Headquarters Gravity*

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Abstract

This paper develops a general equilibrium model to quantify the impacts of multinational firms (MNEs) on exports and income distribution of the host countries. The key feature of this model is that it allows a MNE's export costs to each market to depend on how similar this market is to its production locations (gravity) and to its headquarters location (headquarters gravity). I estimate the model in Chinese firm data and conduct counterfactual experiments. The estimates suggest that MNEs in China face substantially lower export costs than Chinese firms. Shutting down MNEs in China would decrease Chinese manufacturing exports by 49 percent, about half of which is due to MNEs in China having lower export costs than Chinese firms. Furthermore, MNEs' lower export costs benefit Chinese workers by improving their access to international markets but hurt the U.S. workers by intensifying import competition from China.

Keywords: *Multinational Firms; Export; Welfare*

JEL classification: *F12, F23, O19.*

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1 Introduction

Export-led growth has dominated development strategies in recent decades. However, this strategy faces challenge of getting access to foreign markets. Local firms may lack information about the foreign markets and the expertise in international transaction. Their brand names may not be known by foreign consumers. By their very nature, multinational firms (MNEs) excel in these dimensions.[1] Indeed in recent examples of export-led growth such as China and Ireland, their exports have primarily been driven by foreign MNEs.[2]

Given the importance of MNEs in export, this paper aims to answer several questions: How do MNEs differ from local firms in terms of exports? How much are MNEs responsible for the exports of the host countries? Through what channels? What are the welfare and distributional implications of these channels? Providing quantitative assessments to these questions is important for understanding the interaction between trade and multinational production (MP) and for evaluating trade and FDI policies.

To answer these questions, I develop a multi-country general equilibrium model with trade and MP. The key feature of this model is that it allows a MNE's export costs to each market to depend on how similar this market is to its production locations (*gravity*) and to its headquarters location (*headquarters gravity*). Headquarters gravity is motivated by a regularity from Chinese firm data: controlling for the destination market size and the destination distance from China, MNEs in China export more to markets closer to their headquarters. Previous models of MNEs' exports have assumed that MNEs face the same export costs with local firms (Arkolakis et al. (2015), Tintelnot (2014)). By doing this, they attribute the MNEs' outstanding export performances solely to their productivities. By contrast, in my model headquarters gravity allows MNEs to be more export-oriented than local firms even when they are equally productive. As a consequence, my model allows me to separate the MNEs' advantage in export from their productivity advantage.

Headquarters gravity is consistent with the ideas that MNEs can improve their affiliates' access to markets close to their headquarters. This improved access may come from the

[1]See Arnold and Javorcik (2009), Guadalupe et al. (2005), Hanson et al. (2005), and Ekholm et al. (2007) for empirical evidence of MNEs' advantage in export.

[2]In 2001 foreign MNEs in China carry out 68% of Chinese manufacturing exports (Chinese Customs Records). In 2001 foreign MNEs in Ireland account for 90% of Irish manufacturing exports (OECD database).

MNEs' prior experience, brand names, or marketing networks in these markets. Creating brand names or establishing marketing networks would be very costly in markets far away from headquarters. So I allow export costs to increase with the distance between headquarters and destination countries.

To measure headquarters gravity, I estimate my model in Chinese firm data which contains the firms' nationalities and their exports by destination. The key empirical challenge is that the MNEs' export choices are driven both by their productivities and by their export costs. I deal with this identification problem utilizing the model implication that the firm's productivity affect its sales in all markets but its export costs affect only exports. I calibrate the remaining parameters by matching the model-generated trade and MP flows to the data.

The estimates suggest that MNEs in China face substantially lower export costs than Chinese firms. On average, the MNEs' fixed export cost is 82 percent lower than Chinese local firms while their iceberg export cost is 28 percent lower. The export costs of MNEs in China are particularly low to markets close to their headquarters. The fixed export cost of an affiliate to its headquarters country is, ceteris paribus, 80 percent lower than to any other country. The geographic distance, the shared language, and the similar GDP per capita between the headquarters country and the destination are all quantitatively important for the export costs of MNEs in China. These results imply that the MNEs in China indeed act as trade intermediaries bridging Chinese workers with foreign consumers.

I then turn to quantify the impacts of MNEs in China on Chinese exports and the channels of these impacts. The result shows that MNEs in China are responsible for a substantial fraction of Chinese exports. Shutting down MNEs in China would decrease Chinese manufacturing exports by 49 percent. I further explore the role of MNEs' lower export costs on Chinese export. Imposing MNEs in China to have the same export costs with Chinese firms would decrease Chinese manufacturing exports by 23.3 percent. So about half of MNEs' contribution to Chinese exports is due to their lower export costs. The remaining half is due to MNEs' higher productivity.[3] In sum, both the technology and the access to international markets brought by MNEs are quantitatively important for Chinese export booms.

[3]When saying lower export costs or higher productivity, I compare MNEs with local firms.

