Trade Liberalization and Intermediate Imports: Evidence from Chinese Firm-Level Data 2000–2006

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Abstract

This paper studies the impact of trade liberalization on a firm's intermediate imports and aggregate outcomes. In particular, I focus on the heterogeneous impacts across locations within a country. Using Chinese firm-level data which covers the period of China's trade reforms driven by the WTO accession in 2001, I show that a firm in the coastal region, despite the geographic advantage in international trade, is less likely to import, uses fewer imports, and spends less on imported inputs than a inland firm on average. Furthermore, reduced form regressions provide suggestive evidence that coastal firms are less likely to import because domestic inputs are more available than the inland region. Motivated by the empirical findings, I develop a spatial general equilibrium model of a firm's input trade. The model features multiple regions in a country, endogenous market size, and selection of firms. A comparative statics exercise shows that reduction in international trade cost makes the market size and measure of active firms larger in the coastal region, which makes the domestic input bundle relatively cheaper. As a result, the model succeeds to replicate the empirical regularities that a coastal firm is less likely to import and uses fewer imports than a inland firm.

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1 Introduction

As a country opens up to trade, not only consumers but also firms gain from importing goods from abroad. Given that the trade in intermediate goods accounts two-third of international trade (Johnson and Noguera, 2012), it is important to understand the firm's adjustments in input trade and its aggregate implications in order to study the impact of trade reforms and trade shocks. Therefore, in the field of international trade and development economics, there is a growing literature on a firm's input trade. The firm-level studies have pointed out that there are several sources of gains from trade for firms. The examples include gains from input variety *à la* Ethier (1982), gains from foreign advanced technologies embodied in the imported inputs (Halpern et al., 2015), and productivity gains of importing from learning (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008). More recent papers attempt to study the aggregate implications of input trade by addressing the importance of firm heterogeneity (Blaum et al., 2018), the roundabout production (Gopinath and Neiman, 2014); and the interdependency of a firm's sourcing decision across markets (Antràs et al., 2017).

This paper tries to compliment the literature by studying the impact of trade liberalization on intermediate imports by firms in different locations within a country. In particular, I focus on the episode of China's trade reform which was driven by the accession to the World Trade Organization (WTO) in 2001. There are two major reasons to focus on the Chinese experience. First, China implemented substantial trade reforms including the tariff cuts and deregulation of the direct trading right restrictions. Figure 1 shows that the weighted average import tariff over all products in China dropped substantially after the WTO accession, from 14.67% (2000) to 4.25% (2006). The direct trading right restriction, which had prevented the small and medium-sized private firms from importing and exporting directly, were removed by 2004 as a part of China's joining the WTO (Bai et al., 2017). The series of trade reforms encouraged the firm's participation in international trade. The second reason is that the Chinese firm-level data, which covers the period from 2000 to 2006, exhibits interesting geographic variations in the firm-level import patterns. Despite the substantial trade liberalization and potential geographic advantages of the coastal area in international trade, an average coastal firm is less likely to import (i.e., lower extensive margin), uses fewer imports (i.e., lower sub-extensive margin), and spends less on imported inputs *vis-a-vis* domestic inputs (i.e., lower intensive margin) than an average inland firm.

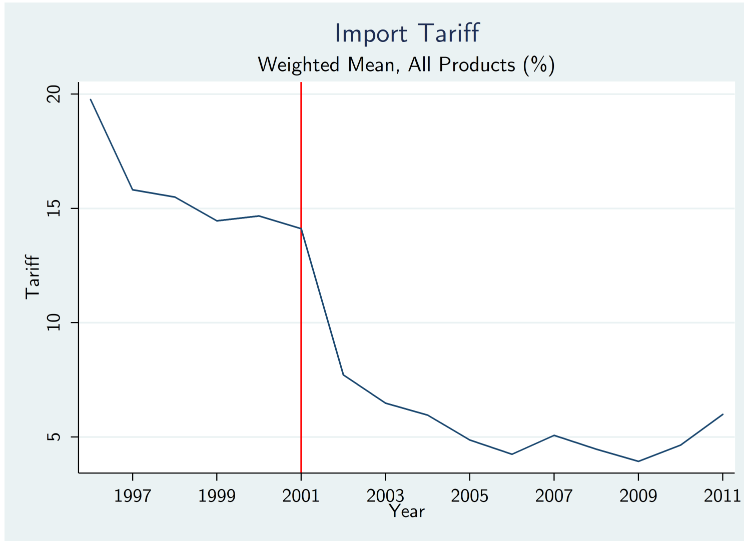

Figure 1: Weighted Average Import Tariff

In order to study the geographic heterogeneity in firms' input trade in response to trade reforms, let's consider the canonical model of a firm's trading decision, i.e., Melitz (2003), with intermediate imports as a benchmark model. Before considering multi-region setup, assume that a country consists of a single region. Suppose that importing intermediate inputs and exporting the output to foreign countries are subject to some forms of fixed costs. Then, as a country opens up trade, more productive firms will start to import and export, i.e., there is productivity sorting of importers and exporters. Meanwhile, opening up trade makes the domestic market more competitive, which will let lower productive firms exit from the market and surviving firms will grow in size.

Having these implications in mind, consider to extend the model to have multiple regions within a country. Regions may differ in many aspects, however, they typically differ in the accessibility to the foreign markets due to domestic geography. Some regions may have international ports while the others do not. Let's label the region with an international port as *coastal* region and the region without as *inland* region. Then, trade reforms, e.g., reduction in trade costs, would have heterogeneous impacts across regions. Coastal firms may be more likely to export, use more imports, and spend more on imported inputs than the inland firms by taking advantage of the effective proximity to the foreign countries. At the same time, since the coastal regions face more competition from the foreign countries, the selection of firms will get tighter and the surviving firms in the coast will get larger in size on average.

This naïve prediction based on the canonical trade model is not supported by the Chinese firm-level data, which covers the period of the China's trade reform in 2000s. First, as expected, the extensive margin of import (i.e., the fraction of firms which use imported inputs, or the import participation rate) increases over time everywhere in China. However, in terms of level, the import participation rate is slightly higher in the inland region than the coastal region despite the fact that coastal regions have the major international ports. Second, the sub-extensive margin of import (measured by the number of imported varieties) is lower on average in the coast than the inland, i.e., the coastal firms use fewer imports. Finally, the intensive margin (i.e., the expenditure share on imported inputs in total intermediate input purchase) is also lower on average in the coast than the inland, i.e., the coastal firms spend less on imports. Moreover, there are suggestive evidences that selection of firms is weaker in the coastal area; percentiles of the firm's productivity (measured by value added per worker) below 50 are lower (i.e., there is larger measure of low productive firms), the number of firms increases more, and the firm size (measured by the median employment) gets smaller in the coast. Finally, a reduced form analysis suggests that the lower import participation by the coastal firms may be explained by the larger availability of domestic inputs at the firm's location, implying that coastal firms are less likely to import because they are more able to find the intermediate inputs locally.

In order to explain those empirical regularities, I develop a spatial general equilibrium model of a firm's trading decision in which international and domestic geographies, firms' trading decisions, market size, and selection of firms are interacted one another. In the model, a household moves freely across locations within a country in search of highest welfare after taking into account the idiosyncratic amenity shock. For the production side, there is a continuum of firms which use labor, domestic, and imported inputs to produce intermediate good. The firm's output is consumed by households and used by other domestic firms as an intermediate input. The firm's import decision entails both extensive margin (binary decision) and sub-extensive margin (decision on the number of imported inputs). The domestic and imported inputs are imperfectly substitutable in a CES fashion. Therefore, the domestic input price index, which is a general equilibrium object and affected by the measure of active firms in each location (i.e., local availability of domestic inputs), impacts the firm's import decisions.

After developing the model, I solve an equilibrium numerically. In the comparative statics exercise, I manipulate the international trade cost and study the responses of aggregate outcomes and the key moments of firm-level import patterns. Intuition of how the model works is as follows: as a country opens up trade, the coastal firms take advantage of the accessibility to foreign markets and start importing and exporting. Due to the roundabout production nature, the import participation by the coastal firms lowers the price indices of the domestic input and consumption bundles. In conjunction with higher profits of coastal firms due to importing and exporting which are eventually transferred to the local households, the coastal region attracts more workers. The influx of workers will increase the measure of active firms in the coast. Increased measure of firms further lowers the price index of domestic input bundle in the coast due to Ethier's (1982) love-of-variety effect. As a result, further decline in the international trade cost allows coastal firms to take advantage of the lower price index of domestic input bundle, to depend less on imported inputs, and to use fewer imported varieties than the inland firms. The numerical simulation succeeds in generating the key patterns of the firm's input trade which is consistent with the data.

This paper will contribute to the three strands of the literature. First, this paper is related to the literature on firms' imports in China. Despite the significant growth in China's intermediate imports triggered by the WTO accession in 2001, only a small number of studies focus on the firm-level imports in China. For example, Feng et al. (2016) use the Chinese firm-level data which covers the period from 2002 to 2006 and demonstrate that product upgrading facilitated by technology embedded in imported inputs helped Chinese firms to increase the scale and breadth of their export participation. On the other hand, Brandt et al. (2017), who examine the effects of China's trade liberalization on the evolution of markups and productivity of individual firms, cast doubt on the benefits from the increased availability of imported inputs. They show that expenditure share of imported inputs in total intermediate input purchase barely increased during their sampled period, 1998 – 2007. This paper compliments their findings by demonstrating the geographic variations in the firm-level import patterns and relating the import decision of a firm to the availability of domestic inputs at the firm's location.

Second, the structural analysis in this paper is closely related to a large body of theoretical and empirical works on foreign sourcing. For example, Gopinath and Neiman (2014) and Halpern et al. (2015) develop structural models of firm's input trade to study its impact on productivity of a firm and an aggregate economy. In there models, the intermediate input aggregator in the production function displays a "love-of-variety" effect with intermediate inputs being imperfectly substitutable *à la* Ethier (1982). This standard, and almost ubiquitous, assumption of imperfect substitution is accepted in this paper too. It means that, the more a firm use imported inputs (i.e., larger sub-extensive margin of import), the lower the price index of the imported input bundle becomes. It is important and interesting to show that, despite this love-of-variety feature, the coastal firms end up using fewer imports than the inland firms on average. It is the key that, in my model, the firm also gains from domestic input variety. That is, as the measure of domestic input varieties produced at the firm's location becomes larger, the price index of the domestic input bundle gets lower. Relatively cheaper domestic input bundle let the firms use fewer imports.

Since my model builds upon a general equilibrium setup, the factor price, the measure of domestic firms, and the domestic input price index are determined endogenously as in Blaum et al. (2018) and Antràs et al. (2017). An important departure of this paper from their works is that the model has the spatial component. Therefore, the model can provide rich implications of the trade reforms on the reallocation of economic activities across locations within a country. To the best of my knowledge, this is the first work to incorporate formally the domestic geography in to the structural model to study the impact of trade liberalization on the firm's intermediate imports and its aggregate outcomes.

