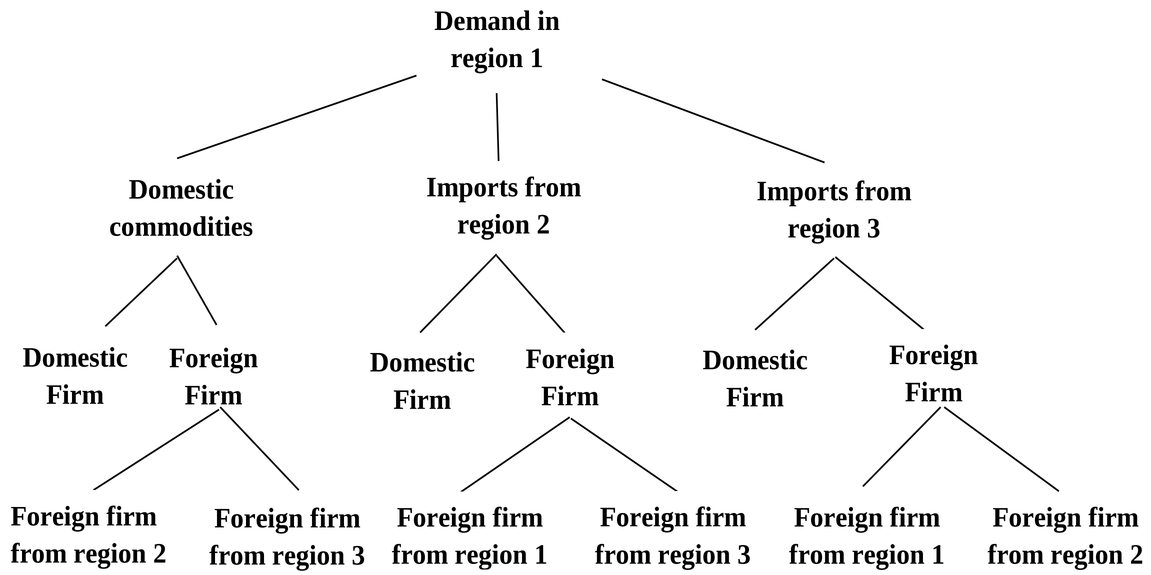

Figure 1 Demand system in a region

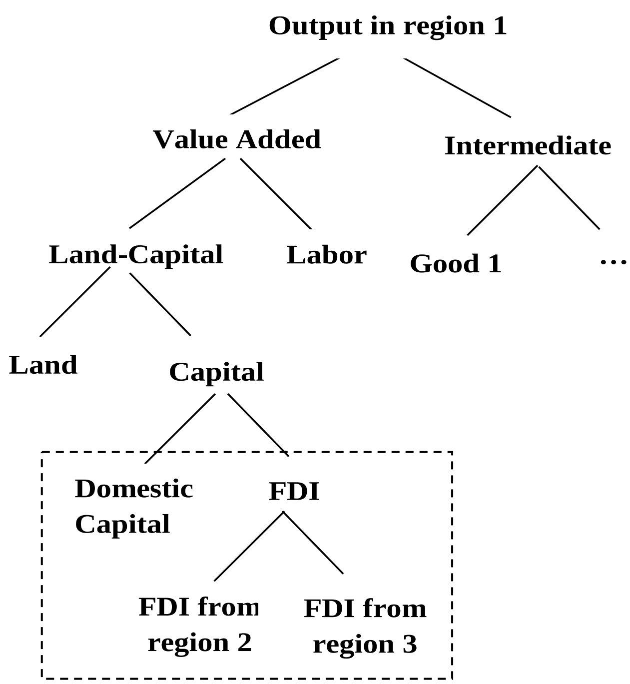

Figure 2 Production tree in a sector

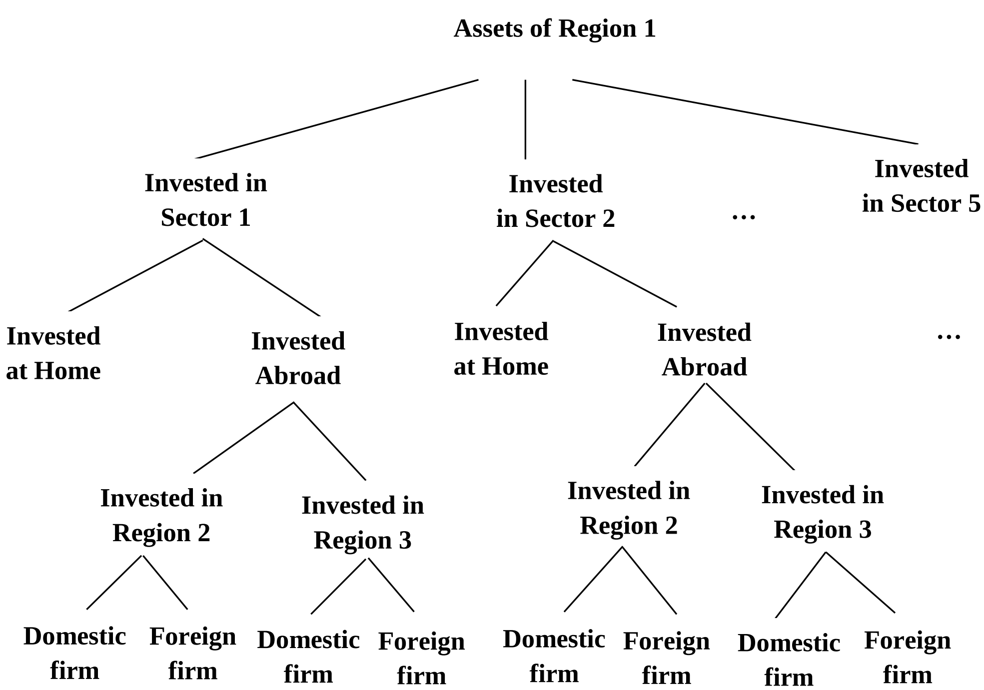