The general equilibrium model also allows me to make welfare statements. Imposing MNEs in China to have the same export costs as Chinese firms would decrease Chinese welfare by 0.1 percent. This small welfare effect, however, is associated with a sizable distributional effect between wage and profits. Imposing MNEs in China to have the same export costs as Chinese firms would decrease Chinese manufacturing wage by 8.8 percent while increase Chinese firm profits by 1.4 percent. Intuitively, the MNEs' lower export costs would raise Chinese labor demand but intensify the competition faced by Chinese local firms. The opposite would happen in the U.S. If MNEs in China have the same export costs as Chinese firms, the U.S. manufacturing wage would increase by 0.07 percent but the U.S. firm profits would decrease by 0.28 percent. The low export costs of MNEs in China would hurt the U.S. manufacturing workers by increasing the import competition from China but benefit the U.S. MNEs by raising their profits from China.

This paper is related to several strands of the literature. First, this paper builds on and contributes to quantitative studies of trade and multinational production. Tintelnot (2014) allows firms to build export platforms at the expense of fixed costs. Ramondo and Rodriguez-Clare (2013), Alviarez (2013), and Arkolakis et al. (2015) aim to quantify the gains from openness in a world with both trade and multinational production. All of these papers assume that MNEs incur the same export costs with the local firms in host countries. Consequently, they cannot capture the MNEs' advantage in serving markets close to their headquarters. This paper is the first attempt to quantify headquarters gravity in a general equilibrium model.

Second, headquarters gravity has important implications for gravity equation. Gravity equation by Tinbergen (1962) predict that given the destination market size an exporter would export less to markets farther away from its production location. In these models the exporter's center of gravity is assumed to lie in its production location. I argue that this assumption does not valid for MNEs. In existence of headquarters gravity, a MNE's center of gravity does not only depend on their production locations, but also depend on their headquarters locations. Since MNEs accounts for a large fraction of international trade, ignoring headquarters gravity in the estimation of gravity equation will bias the elasticity of trade with respect to distance.[4]

Third, this paper contributes to a growing literature about the MNEs' home market advantage. Head and Mayer (2015) find that in auto parts industry it is more difficult to make sales in markets farther away from brand's headquarters. This paper departs from their study by focusing on aggregate trade patterns instead of one industry. Moreover, my model endogenizes the MNEs' choices on production locations and export destinations, whereas in Head and Mayer (2015) these decisions are taken as given. These margins are shown to have important general equilibrium effects. Cosar et al. (2015) emphasize the MNEs' disadvantage in selling outside the home market. This paper complements their study by emphasizing that the MNEs' home bias can be transferred to their affiliates.

Fourth, this paper contributes to the discussions on what MNEs bring to host countries. Previous papers emphasize the advanced technologies brought by MNEs either in the form of technology capital (MacGrattan and Prescott (2009)) or management know-how (Burstein and Monge-Naranjo (2009)). This paper complements this literature by arguing that in addition to technologies MNEs also provide the host countries with improved access to export markets.

The rest of the paper is organized as follows. In Section 2, I describe the data I use and document stylized facts about the exports by MNEs in China. In Section 3, I introduce my model, define the equilibrium, and deliver structural equations for estimation. In Section 4, the headquarters gravity is identified and estimated from Chinese firm data. Section 5 calibrates the general equilibrium model. Section 6 presents counterfactual exercises. Section 7 concludes.

2 Data and stylized facts

2.1 Data Description

The cross-sectional data of essentially all manufacturing firms located in China in 2001 is created by merging the balance sheet data and trade data for all manufacturers and the

[4]The direction of the bias depends on the distribution of MP sales.

registration information of foreign manufacturers.

The balance sheets come from the Annual Survey of Chinese Manufacturing (ASCM)[5] which contains firms' sales, employment, and capital stocks. The firm exports come from the Chinese Customs Records (CCR) which contains the export value of each firm by destination[6]. The registration information of foreign manufacturers in China comes from Foreign-Invested Enterprise Survey in China (FIESC) which contains the nationality of a firm's primary foreign investor. The details on data construction are presented in the appendix.

Figure 1 illustrates the structure of my data. For each manufacturer in China I observe its nationality and its sales by destination. From this example we can see that MNEs in China sell to China (the host country), to their headquarters countries, and to the third countries. In particular, the MNEs' export destinations concentrate around their headquarters. I show below this example is not an exception.

Table 1 summarizes the performance of MNEs in China. Foreign firms account for 27% of Chinese manufacturing production but for 68% of Chinese manufacturing exports. The striking fact is that their exports are extremely concentrated in their headquarters countries. For example, Japanese firms in China account for 19% of Chinese manufacturing exports but for 45% of Chinese manufacturing exports to Japan. This pattern [7] holds for all China's major FDI sources.