Thirdly, this paper contributes to the recent works on domestic value added in exports ratio, DVAR. It is widely known that the DVAR has trended downwards in almost all countries. This downward trend is understood as result of the expansion of global value chains or fragmentation of production across countries. Despite this global trend, China has been experiencing the rising trend of DVAR after 2011 (Goldberg, 2019). Dollar et al. (2019) assert that this is primarily the result of technological advances in China which has allowed firms to substitute for imported goods with domestically produced good, rather than the policy consequence. Import substitution and its consequence on DVAR is also discussed in Kee and Tang (2016), who focus on the DVAR of process trade firms in China. They find that the import substitution by individual processing exporters caused China's DVAR to increase from 65 to 70 percent during the period between 2000 and 2007. This paper contrasts to Kee and Tang (2016) in that I focus on ordinary trade imports rather than process trade imports.[1] Furthermore, this paper departs from their work by taking into account the

[1]Process trade refers to an activity of firms importing inputs from abroad, processing and assembling domestically in China, and re-exporting final products abroad. In China, intermediate inputs entering China as process trade mode are generally exempted from import tariffs (Brandt et al., 2017). Therefore, it is known that sourcing decisions of process trade exporters are distinct from ordinary traders. Furthermore, their final products are to be sold in the foreign markets but not in the domestic markets. Thus, in general equilibrium sense, the process exporters' imports may have smaller impacts on other domestic firms' production and trading decisions.

regional dimension in analyzing the substitution between imported and domestic inputs.[2] While the DVAR is not the primary object of interest, this paper makes its contribution to the literature by addressing that the import substitution is subject to the local availability of domestic inputs and formally studying it in the spatial general equilibrium model.

The rest of this paper is structured as follows; section 2 describes the dataset, documents the key patterns of firm-level imports in China, and implements a reduced form analysis to investigate the empirical relationship between local availability and firm's import decision; section 3 develops a spatial general equilibrium model of a firm's input trade; section 4 summarizes the result of comparative statics; and section 5 concludes.

2 Empirical Evidences

2.1 Data

Firm Level Data

This paper uses the two Chinese firm-level datasets which were merged by Bai et al. (2017). The first dataset is the firm-level data from the Annual Surveys of Industrial Production (ASIP) from 1998 to 2007 conducted by the National Bureau of Statistics of China. Compared to the universe of firms observed in the 2004 Economic Census, the ASIP includes all State-Owned Enterprises (henceforth SOEs) and non-SOEs with revenue over 5 million RMB (approximately 600,000 USD). The data contains information on the firm's industry of production recorded at 3-digit Chinese Industrial Classification (CIC), location (postal code), ownership type, capital stock, and etc. Details of the dataset are documented in Brandt et al. (2014). The second data set is the Chinese customs transaction-level data, which records the universe of transactions by Chinese firms that participate in international trade over the period 2000–2006. The customs data includes basic firm information, the value of each transaction (in USD) by product (8-digit HS) and trading partner. For each transaction, the dataset also records the mode of trade, which I explain in detail below.

In this paper, I will focus on the production and trading behaviors of privately owned or col-

[2] Dollar et al. (2019) demonstrate the variation in DVAR across regions within China and argues that, across Chinese provinces, there is an inverted-U shape relationship in which the DVAR tends to rise with per capita GDP and then decline beyond a certain threshold. Given that rich regions, which are located in the coastal area of China like Beijing, Shanghai, and Guangdong, exhibits lower DVAR, they argue that export success requires the imported inputs with high quality, which drives down the DVAR.

Table 1: List of Industries

#	Description	#	Description	#	Description
13	Grain mill products	37	Coking	61	Boiler, engines, and turbine
14	Forage	38	Basic chemicals	62	Metalworking machinery
15	Vegetable oil refining	39	Chemical fertilizers	63	Other general industrial machinery
16	Sugar manuf.	40	Chemical pesticides	64	Primary sector machinery
17	Slaughtering	41	Paints and printing ink	65	Other special industrial equipment
18	Fish products	42	Man-made chemical products	66	Railroad transport equipment
19	All other food manuf.	43	Special chemical products	67	Motor vehicles
20	Wines, spirits and liquors	44	Daili use chemical products	68	Motor vehicle parts
21	Soft drink	45	Medical products	69	Ship building
22	Tobacco products	46	Chemical fibers	70	Other transport equipment
23	Cotton textiles	47	Rubber products	71	Generators
24	Woolen textiles	48	Plastic products	72	Household electric appliances
25	Hemp textiles	49	Cement	73	Other electric machinery
26	Textiles productions	50	Glass products	74	Telecommunication equipment
27	Knitted fabric	51	Pottery	75	Electronic computer
28	Wearing apparel	52	Fireproof materials	76	Other computer equipment
29	Leather products	53	Other nonmetallic mineral products	77	Electronic element and device
30	Wood products	54	Iron-smelting	78	Communication equipment
31	Furniture	55	Steel-smelting	79	Other electronic equipment
32	Paper products	56	Steel pressing	80	Measuring equipment
33	Printing	57	Alloy iron smelting	81	Cultural and office equipment
34	Stationary products	58	Nonferrous metal smelting	82	Arts and crafts products
35	Toys and athletic products	59	Nonferrous metal pressing	83	Other manufacturing products
36	Petroleum processing	60	Metal products		

lectively owned enterprises, which I label as private firms below. I exclude SOEs from the analysis because they are under the control of the government and may not be profit maximizers. Government intervention may obscure the mechanism of firm's decision makings. Foreign owned enterprises are also ruled out because their trading decisions may be subject to their headquarters' decisions. For example, Japanese firm based in China may be more likely to use intermediate inputs from Japan than domestic private firms, all else being equal.

I further restrict the sample of firms to those in manufacturing sectors. Table 1 lists the 71 sectors in manufacturing, which are based on the industrial classification used in the Chinese Input-Output (IO) Table 2002 constructed by the National Bureau of Statistics of China.[3] In the rest of this paper, I refer each of 71 sectors as a *sector* or *industry*.

For the firm's location information, I use the first two digits of the 6-digit postal code to identify the province. Table 2 lists the 27 provinces and 4 large cities, Beijing, Shanghai, Tianjin, and Chongqing. I refer each of these 31 provinces and cities as a *region*, *location*, or *province*. Coastal regions are marked by asterisk (*) in the table.

In the customs data, each firm is classified into production firm or trading intermediary based

[3]I use the concordance table between the 3-digit CIC and 71 manufacturing sectors in the IO Table 2002 compiled and provided by Brandt et al. (2017).

Table 2: List of Locations

Postal code	Province / City	Postal code	Province / City
01	Inner Mongolia	41	Hunan
03	Shanxi	43	Hubei
05*	Hebei	45	Henan
10*	Beijing	51*	Guangdong
11*	Liaoning	53	Guangxi
13	Jilin	55	Guizhou
15	Heilongjiang	57*	Hainan
20*	Shanghai	61	Sichuan
21*	Jiangsu	65	Yunnan
23	Anhui	71	Shaanxi
25*	Shandong	73	Gansu
30*	Tianjin	75	Ningxia
31*	Zhejiang	81	Qinghai
33	Jiangxi	83	Xinjiang
35*	Fujian	85	Tibet
40	Chongqing		

on the firm's registered names (Bai et al., 2017). I exclude trading intermediaries from the analysis because they import intermediate inputs for resale to other firms but not for their own production. Therefore, their import decisions should be considered as wholesalers but not as producers, which is beyond the scope of this paper.[4]

The customs data records the trading mode of each transaction. In the dataset, there are 18 trading modes defined by the General Administration of Quality Supervision, Inspection and Quarantine of the Chinese Government. Two major trading modes of China's imports are ordinary trade and process trade. This paper focuses on imports of intermediate goods which enter China through ordinary trade mode.[5] I will label a firm as a participant of ordinary trade import if it imports at least one product with ordinary trade mode.

In order to exclude firm's import of consumption goods, I adopt the use of United Nations Broad Economic Categories (BEC) groups to identify intermediate inputs following Feng et al. (2016) and Brandt et al. (2017). Using the concordance table between 6-digit HS code and BEC code provided by the United Nations Statistics Division, I assign the corresponding BEC code to each of HS codes to identify the intermediate good imports.[6] Table 3 summarizes the list of BEC codes which are

[4]In the next subsection, I will briefly describe some key statistics on imports by trading intermediaries.

[5]Process trade refers to an activity of firms which import intermediate inputs from abroad, assemble them domestically, and re-export the final goods to foreign countries. Therefore, the sourcing decisions of process trade firms are fundamentally different from ordinary trade firms (Jarreau and Poncet, 2012; Koopman et al., 2012) and they should be considered together with their export decisions.

[6]Concordance table is available at the UN Trade Statistics website.

Table 3: BEC Codes for Intermediate Goods

Code	Description
111	Food and beverages, primary, mainly for industry
121	Food and beverages, processed, mainly for industry
21	Industrial supplies not elsewhere specified, primary
22	Industrial supplies not elsewhere specified, processed
31	Fuels and lubricants, primary
322	Fuels and lubricants, processed (other than motor spirit)
42	Parts and accessories of capital goods (except transport equipment)
53	Parts and accessories of transport equipment

regarded as intermediate inputs.

In the reduced from analysis, I will look at the firm's imports at sectoral level. In doing so, I assign relevant sectoral codes to each of HS codes if applicable. In this conversion, I use the concordance table provided by Brandt et al. (2017).[7]

Aggregate Data

I use the several aggregate data from different sources. In order to measure the input-output (IO) linkage, I use the IO Table 2002 compiled by the National Bureau of Statistics of China. This IO table has 71 sectors in manufacturing, by which the sectors are defined in this paper.

Tariff data is sourced from the Trade Analysis Information System (TRAINS) database of the United Nations Conference on Trade and Development (UNCTAD). I use the most-favored nation (MFN) applied tariff (ad valorem tariff in %) as a tariff rate of a particular product.

I use the sectoral output data in the other countries to construct the world output of each sector. The data is sourced from United Nation Industrial Development Organization's (2016) Industrial Statistics Database (INDSTAT). This database contains output at 4-digit International Standard Industrial Classification (ISIC). Using the concordance table between 4-digit ISIC and the CIC complied by Dean and Lovely (2010),[8] I compute the world output at 71-sectoral level.

I also use the country-wide aggregate data from the World Bank, China Statistical Yearbook of National Bureau of Statistics of China, and CEPII.