Figure 3 Capital allocation structure

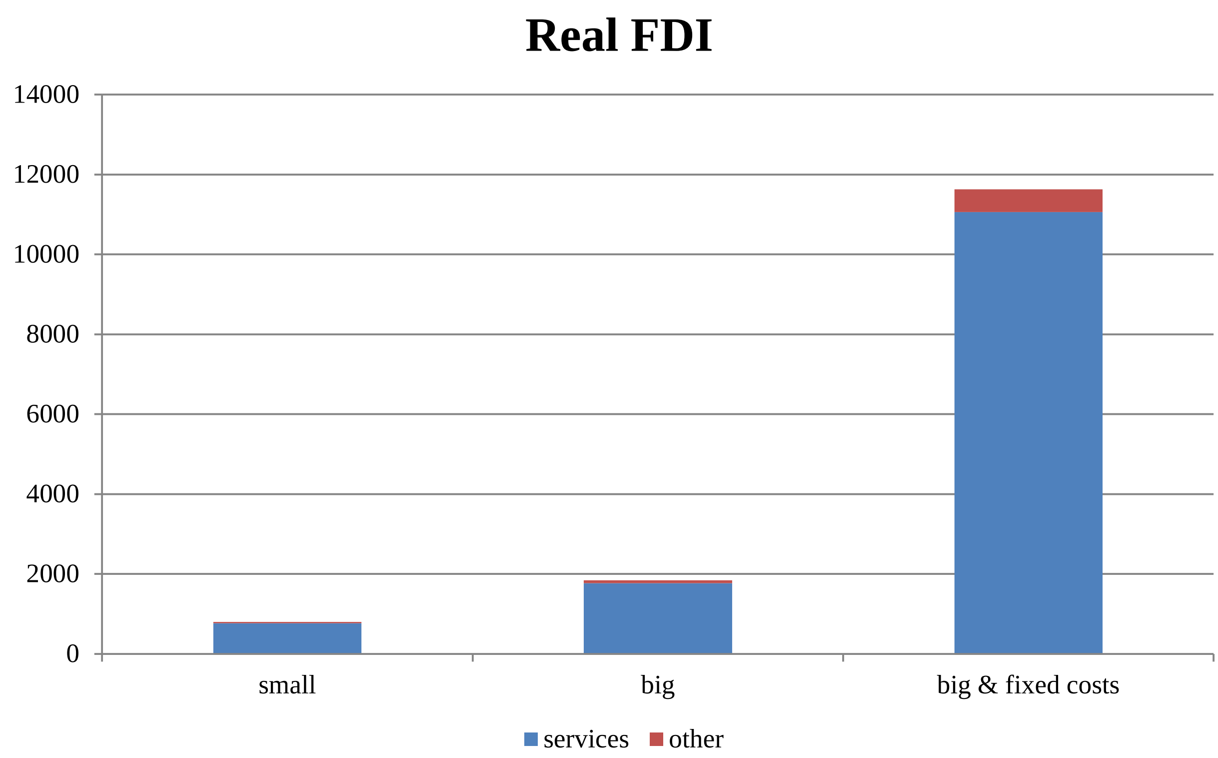

Figure 4 Real FDI changes in China after RCEP (million US$), Source: Author's estimation