Figure 2 illustrates the geographic patterns of MNEs' exports. I normalize the exports of MNEs' in China to each market by Chinese total exports to that market. By Table 1, Japanese firms in China account for 19% of Chinese manufacturing exports. If all firms located in China face the same export costs, the normalized exports of Japanese firms in China should be 0.19 in each destination market. But they are not. The exports of Japanese firms in China are extremely concentrated in Asian and Pacific areas (relative to Chinese total

[5]ASCM contains all state-owned manufacturing firms and other manufacturing firms whose annual sales exceed 5 million RMB (about 0.6 million dollars). The omitted firms are small and unlikely to be engaged with international trade.

[6]The original data contains the value, the destination, the 8-digit HS category, and the mode of trade for each export transaction. Because I am interested in the overall export performance of individual firms, I aggregate the export value in firm-destination level

[7]The patterns shown in Table 1 are not unique in China. Data for OECD countries show that even in these developed countries foreign firms still have much higher export intensity than local firms. BEA data show that the affiliate exports of the U.S. multinationals are biased towards the U.S. The details are presented in the appendix.

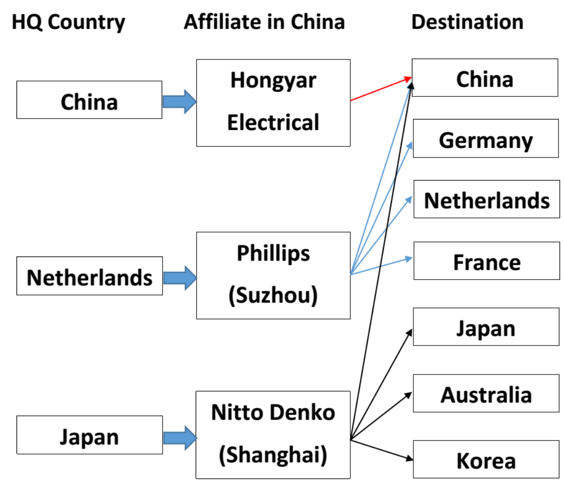


Figure 1: Data Structure: an Example

(Note: All three firms are household appliance producers located in China. Headquarters countries are the locations for their primary foreign investors based on their registration information in the Department of Commerce in China. Exports for each firm to each destination are aggregate export values in 2001. Exports include both ordinary trade and processing trade.)

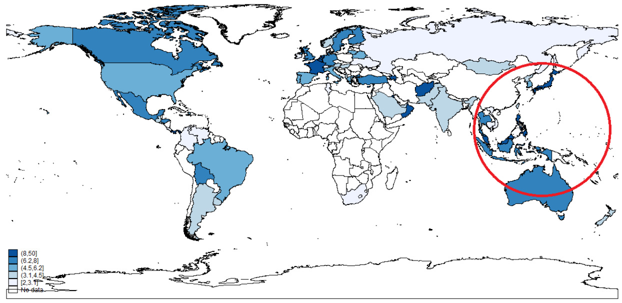
exports). Similar patterns hold for British firms in China. Their exports are concentrated in Atlantic areas. Figure 2 implies that the export costs of MNEs in China depend on their headquarters locations.

2.2 Empirical Regularity

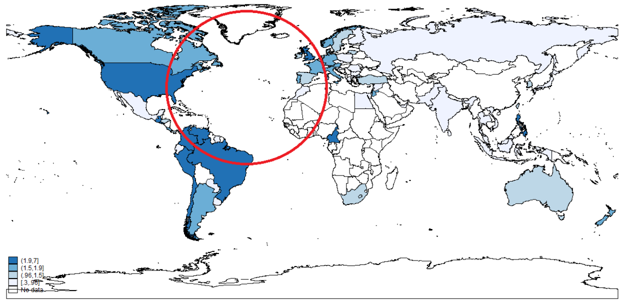
I now turn to describe a new empirical regularity from Chinese firm data. This regularity provides micro data patterns that my structural model should capture.

Fact: Controlling for the firm size, the destination market size, and the destination distance from China, MNEs in China are more likely to export and export more to the markets closer to their headquarters.

Following Morales et al. (2015), I measure the distance between headquarters country i and destination d a vector D_{di} which consists of their geographic distance ($\log(dist_{di})$, whether they speak the same language ($lang_{di}$), whether they have similar GDP per capita ($sgdp_{di}$), and whether they are the same country ($self_{di}$). The probability of firm ν from



(a) Japanese MNEs in China



(b) British MNEs in China

Figure 2: The Exports of MNEs in China: by Destination

(Note: The exports of MNEs in China to each destination are normalized by Chinese manufacturing exports to that destination, i.e. $\frac{X_{d,CHN,i}}{X_{d,CHN}}$ where $X_{d,CHN,i}$ is the exports of MNEs in China from country i to country d and $X_{d,CHN}$ is Chinese manufacturing exports to country d. The darker blue means higher normalized exports.)