[7]Some HS codes have multiple sectoral codes assigned. Among 4,926 6-digit HS codes (version 1996) which are assigned at least one sectoral code, 248 have two corresponding sectoral codes and 28 have more than two. For example, HS code 150.10: Crude peanuts oil has two sectoral codes, 15: Vegetable oil refining and 19: All other food manufacturing. If a firm imports the HS product 150.10, for instance, I assume that the firm imports good 15 and 19.

[8]The digitalized table is provided in Peter Schott's website.

Table 4: Market Size and Firms

	Region	2000	2002	2004	2006	Δ(00-06)
Population	All	125,995	127,319	129,022	129,523	3%
	Coast	48,686	49,466	50,464	51,709	6%
	Inland	77,309	77,853	78,558	77,814	1%
Number of Firms	All	90,136	115,614	191,110	224,891	150%
	Coast	58,535	77,254	137,807	155,730	166%
	Inland	31,601	38,360	53,303	69,161	119%
Median Employment	All	154	164	166	162	5%
	Coast	160	161	160	150	-6%
	Inland	153	165	167	165	8%

Note: population data is sourced from National Bureau of Statistics of China.
Number of firms and median employment are sourced from the ASIP.

2.2 Descriptive Evidences

Before looking at the firm's import patterns, I will provide an overview on market size (measured in population), number of firms, and firm size in the coastal and inland regions in China. The first set of three rows in Table 4 demonstrates the population in China during the sampled period. The coastal region comprises 38.6% of total population in China as of 2000 and the share increases to 40.0% in 2006. In terms of growth rate, Coastal region exhibits the larger population growth (6%) than the inland region (1%).

The second set of three rows shows the number of private firms. Despite the fact that the inland region embraces larger population, firms are more concentrated in the coastal region. In 2006, 69.2% of private firms are located in the coast. The coastal region also exhibits the higher growth (166%) than the inland region (119%). The table confirms that the number of firms increased more than proportional to the increase in population. This can be seen as a suggestive evidence for the agglomeration of firms in the coast.

The last three rows demonstrates the median employment of firms. The result is based on using the balanced panel sample, so that the change in the median employment can be seen as the adjustment of surviving firms. Based on the canonical model of a firm's trading decisions, one would expect that the coastal region face more competition and thus the selection should become tighter. Accordingly, firm size is expected to become larger on average. In contrast to these naïve predictions, the coastal firms become smaller in size while the inland firms become larger. Distribution of productivity, which is measured by the value added per worker, also suggests the weaker selec-

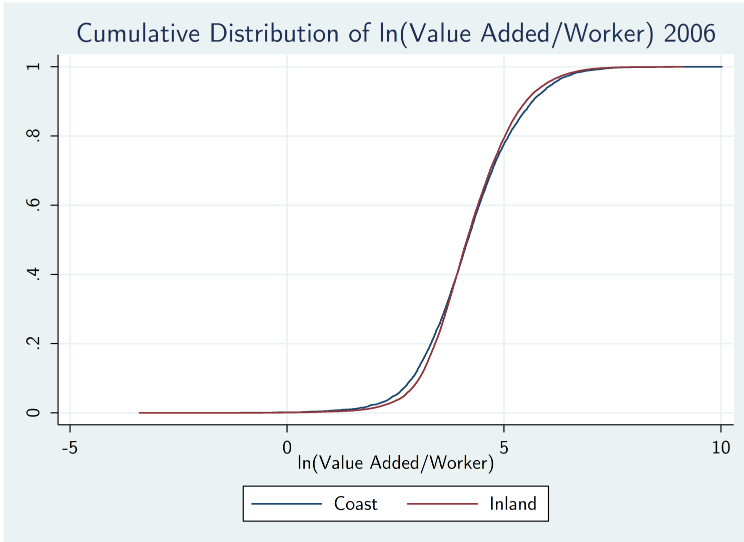

Figure 2: Productivity Distribution (2006)

tion of firms in the coastal area. Figure 2 shows the cumulative distribution of the productivity as of 2006. The figure confirms that the percentiles below 50 are lower in the coastal region than the inland region. This implies that there is a larger measure of lower productive firms in the coast.

Now I will show the firm-level import patterns at the three margins; extensive, sub-extensive, and intensive margins. First, Figure 3 demonstrates the extensive margin of import. The import participation rate (fraction of firms which use imported inputs) is increasing in both regions, from 1.24% (2000) to 2.58% (2006) in the coast and from 1.48% to 2.90% in the inland. The increasing trend in the sub-extensive margin of import is consistent with the reduction in import tariffs and deregulation of the direct trading right restrictions. In terms of level, the import participation rate is lower in the coast than the inland region despite the potential geographic advantage of the coastal region in international trade.

Second, Figure 4 shows the sub-extensive margin of import, which is measured by the number of imported varieties a firm imports. I define a variety by the pair of 8-digit HS code (HS8) and the country of origin. This is the most disaggregated definition of the product in the customs data. The figure summarizes the mean, median, and 75 percentile of the sub-extensive margin. When I compute those moments, I restrict the sample to those firms which import in a given year and its previous year[9]. In terms of level, the mean and median are strictly higher in the inland than

[9]It is known that a firm typically starts importing small number of varieties and increases it afterwards. When I compare the average number of imported varieties for those firms which import in a given year but not in the previous year (i.e., new importers or entrants to the import market) and those which import both in a given year and the previous

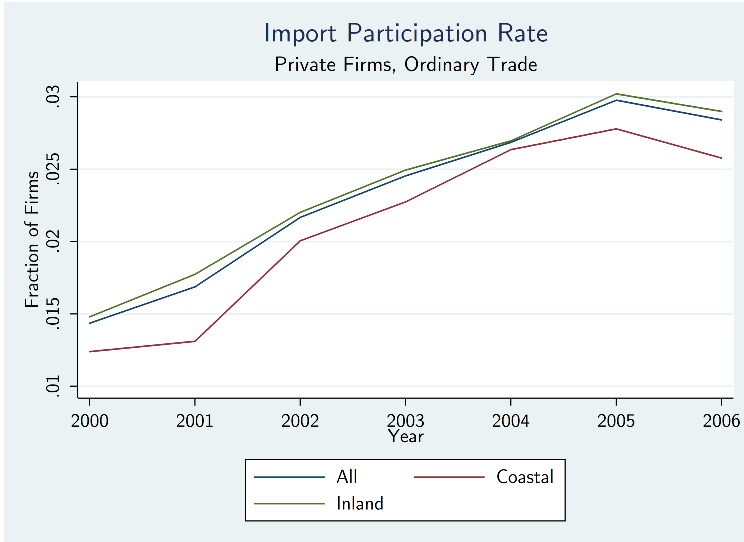

Figure 3: Extensive Margin of Import

the coast during the entire sampled period. Furthermore, despite the successive reduction in trade costs, the average number of imported varieties exhibits downward trend in both regions after 2001.

Finally, Figure 5 shows the intensive margin of import, measured by the share of import expenditure in total intermediate input purchase. When computing the moments, I exclude the firms which import in a given year but not in the previous year. I further restrict the samples to those firms which import intermediate inputs in ordinary trade mode only.[10] For the first four years, the mean import expenditure share is higher in the coastal region than inland region, but it switches after 2004. Median (75 percentile) import expenditure share is higher in the inland region except for the year 2003 (2002). Furthermore, while all the three moments in the inland region keep increasing during the sampled period, in the coastal region, the mean and median expenditure share increase up to 2003 and they turn into declining trend afterward.

Given that the coastal region has potential geographic advantages in international trade compared to the inland region (i.e., the coastal regions have the major international ports), the empir-

year (i.e., continuous or incumbent importers), the average is 4.25 and 8.43, respectively. Therefore, the increasing trend in the import participation rate (Figure 10) may dampen the moments of the sub-extensive margin if I compute them over all importing firms. In order to see the adjustments in sub-extensive margin of incumbent importers, I exclude the new importers from the sample.

[10]In the data set, some firms import intermediate inputs with multiple trading modes; typically, ordinary trade and process trade modes. However, in the manufacturing survey/census, it is not possible to separate the intermediate input expenditure used for the ordinary trade operation from the other usages. Therefore, I excluded firms which import intermediate inputs with multiple modes.

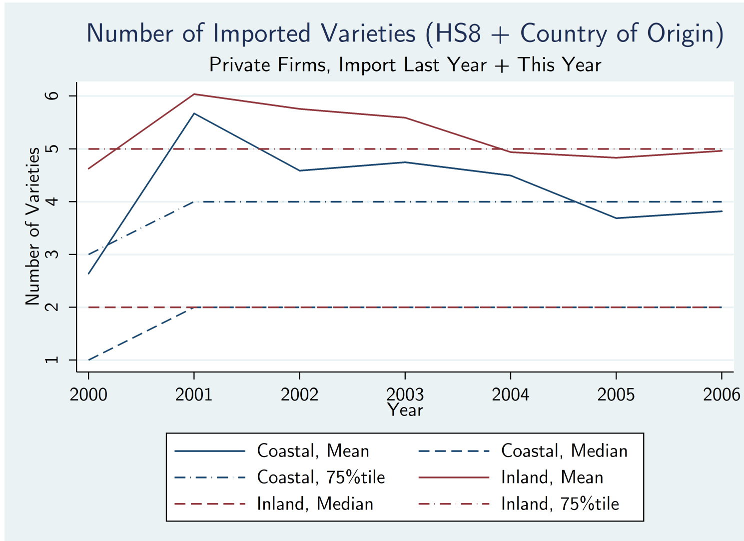

Figure 4: Sub-Extensive Margin of Import

ical findings that the coastal firms, on average, are less likely to import, use fewer imports, and spend less on imported inputs, are puzzling. In order to disentangle this puzzle, let's look at some key statistics on the trading intermediaries. Before the series of trade reforms in China, not all privately owned firms were allowed to import and export directly due to the direct trading right restrictions.[11] As a result, the trading intermediaries had played an important role in Chinese imports and exports. Therefore, lower extensive margin and declining trend in sub-extensive and intensive margins of import in the coastal area might be explained by the growing role of the trading intermediaries. Table 5 demonstrates the number of trading intermediaries and the share of imports by trading intermediaries (in value) in total ordinary trade imports. I include the state-owned and foreign trading intermediaries in the table since the major trading intermediaries were state-owned in the historical context. In the coastal area, the number of intermediaries (across all ownership types) increases from 1,489 (2000) to 1,584 (2006) in the coastal region while it decreases from 3,362 (2000) to 1,797 (2006) in the inland region. However, more importantly, the share of imports by trading intermediaries decreases both in the coast and inland, from 52% to 38% and from 30% to 15%. Thus, there is no evidence indicating the growing role of trading intermediaries in the coastal area.

Another possible explanation for the lower import participation of the coastal firms is that the firms substitute for imported inputs with domestic inputs. Given that the domestic firms can poten-

[11]The details of the direct trading right restrictions are summarized in Bai et al. (2017).