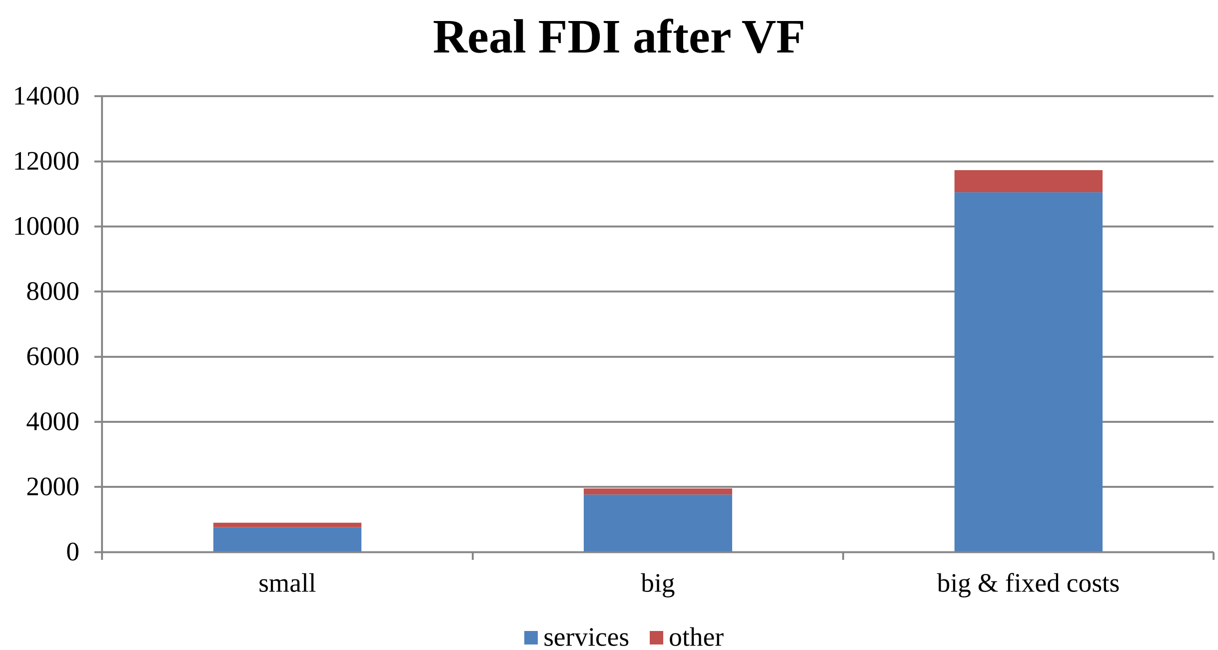

Figure 5 Real FDI changes in China after adding the FDI increase from the vertical fragmentation effect to sector $m1$ (million US$), Source: Author's estimation