Origin	%Firm	%Sales	%Exports	%Sales to HQ Country
DEU	.38	1.82	1.71	11.1
FRA	.17	.33	.33	5
GBR	.44	.94	2.39	3.7
JPN	2.75	4.75	18.71	45.2
KOR	1.11	1.85	9.09	36.7
TWN	3.03	1.8	5.84	14.8
USA	2.09	4.16	9.75	10.7
All foreign	14	27	68	-

Table 1: Multinational Firms in China by Headquarters Country

(Note: Firms from Hong Kong and Macau are excluded. % Firm is the share of MNEs in all manufacturing firms in China in terms of the number of firms. % Sales is the share of MNEs' sales in Chinese manufacturing sales. %Exports is the share of MNEs' exports in Chinese manufacturing exports. %Sales to headquarters country is the share of MNEs' exports to their headquarters country in Chinese manufacturing exports to that country.)

country i serving market d is estimated by:

$$dexp_{\nu,d} = \mathbf{1}\{\beta_0 + fe_d + \beta_1 \log(sales_\nu) + \beta_3 D_{di} + u_{\nu,d} \geq 0\}, \quad d \neq CHN, \tag{1}$$

where $dexp_{\nu,d}$ is a dummy for firm ν serving market d, fe_d is a destination fixed effect, $sales_\nu$ is the firm size in terms of total sales.

Let $exp_{\nu,d}$ be the sales of firm ν in the market d. The intensive margin is estimated by

$$\log(exp_{\nu,d}) = \beta_0 + fe_d + \beta_1 \log(sales_\nu) + \beta_3 D_{di} + u_{\nu,d}, \quad d \neq CHN, \tag{2}$$

The results are presented in table 2. The reduced-form results show that the headquarters location does matter for MNEs' exports. The MNEs' exports would decrease by 4% if the geographic distance between its headquarters and the destination doubles. The shared language and similar GDP per capita between the headquarters and the destination also matter for MNEs' exports. These patterns are robust in more disaggregated data and different specifications. All robustness checks are presented in the appendix.

	Dep. var. *dexp*	Dep. var. log(*exp*)
log(*sales*)	.18***	.48***
	(.002)	(.007)
log(*dist*)	-.02***	-.04***
	(.003)	(.004)
self	1.06***	1.33***
	(.02)	(.06)
lang	.12***	.07**
	(.008)	(.03)
sgdp	.07***	-.01
	(.02)	(.05)
R-square	-	.23
N. of Obs.	1351728	56496

Table 2: Headquarters Gravity: Reduced-form Evidence

(Note: the sample excludes the firms from China, Hong Kong, and Macau. The coefficients of destination dummies are not reported. The extensive margin is estimated by Probit model, which is reported at the left column. The intensive margin is estimated by OLS, which is reported at the right column.)

3 The Model

In this section, I present a model that can capture key features in micro data and guide the identification of the MNEs' advantage in export. I start with the description of the demand and then turn to the firm's problem.

I consider a world with $i = 1, \dots, N$ countries; one primary factor of production, labor L_i; and a continuum of horizontally differentiated varieties of goods. In each country the representative consumer has a Constant Elasticity of Substitution (CES) preference with the elasticity of substitution $\sigma > 1$.

3.1 The Firm's Problem

Each variety is produced by a firm under monopolistic competition. Firm ν originated from country i draws a productivity $\varphi_i(\nu)$. The measure of firms with $\varphi_i \geq \varphi$ is exogenously given by

$$F_i(\varphi) = T_i \varphi^{-\theta}, \quad \varphi > 0, \quad T_i > 0, \quad \theta > \sigma - 1. \tag{3}$$

After drawing productivity, a firm can replicate its technology in multiple production sites by building affiliates. For model tractability, I make the following assumption about the multinational production:

Assumption 1 *Each affiliate produces a distinctive variety, i.e. an affiliate's pricing does not affect the demand faced by other affiliates within firm boundary.*

Assumption 1 implies that, for example, consumers regard Nike sneakers produced in China and Vietnam as two different goods. This "Armington" assumption has to be enforced due to the data limitation. Note that Chinese firm data contains the nationalities of MNEs in China and their exports to each market from China. But I do not observe the MP sales of these MNEs in other countries. Assumption 1 makes my model identifiable in Chinese firm data by separating the affiliate's export decision from the firm's MP decision.

A firm has to choose where to build its affiliates and then where and how much for each of its affiliate to sell. I will first introduce geographical frictions shaping the firm's decisions and then solve the firm's problem in reverse order.

3.1.1 Frictions Shaping Multinational Sales Flows

There are three types of frictions impeding the multinational activities. First, MP incurs an iceberg efficiency loss and a fixed MP cost. So MP sales would fall in distance from the headquarters. Second, transferring products from production sites to destination markets incurs iceberg and fixed trade costs. So export sales would fall in distance from the production sites. These two frictions have been well-documented in the literature.

Motivated by the regularity from Chinese firm data, this paper introduces a new friction. Selling products to the markets far away from headquarters incurs additional iceberg and fixed marketing costs. So export sales would fall in distance from the headquarters. This new friction allows MNE affiliates located in country n to face different trade costs with local firms in country n.