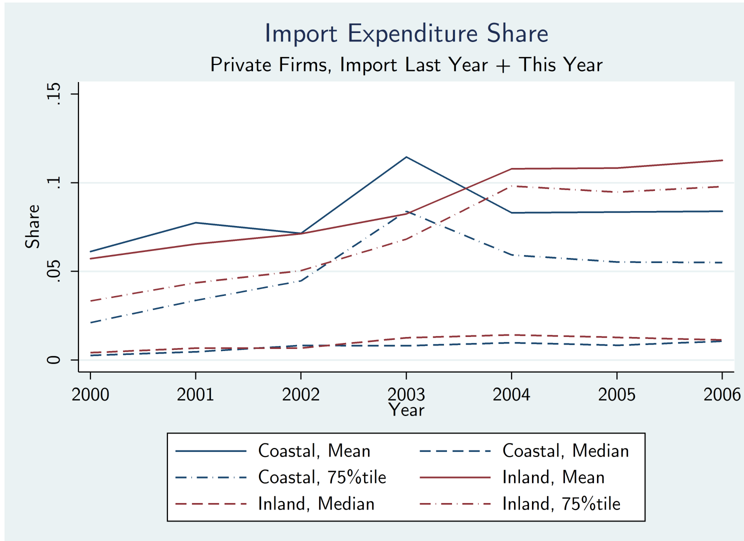

Figure 5: Intensive Margin of Import

tially produce intermediate inputs used by the other firms, increased number of firms may suggest the increased availability of domestic inputs. As I demonstrated in Table 4, the number of firms is larger and increased more in the coast than the inland during the sampled period. The implied larger availability of domestic inputs in the coast may allow for the firms to be less dependent on imported inputs. In order words, the availability of domestic inputs at the firms location, which I call *local availability*, may be a determinant of the firm's outsource decision. In the next subsection, I will implement a reduced form analysis in search of the empirical correlation between the local availability and the firm's import decision.

2.3 Reduced Form Analysis

In this this subsection, I employ reduced form regressions to investigate the correlation between the local availability of domestic inputs and the firm's import decisions by taking advantage of variations across sectors, regions, and time. In particular, I examine if the local availability of domestic input is negatively associated with the firm's binary decisions of import. In this subsection, subscript and superscript j, k is used as an index of a sector listed in Table 1, subscript m, n is used as an index of a region listed in Table 2, and subscript i indexes a firm. A dependent variable of interest is the binary variable $\mathbb{I}^k_{i,j,m,t} \in \{0, 1\}$, which takes 1 if private firm i in industry j (e.g., motor vehicle sector) located at region m (e.g., Guangdong province) imports input k (e.g., metal products) in year t (with ordinary trade mode), and takes 0 otherwise. I relate this binary depen-

Table 5: Trading Intermediaries

		00	01	02	03	04	05	06
Number of Trading Intermediaries								
Coastal	SOE	989	1,034	982	883	*1,052*	*933*	521
	Private	386	619	626	549	*2,802*	*3,962*	903
	Foreign	114	90	78	131	*250*	*237*	160
	Total	1,489	1,743	1,686	1,563	*4,104*	*5,132*	1,584
Inland	SOE	3,267	3,266	2,989	2,648	*2,652*	*2,289*	1,438
	Private	37	48	54	49	*1,244*	*1,743*	289
	Foreign	58	45	38	36	*56*	*114*	70
	Total	3,362	3,359	3,081	2,733	*3,952*	*4,146*	1,797
Share of Trading Intermediaries in Total Ordinary Trade Import								
Coastal	SOE	47%	43%	43%	41%	*37%*	*34%*	29%
	Private	4%	6%	6%	5%	*18%*	*26%*	9%
	Foreign	1%	1%	1%	1%	*0%*	*0%*	0%
	Total	52%	50%	51%	48%	*55%*	*59%*	38%
Inland	SOE	30%	29%	26%	22%	*19%*	*17%*	15%
	Private	0%	0%	0%	1%	*2%*	*2%*	0%
	Foreign	0%	0%	0%	0%	*0%*	*0%*	0%
	Total	30%	29%	26%	23%	*21%*	*19%*	15%

dent variable to the local availability of input k (i.e., metal products) at the firm's location m (i.e., Guangdong province) in year t. I expect that higher availability of domestic input is negatively associated with the probability to import.

In order to measure the local availability of domestic input, I first define the aggregate local output share $ALOS^k_{m,t}$. This is the regional output of sector k at region m in year t, $Y_{k,m,t}$, normalized by the world output of that sector $Y^W_{k,t}$:

$$ALOS^k_{m,t} = \frac{Y_{k,m,t}}{Y^W_{k,t}} = \frac{\sum_{i \in \Omega_{k,m,t}} Y_{i,k,m,t}}{Y^W_{k,t}}. \tag{1}$$

Regional output $Y_{k,m,t}$ is defined as the sum of each individual firm's output (sales income) $Y_{i,k,m,t}$ over the set of firms in industry k at region m in year t, denoted by $\Omega_{k,m,t}$. This set includes SOEs and foreign firms, unless otherwise specified. $Y^W_{k,t}$ is the world output of sector k in year t, which is sourced from the UNIDO INDSTAT. Aggregate local availability index $ALAI^k_{m,t}$ is defined as the weighted sum of the aggregate local output share $ALOS^k_{n,t}$ over the set of Chinese regions $n \in \mathcal{N}$:

$$ALAI^k_{m,t} = \sum_{n \in \mathcal{N}} \omega_n ALOS^k_{n,t}, \tag{2}$$

where the exogenous weight ω_n is given by:

$$\omega_n = \begin{cases} 1 & \text{if } n = m \\ 1/2 & \text{if } n \text{ is adjacent to } m \\ 1/4 & \text{otherwise} \end{cases}, \tag{3}$$

that is, I discount the aggregate local output share of the neighboring regions by 1/2 and the one of other regions by 1/4. I also define the private local output share ($PLOS^k_{m,t}$) and private local availability index ($PLAI^k_{m,t}$) by letting $\Omega_{k,m,t}$ be the set of *private firms* in sector k at region m in equation (1).

I specify the latent variable model as follows:

$$\mathbb{I}^{k*}_{i,j,m,t} = \beta \ln \left(ALAI^k_{m,t} \right) + \boldsymbol{\gamma}' \mathbf{X}^k_{i,j,m,t} + \mathbb{I}_j \delta_j + \mathbb{I}_m \delta_m + \mathbb{I}_t \delta_t + \varepsilon^k_{i,j,m,t}, \tag{4}$$

where control variables $\mathbf{X}^k_{i,j,m,t}$ include log share of sector k input in total input expenditure of sector j (i.e., input-output coefficient or input expenditure share of input k in sector j), $\ln(a^k_j)$, import tariff on good k, τ^k_t, log capital stock of firm i, $\ln(K_{i,j,m,t})$, and one for constant. I also control for fixed effects of firm's industry of production (j), region (m), and year (t), which are represented by $\mathbb{I}$s in the right hand side of equation (4).

Coefficient on β is the central object of interest and it is expected to be negative, i.e., local availability of domestic input is negatively associated with the probability to import. Coefficient on input expenditure share, γ_a, is expected to be positive, i.e., the more important (in terms of expenditure share) the sectoral input is for a firm's industry of production, the more likely to import the firm is. Import tariff would be negatively associated with probability to import, i.e., $\gamma_\tau < 0$. Lastly,

Table 6: Probit Regression: Local Availability and Sectoral Import

	(1)	(2)	(3)
ln(ALAI)	-0.154***		-0.154***
	(0.0332)		(0.0330)
ln(PLAI)		-0.108***	
		(0.0257)	
PLAI/ALAI			-0.0147
			(0.0861)
ln(Input Share)	3.014***	2.864***	3.013***
	(0.273)	(0.272)	(0.275)
Tariff	-0.00404	-0.00399	-0.00402
	(0.0127)	(0.00543)	(0.00539)
ln(Capital)	0.794***	0.327***	0.328***
	(0.00544)	(0.0124)	(0.0124)
Industry, Province, and Year Dummies	YES	YES	YES
Observations	1,595,359	1,595,359	1,595,359

Standard errors (clustered at firm's industry of production) in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

larger firms would be more likely to use imported input, i.e., $\gamma_K > 0$.[12]

It is worth emphasizing that the estimation results presented below should be read as empirical correlation but not causality due to a potential endogeneity problem. Suppose that firm i, all else being equal, is inclined to use more domestic input from sector k rather than using imported input in order to, for example, save on costs associated with importing, i.e., the error term in regression equation (4), $\varepsilon^k_{i,j,m,t}$, is lower. Then, the firm may endogenously choose the location with higher local availability of sector k. The firm's endogenous location choice will lead to the downward biased estimate of β. In order to partially aid this endogeneity problem, the following regressions use balanced panel of firms. However, a potential bias due to selection still remains. Therefore, the result should be seen as correlation but not causality.

I estimate the model by the probit regression. Firms included in the following regressions are privately owned. I excluded the firms in the following four regions due to the small number of importers (less than 10): Gansu, Qinghai, Guizhou, and Tibet. I also drop the observations if the input expenditure share (a^k_j) is 0, i.e., if industry j does not use input from sector k for the production.[13]

[12]Firm-level studies have shown that importing firms tend to be larger and more productive compared to non-importing firms, as summarized in Bernard et al. (2012).

[13]I have excluded the trading intermediaries from the sample which were identified by their names. However, there

Table 6 demonstrates the result. Standard errors are clustered at the firm's industry of production (j). The table summarizes the regression results where I included fixed effects of industry of production, region, and year. The sign and statistical significance of the key coefficients remain unchanged with different combinations of fixed effects included. Column (1) shows that the aggregate LAI is negatively associated with the probability to import, which is consistent with the expectation. For the other control variables, the table confirms that the input share is positively associated with probability of import and the coefficient is statistically significant; import tariff is negatively associated but not significant; and firm's capital stock is positively associated and the coefficient is statistically significant. These results are in line with the expectations.

In the second specification, I use the private LAI in lieu of the aggregate LAI. The previous subsection demonstrated that the number of private firms increased by approximately 150% during the sampled period in China. In contrast, the number of SOEs has been declining over time. Using the private LAI will allow to draw relationship between the growing presence of private firms and a firm's import decisions. As presented in column (2), negative correlation between the LAI and the probability of import remains robust. In the last specification in column (3), I included aggregate LAI and the private LAI relative to the aggregate LAI. Coefficient on private LAI share demonstrates whether the *relative* presence of private firms is correlated with the probability to import, conditional on the aggregate level of local availability. The coefficient on aggregate LAI remains negative and significant. For the private LAI share, the coefficient is negative but insignificant.