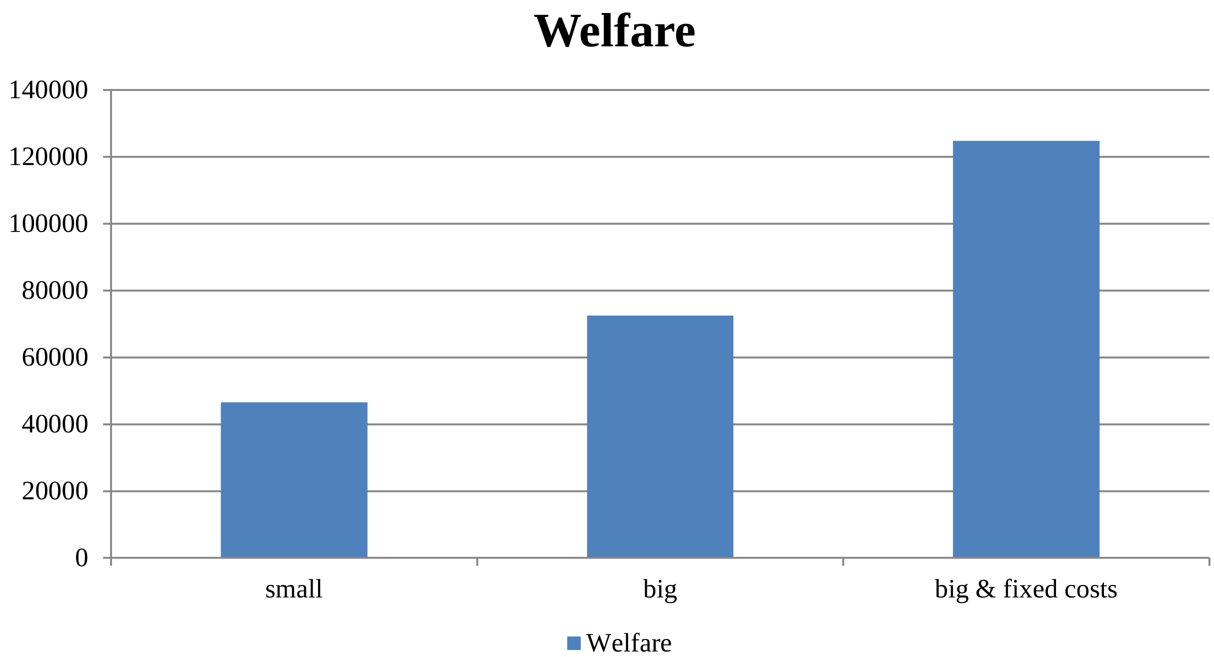

Figure 6 Welfare changes in China after RCEP (million US$) Source: Author's estimation

Table 1 Tariff equivalences of NTBs by region and sector

	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

Source:Petri et al. (2012)

Table 2 Major Parameters in the Model

	Markup Ratio	Elasticity of Substitution	Shape Parameter	Elasticity of Transformation
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.

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

Data source: GTAP documents, Chapter 14 Behavior parameters

Table 4 Simulated reductions of tariff and NTBs in China and PTN under RCEP

Exporter	Importer	a	m1	m2	s1	s2
Tariff barrier						
CN	PTN	0.281	0.02	0.064		
PTN	CN	0.052	0.037	0.18		
Non-tariff barrier						
CN	PTN	0.154	0.123	0.123	0.194	0.195
PTN	CN	0.084	0.135	0.135	0.194/0.578	0.195/0.585

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

Table 5 Changes in FDI of China from RCEP partner countries (PTN) and the rest of the world (ROW) in scenario 2 & 3 (%)

	Scenario 2		Scenario 3	
	PTN	ROW	PTN	ROW
a	0.4	0.4	19.6	19.6
m1	4.6	5.0	29.0	-11.8
m2	3.0	3.0	24.5	24.5
s1	3.2	2.8	28.3	44.6
s2	4.2	4.2	28.1	28.1

Source: Author's estimation

Table 6 Changes in sales of firms operated in each region to the three markets under the scenario of small step (%)

Sector	Sales of firms in China			Sales of firms in PTN			Sales of firms in ROW		
	China	PTN	ROW	China	PTN	ROW	China	PTN	ROW
a	0.7	-2.6	-2.3	5.1	1.8	2.0	2.9	-0.3	-0.2
m1	-4.5	52.8	7.7	31.2	-3.2	-2.9	-11.6	-0.9	-0.6

m2	-3.3	90.6	6.8	111.5	-0.6	-3.0	-9.4	2.4	-0.2
s1	1.9	60.9	3.2	24.7	2.2	-3.8	-3.3	6.1	0.1
s2	2.1	57.1	4.4	22.5	2.0	-2.1	-3.9	6.8	0.1

Source: Author's estimation

Table 7 Changes in sales, firm number and FDI demand of foreign firms owned by PTN operated in China under the scenario of small step (%)

Sector	Sales			Firm Number			FDI Demand		
	China	PTN	ROW	China	PTN	ROW	China	PTN	ROW
a	-0.1	-3.2	-3.1				1.3	-1.8	-1.7
m1	-5.6	51.3	6.6	-5.1	192.1	7.1	-3.8	54.8	8.6
m2	-4.6	86.1	5.5	-4.2	406.9	5.7	-1.6	92.3	8.6
s1	-0.3	55.7	0.8	-0.7	204.4	2.4	1.9	64.3	5.0
s2	0.8	55.9	3.1	-2.6	192.6	2.3	2.4	63.3	3.8

Source: Author's estimation