These frictions are illustrated in Figure 3. To build an affiliate in country n, firm ν from country i has to pay a fixed MP cost $f_{ni} > 0$ in terms of n's labor. MP also incurs iceberg

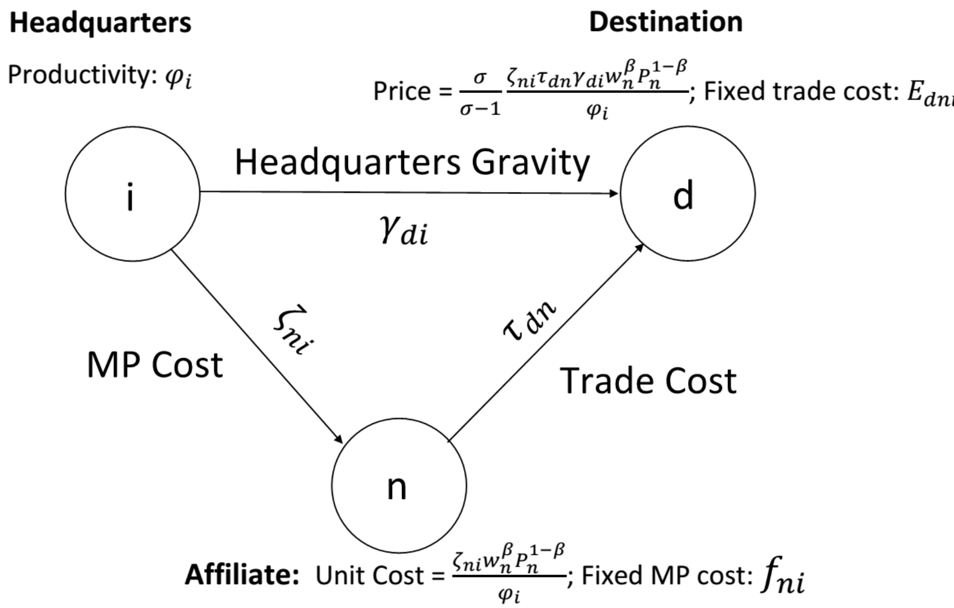


Figure 3: Spatial Frictions Shaping Multinational Sales Flows

efficiency losses. The unit cost for firm ν to produce in country n is

$$c_{ni}(\nu) = \zeta_{ni} w_n^{\beta} P_n^{1-\beta} / \varphi_i(\nu), \tag{4}$$

where ζ_{ni} is the iceberg efficiency loss for MP from country i to n, w_n is the wage in country n, P_n is the price index for the composite final good consumed in country n, and $\beta \in (0, 1]$ is the value-added share.

Firm ν's affiliate in country n incurs standard iceberg trade cost τ_{dn} to serve market d. It also faces an additional iceberg cost γ_{di} to destination d far away from its headquarters country i. These iceberg costs enter firm pricing multiplicatively. Under monopolistic competition the price of firm ν's affiliate in country n serving market d is

$$p_{dni}(\nu) = \bar{m} \frac{\zeta_{ni} \tau_{dn} \gamma_{di} w_n^{\beta} P_n^{1-\beta}}{\varphi_i(\nu)}, \quad \bar{m} = \frac{\sigma}{\sigma - 1}. \tag{5}$$

Note that firm ν from country i shares the common γ_{di} with all of its affiliates to destination d. This γ_{di} is a metaphor that represents to prior experience, brand names, marketing networks, and all other factors firm ν has to market d that can be transferred to its affiliates. By creating an affiliate abroad, firm ν does not only transfer its production technology but also its market access to the host countries.

As in Eaton, Kortum, Kramarz (2011), I introduce fixed trade costs and idiosyncratic shocks to rationalize the micro trade patterns. Firm ν's affiliate in country n incurs a fixed cost $\varepsilon_{dn}(\nu)E_{dni}$ to serve market d. The common component E_{dni} captures both standard gravity that depends on the distance between the destination and the production site and headquarters gravity. $\varepsilon_{dn}(\nu)$ is a affiliate-destination-specific entry shock. Furthermore, an affiliate in country n faces an affiliate-destination-specific demand shock $\xi_{dn}(\nu)$ to serve market d. The idiosyncratic demand shock $\xi_{dn}(\nu)$ and entry shock $\varepsilon_{dn}(\nu)$ are assumed to satisfy

$$(\log(\xi_{dn}(\nu)), \log(\eta_{dn}(\nu))) \sim_{IID} N(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\xi^2 & \sigma_{\xi\eta} \\ \sigma_{\xi\eta} & \sigma_\eta^2 \end{pmatrix}), \quad \eta_{dn}(\nu) = \frac{\xi_{dn(\nu)}}{\varepsilon_{dn}(\nu)}. \tag{6}$$

To save notations I denote the vectors of shocks faced by each affiliate $(\xi_{dn}, \eta_{dn})_{d=1}^N$ as (ξ, η) and the c.d.f. of these stochastic vectors as $G(\xi, \eta)$.