The main takeaway of the reduced form analysis is that the probability that a firm uses imported input of a given sector is negatively correlated with its local availability. As mentioned earlier, however, the reduced form results can only be read as correlation. Despite the shortcoming, the empirical findings above suggest that the firms in the coastal area participate less in intermediate imports (at extensive, sub-extensive, and intensive margins) due to the larger availability of domestic inputs.

3 Model

In this section, I develop a spatial general equilibrium model of a firm's trade. The model features multiple regions with domestic geography, heterogeneous firms making import and export deci-

are some production firms which purchase imported inputs not for their production, but for reselling to the other firms. Excluding the sample with $a_j^k = 0$ allows us to eliminate these production intermediaries.

sions, and endogenous market size by allowing households to move across locations. The model attempts to describe the two key empirical findings presented above. First, despite the successive reduction in trade barriers and the geographic advantages of the coastal region in international trade, a coastal firm is less likely to use imported inputs, uses fewer imports, and spends less on imported inputs than an inland firm. Being motivated by the reduced form analysis, the model lets domestic and imported inputs be imperfectly substitutable. Firms make import decisions at extensive, sub-extensive, and intensive margins given the price index of domestic input, the prices of imported inputs, and other aggregate variables. The model allows the domestic input price index to be mechanically associated with the availability of domestic inputs.

Second empirical observations to be explained by the model are that the number of firms increases more and the selection seems to be weaker in the coastal region than the inland region. Given that the coastal region is relatively more open to the foreign market, this is not in line with the naïve prediction based on the canonical model of a firm's trading decision. In my model, households are assumed to be mobile across domestic locations so that market size is endogenously determined. The number of households in each location has an implication for the equilibrium measure of active firms, which in turn affects aggregate variables and thus the firm's trading decisions.

3.1 Environment

The model features two countries, single sector, and single factor of production. Two countries are China and foreign country, which are denoted by superscript D and F, respectively. China is assumed to be a small open economy so that foreign aggregate variables are taken as given. China consists of multiple locations indexed by $m, n \in \mathcal{N} = \{1, 2, ..., N\}$. Locations can differ from one another in terms of productivity, amenities, their geographic location relative to one another, and accessibility to the foreign country (e.g., whether it has an international port). Labor is mobile across locations but have idiosyncratic draws for preference for each location.

In each Chinese region, there are households each of which supplies one unit of labor inelastically at local wage and consumes a bundle of domestic varieties. Varieties are denoted by i and j. The domestic varieties are produced by a continuum of intermediate good producers (firms). Output of a firm is sold to domestic consumers (and foreign consumers if it exports) and the other domestic firms as an intermediate input.

When I express a bilateral flow of good between two locations, the first subscript denotes the origin and the second subscript denotes the destination. In the rest of this section, I will describe household and firm's behaviors in a Chinese region unless otherwise specified.

3.2 Consumer Preferences

Preference for a household ω residing in location n depends on goods consumption (C_n) and idiosyncratic amenity shock to the utility from residing in that location:

$$U_n(\omega) = b_n(\omega)C_n. \tag{5}$$

The goods consumption index C_n is defined over consumption of a continuum of domestic varieties available in China:

$$C_n = \left(\sum_{m \in \mathcal{N}} \int_{j \in \Omega_m^D} c_{mn}(j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}, \tag{6}$$

where $c_{mn}(j)$ is consumption of variety j produced at location m and sold at location n. Ω_m^D is a set of domestic varieties produced at location m which is determined endogenously in the model. $\sigma > 1$ determines the elasticity of substitution between varieties. Households do not consume foreign varieties directly. Dual price index for goods consumption $\tilde{P}_n^D$ is determined as:

$$\tilde{P}_n^D = \left(\sum_{m \in \mathcal{N}} \int_{j \in \Omega_m^D} \tilde{p}_{mn}^D(j)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}, \tag{7}$$

where $\tilde{p}_{mn}^D(j)$ is the price of verity j produced at location m and sold at n. Due to domestic trade costs, the price of a given variety may differ across destination locations. The idiosyncratic amenity shocks $b_n(\omega)$ capture heterogeneous preferences for living in each location. Following Redding (2016), I assume that the shocks are drawn independently across locations and households from a Frèchet distribution:

$$b_n(\omega) \sim G_n(b) = \exp(-B_n b^{-\eta}), \tag{8}$$

where the scale parameter B_n determines average amenities for location n and the shape parameter η governs the dispersion of amenities across households. Each household residing in location n supplies one unit of labor inelastically.

Given the specification above, indirect utility of household ω residing in location n is:

$$U_n(\omega) = \frac{v_n}{\tilde{P}_n^D} b_n(\omega), \tag{9}$$

where v_n is nominal household expenditure, which will be formally determined below. Each household chooses the location that offers the highest utility after taking into account the idiosyncratic preferences. Taking advantage of the properties of the Fréchet distribution of the amenity shocks, the probability that a household chooses to live in location $n \in \mathcal{N}$ is given by:

$$\frac{L_n}{\overline{L}} = \frac{B_n \left(v_n/\tilde{P}_n^D\right)^\eta}{\sum_{m\in\mathcal{N}} B_m \left(v_m/\tilde{P}_m^D\right)^\eta}, \tag{10}$$

where $\overline{L} = \sum_n L_n$ is the total number of workers in China, which is fixed.

I assume that foreign households may consume Chinese varieties directly and have the CES preference with the same elasticity of substitution σ. Since China is assume to be small open economy, the foreign consumer price index $\tilde{P}^F$ and the aggregate household expenditure E^F are given in the model.

3.3 Intermediate Good Producers

In each Chinese region, there exists a continuum of intermediate good producers (or firms), each of which produces a unique differentiated variety. Firms are heterogeneous in their core productivity *à la* Melitz (2003). Let φ be productivity of a firm. Each firm uses labor and intermediate inputs in a Cobb-Douglas fashion. Marginal cost of a firm with productivity φ based at location n is:

$$mc_n(\varphi) = \Lambda \frac{1}{\varphi} w_n^{\beta_L} p_n(\varphi)^{\beta_M}, \tag{11}$$

where β_L and β_M are share of labor and intermediate inputs in the total production cost, which are summed up to one. $\Lambda = \beta_L^{-\beta_L} \beta_M^{-\beta_M}$ is constant, $p_n(\varphi)$ is a firm-specific price index of the input bundle.

A firm's input bundle depends on the firm's import decision. If the firm does not import, it uses a domestic input bundle which is common for all firms within the location. Otherwise, the input bundle is a CES aggregate of domestic and foreign input bundles, the latter of which is firm-specific. Formally, the price index of a firm's input bundle can be expressed as:

$$p_n(\varphi) = \begin{cases} p_n^D & \text{if firm } \varphi \text{ does not import} \\ \left[\left(p_n^D \right)^{1-\epsilon} + \left(p_n^F(\varphi) \right)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} & \text{otherwise,} \end{cases} \tag{12}$$

where p_n^D and $p_n^F(\varphi)$ are, respectively, the price indices of domestic and foreign input bundles. $\epsilon > 1$ is the elasticity of substitution. Analogous to consumer price index in Equation (7), the price index of a domestic input bundle is defined as:

$$p_n^D = \left(\sum_{m \in \mathcal{N}} \int_{j \in \Omega_m^D} p_{mn}^D(j)^{1-\rho^D} dj \right)^{\frac{1}{1-\rho^D}}, \tag{13}$$

where the elasticity of substitution is $\rho^D > 1$. This formulation implies that a firm uses all domestic varieties available in China and it also captures the idea of roundabout production. More importantly, the CES price index features love-of-variety effect. Therefore, the larger the measure of varieties in the local market (i.e., local availability of domestic inputs) is, the lower the price index is unless the domestic trade costs are zero. Since the domestic and imported inputs are imperfectly substitutable in a CES fashion as in equation (12), lower domestic input price implies the smaller expenditure share on imported inputs. The price index of foreign input bundle is also a CES price index defined over prices of foreign varieties which the firm imports:

$$p_n^F(\varphi) = \left(\sum_{j \in \Omega_n^F(\varphi)} (p_{jn}^F)^{1-\rho^F} \right)^{\frac{1}{1-\rho^F}}, \tag{14}$$

where p_{jn}^F is the price of foreign variety j used at Chinese location n and $\Omega_n^F(\varphi)$ denotes the set of foreign varieties, or the foreign sourcing strategy following the terminology of Antràs et al. (2017), which is endogenously chosen by the firm. As I formally introduce below, the foreign varieties are discrete. The elasticity of substitution is $\rho^F > 1$.

Each firm is infinitesimal in a market and supplies a unique differentiated variety. Therefore, with the standard Dixit-Stiglitz monopolistic competition assumption on market structure, it charges a constant markup over marginal cost. Given the elasticities of substitution, the markup is $\sigma/(\sigma-1)$ when it sells to domestic and foreign consumers and $\rho^D/(\rho^D-1)$ when it sells to other firms.[14] With standard iceberg trade costs across locations, the price of variety φ produced at location m and sold to consumers and firms at location n and to foreign consumers are, respectively:

$$\begin{aligned}
\tilde{p}_{mn}^D(\varphi) &= \tau_{mn}^D \frac{\sigma}{\sigma-1} mc_m(\varphi), \\
p_{mn}^D(\varphi) &= \tau_{mn}^D \frac{\rho^D}{\rho^D-1} mc_m(\varphi), \text{ and} \\
\tilde{p}_{mF}^D(\varphi) &= \tau_{mF} \frac{\sigma}{\sigma-1} mc_m(\varphi),
\end{aligned}$$

International trade costs may vary across Chinese locations, i.e., τ_{mF} may be different from τ_{nF} for all $n \neq m$, due to domestic trade cost. For example, if an international port is located in region ℓ, then a firm based at region m has to incur the trade cost $\tau_{mF} = \tau_{m\ell}^D \tau_{\ell F}$ to serve the foreign market.