The timing of the firm's decisions is assumed as follows. Firstly firm ν draws its productivity $\varphi_i(\nu)$. Then for each possible production site n, firm ν decides whether to build an affiliate there. If yes, the fixed MP costs will be paid. Then, the idiosyncratic entry and demand shocks are realized. Finally firm ν decides which markets to export its products and how much to sell for its affiliates.

3.1.2 Export Entry and Sales

I solve the firm's decision by reverse order. I start with the scenario in which firm ν from country i has created an affiliate in country n. If this affiliate serves country d, its sales would be

$$x_{dni}(\nu) = \xi_{dn}(\nu) p_{dni}(\nu)^{1-\sigma} P_d^{\sigma-1} X_d, \tag{7}$$

where X_d is the total absorption in country d.

The condition under which this affiliate will serve market d is its operating profit for serving d exceeding its fixed trade cost $w_d \varepsilon_{dn}(\nu) E_{dni}$:

$$\frac{1}{\sigma}\eta_{dn}(\nu)[\bar{m}\frac{\zeta_{ni}\tau_{dn}\gamma_{di}w_n^{\beta}P_n^{1-\beta}}{\varphi_i(\nu)}]^{1-\sigma}P_d^{\sigma-1}X_d \geq w_d E_{dni}. \tag{8}$$

Equation (7) and (8) characterize, respectively, the entrant sales and the entry condition. These two equations, after transformation, will be used to estimate the parameters of headquarters gravity, γ_{di} and E_{dni}, from Chinese firm data.

3.1.3 The Firm's Choice of Production Sites

Firm ν from country i will build an affiliate in country n if its expected operating profit (with respect to idiosyncratic entry and demand shocks) in country n exceeds its fixed MP cost. By Equation (7) and (8), the operating profit for firm ν from its affiliate in country n is given by[8]

$$\pi_{ni}(\xi,\eta,\varphi_i) = \sum_{d=1}^{N}\frac{\xi_{dn}}{\eta_{dn}}\max\{\frac{1}{\sigma}\eta_{dn}[\bar{m}\frac{\zeta_{ni}\tau_{dn}\gamma_{di}w_n^{\beta}P_n^{1-\beta}}{\varphi_i}]^{1-\sigma}P_d^{\sigma-1}X_d - w_d E_{dni}, 0\}. \tag{9}$$

Firm ν will establish an affiliate in country n if and only if the operating profits exceed MP fixed costs:

$$\int_{\xi}\int_{\eta}\pi_{ni}(\xi,\eta,\varphi_i)dG(\xi,\eta) \geq w_n f_{ni}. \tag{10}$$

3.2 Aggregation

In this section I will add up firms' trade and MP decisions into aggregate trade and MP flows. By doing this, I take advantage of the Pareto-distributed productivity and the i.i.d. idiosyncratic shocks. My approach is based on Eaton, Kortum, and Kramarz (2011). But I have to deal with the additional complication that MP incurs fixed costs.

I start with transforming the entry conditions in Equation (8) and (10) into cost thresholds. Note that the unit cost for an affiliate in country n from country i to serve country d is $c_{dni}(\nu) = \frac{\zeta_{ni}\tau_{dn}\gamma_{di}w_n^{\beta}P_n^{1-\beta}}{\varphi_i(\nu)}$. By Equation (8), an affiliate in country n from country i will

[8] I omit the firm index ν to save notations.

serve country d if and only if its unit cost c_{dni} is below a threshold $\bar{c}_{dni}(\eta_{dn}(\nu))$ defined as

$$\bar{c}_{dni}(\eta_{dn}) := (\eta_{dn}\frac{X_d}{\sigma w_d E_{dni}})^{\frac{1}{\sigma-1}}\frac{P_d}{\bar{m}}. \tag{11}$$

Similarly an affiliate from country i in country n has a unit cost $c_{ni}(\nu)$ defined by Equation (4). Note that $c_{ni}(\nu)$ determines its expected operating cost in country n. I can express $\pi_{ni}(\xi,\eta,\varphi_i)$ in Equation (9) as $\pi_{ni}(\xi,\eta,c_{ni}(\nu))$. So a firm will build an affiliate in country n if $c_{ni}(\nu)$ is below $\hat{c}_{ni}$ which satisfies

$$\int_\xi\int_\eta \pi_{ni}(\xi,\eta,\hat{c}_{ni})dG(\xi,\eta) = w_n f_{ni} \tag{12}$$

Now I turn to aggregate individual firms' choices over their productivity φ_ν and their idiosyncratic shocks (ξ,η). Since the productivity follows a Pareto distribution with dispersion parameter θ, the measure of firms from country i to build affiliates in country n is given by

$$J_{ni} = \Phi_{ni}\hat{c}_{ni}^{\theta}, \quad \Phi_{ni} = T_i(\zeta_{ni}w_n^{\beta}P_n^{1-\beta})^{-\theta}. \tag{13}$$

If firm ν from country i serves market d by its affiliate in country n, it must be profitable for this firm to build an affiliate in country n and to serve market d by its affiliate. Equivalently, it must be that

$$\begin{aligned} c_{dni}(\nu) &\leq \bar{c}_{dni}(\eta_{dn}(\nu)), \\ c_{ni}(\nu) &\leq \hat{c}_{ni}, \end{aligned} \tag{14}$$

where $\bar{c}_{dni}$ is defined by Equation (11) and $\hat{c}_{ni}$ is defined by Equation (12).

Equation (14) is equivalent to

$$c_{dni}(\nu) \leq \min\{\bar{c}_{dni}(\eta_{dn}(\nu)), \tau_{dn}\gamma_{di}\hat{c}_{ni}\}. \tag{15}$$

Let $\Psi_{dni} = T_i(\zeta_{ni}\tau_{dn}\gamma_{di}w_n^{\beta}P_n^{1-\beta})^{-\theta}$. If I integrate out φ_i over the region defined by Equation (15), the price index in country d can be given by[9]

$$P_d = \bar{m}[\frac{\theta}{\theta-(\sigma-1)}\int_\xi\int_\eta\sum_{n,i}\Psi_{dni}\xi_{dn}(\min\{\bar{c}_{dni}(\eta_{dn}),\tau_{dn}\gamma_{di}\hat{c}_{ni}\})^{\theta-(\sigma-1)}dG(\xi,\eta)]^{-\frac{1}{\sigma-1}}. \quad (16)$$

Given the aggregate price index, I can solve individual sales by Equation (7) and add them up into the aggregate sales of country i's affiliates in country n to destination d:

$$X_{dni} = \frac{\theta\sigma}{\theta-(\sigma-1)}\Psi_{dni}w_d E_{dni}\int_\xi\int_\eta\frac{\xi_{dn}}{\eta_{dn}}\bar{c}_{dni}^{\sigma-1}(\eta_{dn})[\min\{\bar{c}_{dni}(\eta_{dn}),\tau_{dn}\gamma_{di}\hat{c}_{ni}\}]^{\theta-(\sigma-1)}dG(\xi,\eta). \quad (17)$$

Again by integrating out φ_i over the region defined by Equation (15), I can get the measure of affiliates from country i in country n serving country d:

$$J_{dni} = \Psi_{dni}\int_\xi\int_\eta[\min\{\bar{c}_{dni}(\eta_{dn}),\tau_{dn}\gamma_{di}\hat{c}_{ni}\}]^\theta dG(\xi,\eta). \quad (18)$$

The fixed trade cost associated with this "trilateral trade" is then given by

$$M_{dni} = w_d E_{dni}\Psi_{dni}\int_\xi\int_\eta\xi_{dn}/\eta_{dn}[\min\{\bar{c}_{dni}(\eta),\tau_{dn}\gamma_{di}\hat{c}_{ni}\}]^\theta dG(\xi,\eta). \quad (19)$$

The net profit earned by firms in country i is their operating profits net of fixed trade and MP costs:

$$\Pi_i = (1/\sigma)\sum_{d,n}X_{dni} - \sum_{d,n}M_{dni} - \sum_n w_n f_{ni}J_{ni}. \quad (20)$$

Now I get all income flows in this economy. The total labor income in country i can be derived by adding up the production workers' wages, the fixed marketing costs, and the fixed MP costs:

$$w_i L_i = (1-\frac{1}{\sigma})\beta\sum_{d,k}X_{dik} + \sum_{n,k}M_{ink} + \sum_k w_i f_{ik}J_{ik}. \quad (21)$$

Finally, the total absorption in i is the sum of labor income, the firms' net profit, and

[9]The algebra of these integrals is presented in the appendix.

the expenditure on the intermediates.

$$X_i = w_i L_i + \Pi_i + (1 - \frac{1}{\sigma})(1 - \beta) \sum_{d,k} X_{dik}. \tag{22}$$

3.3 Equilibrium

Definition 2 *Given* $(L_i, f_{ni}, \zeta_{ni}, \tau_{dn}, \gamma_{di}, E_{dni}, \sigma_\xi, \sigma_\eta, \sigma_{\xi\eta})$ *and* F_i*, the equilibrium is* $(w_i, X_i, P_i)_{i=1}^N$ *such that (i)* $\bar{c}_{dni}$ *is defined by equation (11) and* $\hat{c}_{ni}$ *is defined by equation (12), (ii) the sales of affiliates in n from i to d is given by equation (17), (iii) the current account balance conditions, equation (21) and (22), hold, and (iv) the aggregate price index is given by equation (16).*

The equilibrium outcomes $(w_i, X_i, P_i)_{i=1}^N$ can be computed by solving equation (16), (21), and (22). I develop an iterative algorithm to compute the equilibrium outcomes. The details of this algorithm are presented in the appendix.