Sales of a firm with productivity φ based at location m is given by:

[14] The elasticity of substitution ρ^D is potentially different from the one in the consumer price index σ. The CES aggregators of consumption bundle and input bundle can be seen as a retailer and wholesaler. If $\sigma > \rho^D$, the price of the bundle costs more at the wholesaler than the retailer. Then, a firm would find it optimal to purchase input bundle at the wholesaler. In order to avoid this situation, in the numerical simulation, I assume that these elasticities of substitution are same.

$$
\begin{aligned}
r_m(\varphi) =& r_m^D(\varphi) + r_m^F(\varphi) + r_m^I(\varphi) \\
=& \sum_{n \in \mathcal{N}} \underbrace{\frac{E_n^D}{(\tilde{P}_n^D)^{1-\sigma}} \left(\tilde{p}_{mn}^D(\varphi)\right)^{1-\sigma}}_{\text{Sales to domestic consumers in region } n} \underbrace{+ \mathbb{I}_n^E(\varphi) \frac{E^F}{(\tilde{P}^F)^{1-\sigma}} \left(\tilde{p}_{mF}^D(\varphi)\right)^{1-\sigma}}_{\text{Sales to consumers in foreign country}} \\
&+ \sum_{n \in \mathcal{N}} \int_{j \in \Omega_n^D} \underbrace{\left(\beta_M \frac{r_n(j)}{\mu_n(j)} \frac{(p_n^D)^{1-\epsilon}}{p_n(j)^{1-\epsilon}} \frac{(p_{mn}^D(\varphi))^{1-\rho^D}}{(p_n^D)^{1-\rho^D}} + f_n \frac{(p_{mn}^D(\varphi))^{1-\rho^D}}{(p_n^D)^{-\rho^D}} \right)}_{\text{Sales to intermediate good producer } j \text{ in region } n} dj
\end{aligned} \tag{15}
$$

The firm's sale can be decomposed into three terms: the first term captures the sales to consumers in China, where $E_n^D = L_n v_n$ is aggregate household expenditure at location n; the second term is sales to consumers in foreign country where $\mathbb{I}_n^E(\varphi)$ is an indicator function which takes one if the firm exports and zero otherwise; the last term is sales to the other domestic firms in China. Sales to firm j at location n can be further decomposed into two parts; the first component captures the firm j's demand for variety φ used for its production; and the second component captures the demand for variety φ used to startup firm j's business. I assume that a firm based at location n has to purchase f_n units of domestic input bundle priced at p_n^D to startup the business. Therefore, $f_n p_n^D$ is total expenditure to startup the business and the standard CES formula gives the expenditure share on variety φ. [15]

Now I will explain a firm's import and export decisions. Suppose that there exists a fixed integer number $\overline{J}^F$ of available foreign input varieties which can be used by Chinese firms. These varieties may differ in their f.o.b prices and qualities. Let p_j^F be the quality adjusted gross (of trade cost) price (i.e., f.o.b price) of the foreign variety j. I assume that the quality adjusted f.o.b. price is same for all firms, i.e., no heterogeneity in saliency of the input across firms. I order the varieties by ascending order of the quality adjusted price and label them from 1 to $\overline{J}^F$. A firm has to incur f_n^I units of labor (at the firm's location) as a fixed cost to outsource each variety. Then, the firm will start with importing variety 1 and add variety 2, 3, and so on as long as the marginal benefit of adding additional variety overweighs the fixed cost. The model thus delivers a perfect "pecking order" in

[15] This specification of entry cost is in contrast to the standard model of a firm's trading decisions, e.g., Melitz (2003), in which firm has to hire a given units of labor. I modify the standard specification provided that there is a suggestive evidence of weaker selection in the coastal area. In my model, firms may use imported inputs, which will lower the marginal costs of production *ceteris paribus*. Due to the roundabout production nature, having more importing firms and/or having cheaper imported inputs will lower the price index of domestic input bundle. Given that the imported inputs are relatively cheaper in the coast, the domestic price index may be cheaper in the coast, which leads the lower entry cost and the weaker selection.

the sub-extensive margin of imports.[16] Therefore, the firm's sourcing strategy can be characterized by a scalar, the number of imported varieties J^F. Exporting is also subject to the fixed cost. A firm has to hire f_n^E units of labor (at the firm's location) to serve the foreign consumers.

Given a number of imported varieties (J^F) and export decision ($\mathbb{I}^E$), the firm's profit net of fixed costs is given by:

$$\pi_n\left(\varphi, J^F, \mathbb{I}^E\right) = \pi_n^{\text{Op}}\left(\varphi, J^F, \mathbb{I}^E\right) - J^F f_n^I w_n - \mathbb{I}^E f_n^E w_n - f_n \tilde{p}_n^D, \tag{16}$$

where $\pi_n^{\text{Op}}\left(\varphi, J^F, \mathbb{I}^E\right)$ is operational profit gross of fixed costs of import, export, and entry, which is given by:

$$\pi_n^{\text{Op}}\left(\varphi, J^F, \mathbb{I}^E\right) = \frac{1}{\sigma}\left[r_n^D\left(\varphi, J^F\right) + r_n^F\left(\varphi, J^F, \mathbb{I}^E\right)\right] + \frac{1}{\rho^D} r_n^I\left(\varphi, J^F\right). \tag{17}$$

The firm chooses $J^F \in \left\{1, 2, ..., \overline{J}^F\right\}$ and $\mathbb{I}^E \in \{0, 1\}$ to maximize the profit.

Finally, I conclude describing the firm's behavior by introducing free entry. I assume that the firm's productivity in each location is distributed according to a Pareto distribution with shape parameter θ. Then, the measure of firms with productivity grater than z in location n can be expressed as:

$$\mu_n(T_n, z) = T_n z^{-\theta}, \tag{18}$$

where T_n captures the measure of potential firms or entrepreneurs. I assume that T_n is defined as:

[16] In order to see whether the firm-level import data exhibits pecking order in the sub-extensive margin of imports, I follow Eaton et al. (2011) and see the fraction of firms which obey a hierarchy in the sense that any firm importing from the $k+1$st most popular source country necessarily imports from the kth most popular source country as well. Across all products, about 16.41% of firms obey a hierarchy. The pecking order is more evident when I look at the source countries for each of sectoral good. For each of 71 industries of imported products, I compute the fraction of firms which obey a hierarchy. The mean fraction is 22.97%, median is 21.68%, 75 percentile is 25.06%, and 90 percentile is 30.40%. Given that the current theoretical model has single sector, the assumption of a perfect pecking order in the sub-extensive margin of import may not be too extreme.

$$T_n = \left(\frac{L_n}{\overline{L}}\right)^{\alpha}. \tag{19}$$

As I showed in the previous section, the number of firms increased more than proportional to the population. Parameter $\alpha > 1$ governs the agglomeration of firms.

I assume that potential entrants know their productivity *a priori* and decide whether to become active or not. Starting up business at location n requires to purchase f_n units of domestic input bundle priced at p_n^D. Therefore, in an equilibrium, the least productive firm in each location must have zero profit. The productivity cutoff $\overline{\varphi}_n$ is determined such that,

$$\pi_n^{\text{Op}}(\overline{\varphi}_n) - \left(J^F(\overline{\varphi}_n) f_n^I + \mathbb{I}_n^E(\overline{\varphi}_n) f_n^E\right) w_n = f_n p_n^D \tag{20}$$

The left hand side of equation (20) is the firm's profit net of fixed costs of import and export.

3.4 Aggregation

Nominal household expenditure v_n consists of three components; labor income, the lump-sum transfer of profits generated by the local firms, and net export *vis-a-vis* the foreign country. Therefore, the aggregate household expenditure in region n, E_n, is given by:

$$E_n = v_n L_n = w_n L_n + \int_{i \in \Omega_n^D} \pi_n(i) di - NEX_n, \tag{21}$$

where NEX_n is net export of location n. Finally, labor market clearing condition is given by:

$$w_n L_n = \int_{i \in \Omega_n^D} \left(\beta_L tvc_n(i) + J_n^F(i) f_n^I w_n + \mathbb{I}_n^E(i) f_n^E w_n\right) di, \tag{22}$$

where $tvc_n(i)$ is total variable cost of firm i based at location n, which is given by:

$$tvc_n(i) = \frac{\sigma - 1}{\sigma}\left[r_n^D(i) + r_n^F(i)\right] + \frac{\rho^D - 1}{\rho^D} r_n^I(i). \tag{23}$$

A equilibrium of the model is represented by the measure of workers (L_n), price indices of consumption bundle ($\tilde{P}_n^D$) and domestic input bundle (p_n^D), wage (w_n), and productivity cutoff of the active firm ($\overline{\varphi}_n$) at each location $n \in \mathcal{N}$ such that each household maximizes utility, each firm maximizes profit, the least productive firm has zero profit, and goods and labor markets are clear.

4 Comparative Statics

In this section, I will solve the model numerically. Then, I will study how the equilibrium objects, such as the labor allocation, the measure of active firms, price indices, and some key moments on the firm's trading decisions evolve in response to the exogenous change in international trade cost.

4.1 Solution Algorithm

Before showing the results, I briefly describe the solution algorithm of the model. Since the model generates the perfect pecking order of the sub-extensive margin of imports, the firm's import decisions are characterized by $\overline{J}^F + 1$ productivity cutoffs, i.e., the cutoffs gives the productivity intervals which determines the number of imported varieties. The export decision is also characterized by a export productivity cutoff. Given these features, the solution algorithm proceeds as follows: (1) for a given entry cutoff of the productivity in each location, solve the equilibrium assuming that all active firms do not import nor export; (2) given the aggregate variables obtained in (1), determine the productivity cutoffs for import and export and solve the aggregate equilibrium variables; (3) update the trading cutoffs given the aggregate variables in the previous step; (4) repeat (3) until the trading cutoffs are converged; (5) update the entry cutoff such that the firm with the cutoff productivity has zero profit; (6) repeat (1) – (5) until the entry cutoff is converged. In solving the equilibrium, the wage in the region 1 is taken as a numeraire.

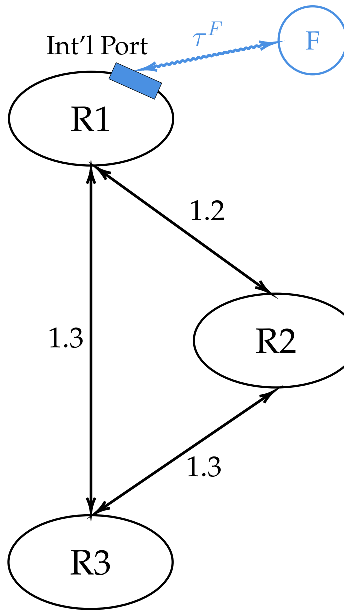

Figure 6: Domestic Geography in the Comparative Statics

4.2 Parameter Values

In the simulation, there are three regions (1, 2, and 3) and a single foreign country. Geography over the locations are summarized in Figure 6. Numbers attached to the arrays connecting the locations indicate the iceberg trade costs. International port is located at region 1 so it can be seen as the coastal region. All goods coming from and going out to the foreign country must go through region 1. Therefore, international trade cost for a firm based at region 2 is $\tau_{F2} = \tau^F \times \tau_{12}^D$. Region 2 and region 3 are the inland regions, but region 3 is relatively isolated from the other two regions. In the comparative statics below, I manipulate the international trade cost between region 1 and the foreign country, τ^F.

Other parameter values used in the numerical simulation are listed in Table 7. The number of available foreign varieties, $\overline{J}^F$, is set to 10. Inverse of the quality adjusted f.o.b. price of imported variety p_j^F for $j = \{1, 2, ..., \overline{J}^F\}$ is drawn independently from a Pareto distribution with the shape parameter θ^I and the location parameter $\underline{z}^I$.

Table 7: Parameter Values

Parameter	Description	Value
Labor endowment and available foreign varieties		
$\overline{L}$	Total labor in China	100
$\overline{J}^F$	Available foreign varieties	10
Elasticities		
β_L	Cobb-Douglas share on labor	0.517
σ	CES aggregator of consumption bundle	6
ρ_D	CES aggregator of domestic input bundle	6
ρ_F	CES aggregator of imported input bundle	6
ϵ	CES aggregator of input bundle	7
α	Agglomeration	1.4
Fixed costs		
f_m,	Fixed cost of export (unit of labor)	1.5
f_m^I	Fixed cost of import (unit of labor)	4.75
f_m^E	Fixed cost of entry (unit of domestic input bundle)	2
Distribution Parameters		
θ	Productivity φ: Pareto	$\theta = 6$
$\theta^I, \underline{z}^I$	Inverse of quality adjusted price $1/p_j^F$: Pareto	$\theta^I = 6.3, \underline{z}^I = 0.22$
η, B_n	Idiosyncratic amenity shock b_n: Fréchet	$B_n = 1, \eta = 1.5$

4.3 Result

In the figures below, blue lines, orange lines, and yellow lines, respectively, depict the equilibrium outcomes and moments in region 1, region 2, and region 3. The horizontal axis is the international trade cost between region 1 and the foreign country. First, Figure 7 shows the price indices of consumption and domestic input bundles in each location. Since the elasticities of substitution for the CES aggregator of these two bundles are same, the two price indices coincide. In any regions, the price indices decline as the trade cost declines. Due to the domestic geography, reduction in trade cost has heterogeneous impacts across locations. The price indices are more responsive to the trade cost in region 1 than region 2 and 3. In terms of level, the price indices are lowest in region 1 and highest in region 3. There are three factors which lead the lowest price in region 1: first, region 1 has relatively lower domestic trade costs to the other two regions; second, imported inputs are relatively cheaper because it has an international port; and third, the measure of active firms in region 1 is largest among three regions, which I explain below.

Figure 8 demonstrates the responses of the measure of active firms (solid lines, the scales is on the left vertical axis) and the number of households (dashed lines, the scale is on the right vertical axis) in each region. In region 1, the measure of active firms and the number of workers increase as

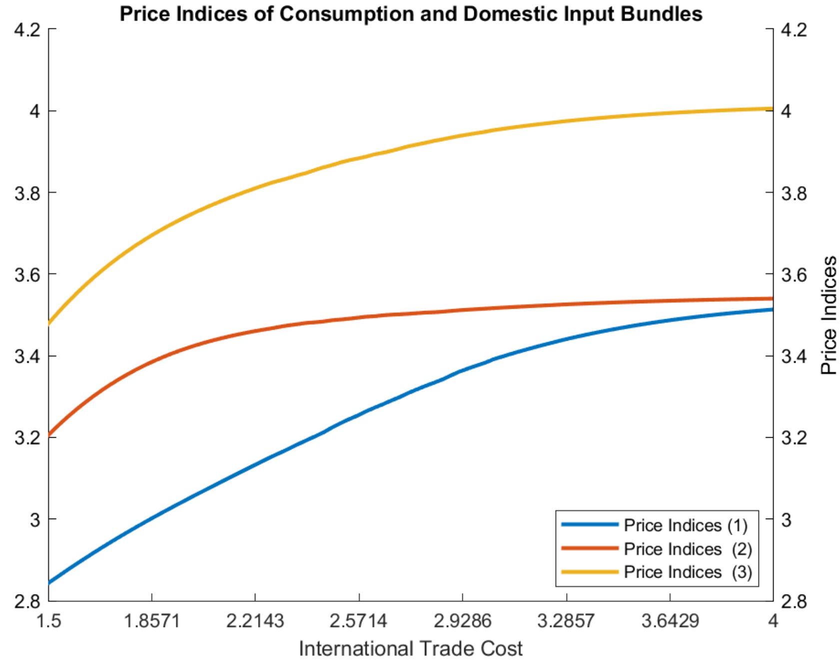

Figure 7: Consumer Price Index and Domestic Input Price Index

international trade is liberalized, and they turned into declining trend at the very end. Responses in the measure of active firms and the number of households in region 2 and 3 exhibit the mirror images of the ones in region 1. In terms of levels, region 1 embraces the largest measure of firms and households, which is followed by region 2 and region 3.

In the model, the measure of active firms in region n is determined by the overall measure of potential entrants (T_n) and the entry cutoff ($\overline{\varphi}_n$). The measure of potential entrants is determined by the number of households as in equation (19). Therefore, the largest population in region 1 makes the measure of potential entrants largest too. Furthermore, the entry cutoff in region 1 is lowest among three regions.[17] The lower entry cutoff in region 1 is due to the lower price index of domestic input bundle as presented in Figure 7. The large population and the lower entry cutoff in together lead to the largest measure of active firms in region 1.

Why does the region 1 attract households from the other regions in response to trade liberalization? When a country opens up trade, as I will demonstrate in the next two figures, firms in region 1 are more like to export and import. The firms' participation in international trade gener-

[17]The entry cutoff of region 1 is lowest as long as the international trade cost is above 1.92. Further reduction in trade cost let the region 2 have the lowest entry cutoffs.

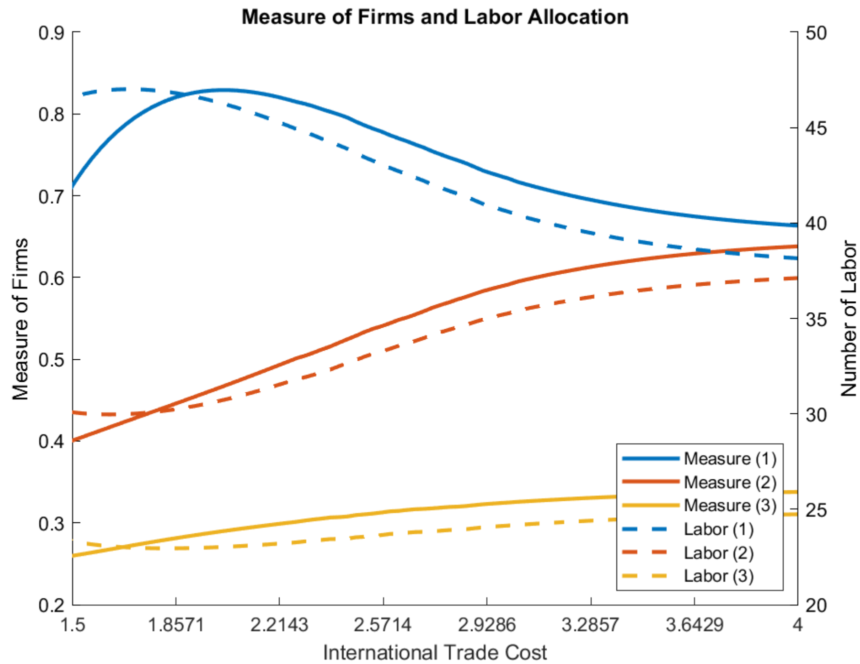

Figure 8: Measure of Active Firms and Labor Allocation

ates larger profits in region 1, which are transferred to the local households in a lump-sum way. In conjunction with the lower consumer price index, there is an influx of households to region 1. As I discussed, it positively affects the measure of potential entrants in region 1. Despite the fact that the entry cutoff keeps increasing due to more competition from abroad, the measure of firms keeps increasing since the first effect (i.e., increase in the measure of potential entrants) dominates the second effect (i.e., increase in the entry cutoff). As the trade cost is lowered further, the measure of active firms starts to drop despite the successive influx of workers into region 1. This is because the competition effect starts to dominates the other. Finally, the household starts to moves out from region 1 to the other regions. This is driven by the declining wage due to the larger labor supply in region 1.

Figure 9 and 10 show the export and import participation rates in each region. The figures show that they are monotonically increasing in reduction in the trade cost. For export, the fraction of firms which export is highest in in region 1, which is followed region 2 and region 3. Since China is small open economy, export participation depends simply on a firm's marginal cost and the international trade cost it faces. Therefore, firms in region 1 are more likely to serve the foreign country by taking advantage of the lower international trade cost.

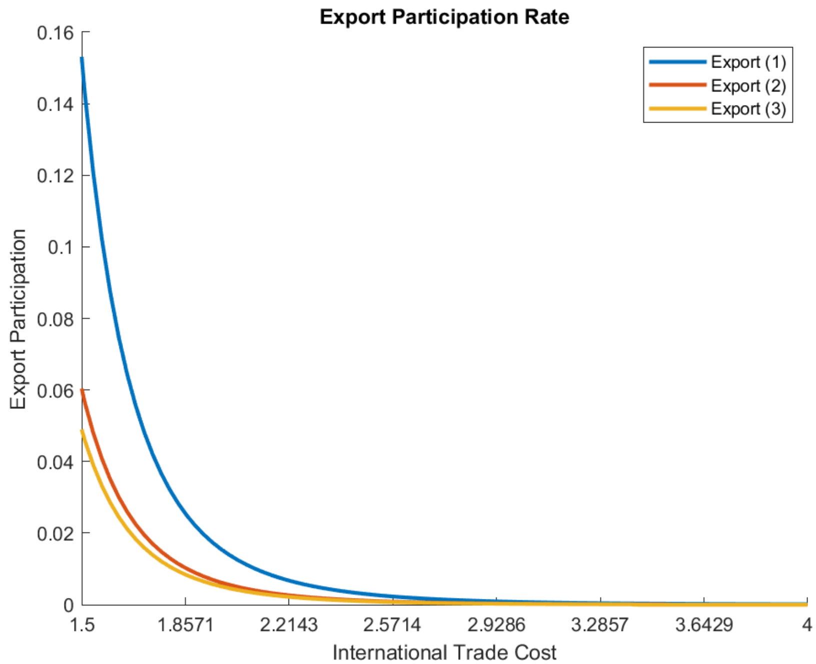

Figure 9: Export Participation Rate

In contras to export decision, an import decision is more complex in the sense that a firm can substitute for imported input with domestic input depending on the relative price. When the trade cost is relatively higher, firms in region 1 are most likely to use imported inputs among three regions, taking advantage of the lower international trade cost. However, as the trade cost gets below 2.3, despite the fact that region 3 is most distant from the international port, the import participation rate in region 3 becomes higher than region 1. This is due to the relatively lower (higher) price index of domestic input bundle in region 1 (region 3), as seen in Figure 7. Cheaper domestic input bundle will allow firms in region 1 to be less dependent on imported inputs, which leads the lower import participation rate. In my simulation, region 2 exhibits the lowest import participation rate, which may be due to the relatively better access to the domestic input varieties in region 1 (and region 3) and the moderate international trade cost. Lower import participation rate in the coast than the inland is consistent with the empirical regularities presented in Figure 3.

Next I look at the sub-extensive margin of imports, i.e., the number of imported varieties. Figure 11 depicts responses of the average and median number of imported varieties. Since the extensive margin of import is increasing as trade costs declines (Figure 10), the impacts of trade liberalization on these moments would be compositional, i.e., the entrants in import market, as well as the adjust-

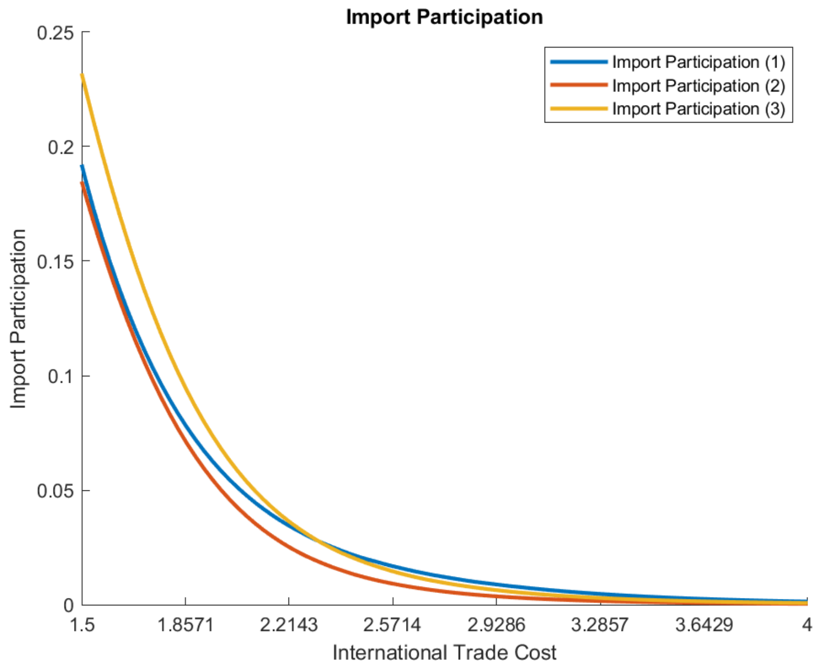

Figure 10: Import Participation Rate

ments by incumbent importers, in together affect those moments. Therefore, in order to highlight the adjustments by incumbents (as I did in section 2), I compute the moments over those firms which uses imported inputs under the highest trade cost (i.e., when $\tau^F = 4$).

The figure demonstrates that, when the trade cost is relatively high ($\tau_F > 2.7$), the mean sub-extensive margin is (weakly) higher in region 1 than region 2 and 3. As the trade cost gets lowered ($\tau_F < 2.7$), the mean sub-extensive margin in region 3 exceeds region 1. Further decline in trade cost ($\tau < 2.4$) lets region 2 have the highest mean sub-extensive margin. For the median, the figure confirms that the region 2 exhibits (weakly) higher sub-extensive margin than region 1 and 2. In my model, the lower sub-extensive margin of import in region 1 may be explained by the lower price index of the domestic input bundle. Therefore, the model generates the patterns in the data that the coastal firms use fewer imports than the inland firms on average. However, the model could not generate the declining trend in sub-extensive margin in response to the trade liberalization, as shown in Figure 4.

Finally, Figure 12 shows the response of the intensive margin of import, i.e., the expenditure share on imported inputs. Analogously, I compute the moments (mean and median) over those firms which use imported inputs from the beginning. The import expenditure share is monotoni-

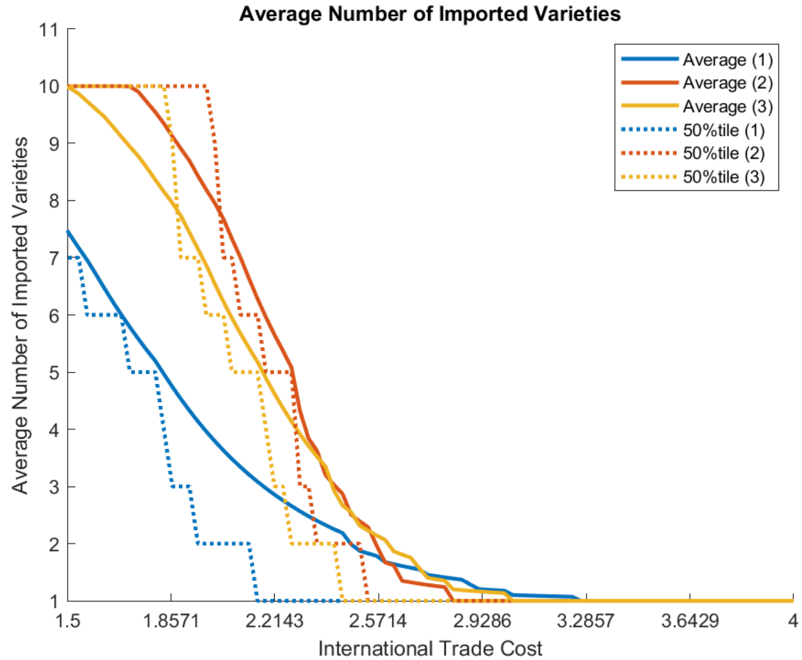

Figure 11: Average and Median of Sub-Extensive Margins of Import

cally increasing in the reduction in trade cost. In terms of level, firms in region 1 spends most on imports on average, which is followed by region 3 and region 2. This is not consistent with the empirical observations in Figure 5 in the cross section and over time; i.e., data reveals that the coastal firms spends less on imported inputs than the inland firms on average, and the mean intensive margins is declining over time.

4.4 Discussion

The comparative statics exercise generated several important patterns which are supported by the empirical findings: first, the market size and the measure of active firms increase more in the coastal region in response to the reduction in trade cost; second, firms in the coastal region are less likely to import and use fewer imports. However, the model could not explain the empirical regularities that the intensive margin of import is lower in the coast and the sub-extensive and intensive margins are declining over time. I will briefly discuss what are potentially misspecified or missing in the model.

In the reduced form analysis, I used the variation in local availability across regions and sectors

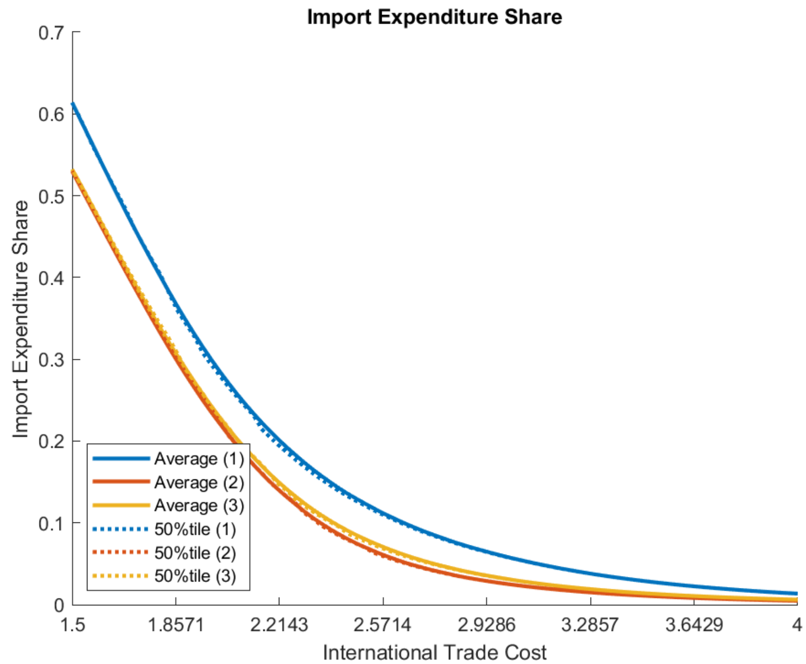

Figure 12: Average and Median of Intensive Margins of Import

and included the input-output coefficient in the regressions. The underlying assumption was that firms in different sectors use the inputs from different sectors in different intensities. The model, however, does not have the sectoral input-output linkage. For example, suppose that a region has (e.g., Ricardian or endowment based) comparative advantage in a given sector. Then, the region may attract the firms which use the output of that sector intensively, which would allow for a firm to use fewer imports and spend less. Furthermore, as the data shows, there is a large variation in tariff cuts across sectors, i.e., some sectors had larger drop in tariff while the others did not. Therefore, the single sector setup of my model may have leveled off an important geographic variations coming from sectoral composition, input-output linkage, and sector-specific trade shocks.

Another important factor which is missing in the comparative statics exercise is that change in domestic trade costs, which is highlighted in the recent work by Tombe and Zhu (2019). In my model, reduction in domestic trade costs will potentially discourage the firm's import participation since the domestic input bundle becomes relatively cheaper. Therefore, development of domestic infrastructure in China may be an answer to the declining sub-extensive and intensive margin of imports. Incorporating the shocks to domestic trade cost would be an important factor in quantifying the model in the future.

5 Conclusion

In this paper, I studied the impact of trade reforms on the firm's intermediate imports. Using the Chinese firm-level data matched with the detailed customs transaction level data, I demonstrated the novel empirical observations on the firm-level import patterns across regions within China. There were two major findings: despite the potential geographic advantages, the coastal firms are less likely to import, use fewer imports, and spend less on imported inputs than the inland region; in contrast to the naïve prediction based on the canonical heterogeneous firm model, there were suggestive evidences for the weaker selection of firms in the coastal area. Furthermore, I implemented the reduced form regressions to relate the firm's sectoral import decision to the local availability of domestic inputs. I confirmed the negative correlation between local availability and probability of importing.

Motivated by the empirical findings, I developed a spatial general equilibrium model of a firm's trading decisions. Comparative statics showed that, as trade barrier collapses, the coastal region attracts workers which leads the increase in the measure of active firms. The coast region has relatively lower domestic input price, which lets the coastal firms be less likely to import and use fewer imports than the inland firms. However, the model could not explain the lower import expenditure share in the coast and the declining trends in sub-extensive and intensive margin of import over time.

There are several important future tasks which are worth mentioning. First, there is a couple of important empirical regularities that were not replicated by the model. It would be important to incorporate the sectoral dimension into the model, such as sectoral input-output linkage. Second obvious step will be the quantification of the model. In doing so, it would be important to take into account the change in domestic trade costs within China. Infrastructural development represented by the change in highway network would be helpful to identify the change in domestic trade costs. Finally, after quantifying the model, doing counterfactual analysis constitutes an important future work. Interesting and important questions to be studied include, e.g., the impact of further reductions in international and domestic trade costs. In the context of recent trade war, it is also particularity interesting and important from the policy perspective to study the impact of sector specific trade shocks on the firm's import participation and the aggregate outcomes.

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