4 Estimating Headquarters Gravity

The main objective of this section is to quantify how the MNEs' export costs depend on their headquarters locations. Identification of the MNEs' export costs comes from the fact that productivity affects the firms' sales in all markets but export costs affect the firms' sales only in certain export markets.

Before estimation, I have to set values to two parameters that are unidentified in my model. First I set the elasticity of substitution $\sigma = 4$ from Arkolakis et al. (2015). Second I calibrate the value-added share $\beta = 0.35$.[10]

4.1 Estimating Headquarters Gravity Parameters

As illustrated in Figure 3, γ_{di} and E_{dni} are the parameters of headquarters gravity. I estimate these parameters by a Heckman two-step framework developed by Irarrazabal,

[10]The median value-added share of manufacturing firms in China is 0.25. It is well-known that Chinese manufacturing value-added share is lower than the world average. So I adjust $\beta = 0.35$.

Moxnes, and Opromolla (2013). In the first step I estimate the firm's export entry condition. In the second step I estimate γ_{di} from the export sales given entry. This two-step framework is computationally practical for my purpose.

4.1.1 Export Entry

Note that the export entry condition, Equation (8), involves an unobserved productivity term $\varphi_i(\nu)$. By Equation (7), I can substitute $\varphi_i(\nu)$ in Equation (8) by firm ν's sales in China, $x_{nni}(\nu)$. By doing this, I get a new entry condition that only involve the observables, the idiosyncratic shocks, and the parameters to be estimated. Let $y_{dni}(\nu)$ be the dummy for firm ν's affiliate in country n to serve market d. Then

$$\begin{aligned} y_{dni}(\nu) &= \mathbf{1}\{\log(x_{nni}(\nu)) + \log(\eta^*_{dn}(\nu)) \geq H_{dni}\}, \quad n = CHN, d \neq n, \\ H_{dni} &= \log\sigma + \log(w_d E_{dni}) + (\sigma-1)\log(\gamma_{di}) - (\sigma-1)\log(\gamma_{ni}) - \kappa_{dn}, \end{aligned} \tag{23}$$

where $\eta^*_{dn}(\nu) = \eta_{dn}(\nu)/\xi_{nn}(\nu)$, and $\kappa_{dn} = \log(X_d P_d^{\sigma-1}/X_n P_n^{\sigma-1}) - (\sigma-1)\log(\tau_{dn})$.

H_{dni} is a compound entry hurdle that consists of mainly three parts. First it increases with respect to the fixed trade cost $w_d E_{dni}$. Second it increases as the destination d becomes farther to the headquarters country i (γ_{di} grows.). Third it increases with respect to κ_{dn} which reflects the destination market size.

By construction, $\log(\eta^*_{dn}(\nu))$ is i.i.d. normally distributed with mean 0 and variance $\sigma^2_{\eta^*} := \sigma^2_\eta + \sigma^2_\xi$. H_{dni} and σ_{η^*} can be estimated by Equation (23) using data on $y_{dni}(\nu)$ and $x_{nni}(\nu)$. σ_{η^*} is identified by the fact that the export destinations of smaller firms are not necessarily included in the export destinations of larger firms. If $\sigma_{\eta^*} = 0$, Equation (23) suggests that, for example, a Japanese firm in China will certainly serve Korea if a smaller Japanese firm in China does it.

H_{dni} is identified by the variation of $y_{dni}(\nu)$ within each (d,i) pair. Intuitively, for example, some Japanese firms in China serve Australia while others do not. To identify H_{dni}, I restrict the sample so that each headquarters-destination pair has at least 20 entrants and 20 non-entrant[11]. This leaves me 311 (d,i) pairs.

[11] I also exclude Chinese local firms in estimation.

Equation (23) is estimated by a maximum likelihood estimator with the likelihood function:

$$l_1(\Theta_1) = \sum_{d\neq n}\sum_{i}\sum_{\nu}[1-y_{dni}(\nu)]\log\{\Phi[\frac{H_{dni}-\log x_{nni}(\nu)}{\sigma_{\eta^*}}]\}+y_{dni}(\nu)\log\{1-\Phi[\frac{H_{dni}-\log x_{nni}(\nu)}{\sigma_{\eta^*}}]\}, \quad (24)$$

where $y_{dni}(\nu) = 1$ indicates that firm ν enters market d, $\Theta_1 = \{H_{dni}, \sigma_{\eta^*}\}$ with $n = CHN$ and $d \neq n$. $\Phi[.]$ is the cdf of the standard normal distribution. The result suggests that $\sigma_{\eta^*} = 4.93$ with standard error 0.0033.

Figure 4 reports the estimated entry hurdle, $H_{d,CHN,n}$, normalized by total absorption of destination country and the distance between China and destination country, versus the distance between the headquarters country and the destination. It shows that MNEs in China must be larger (in terms of their sales in China) to serve the markets farther away from their headquarters. Figure 5 shows cultural and economic distances matter as well. These results are entirely data-driven since I do not put any structure on H_{dni} in Equation (23).

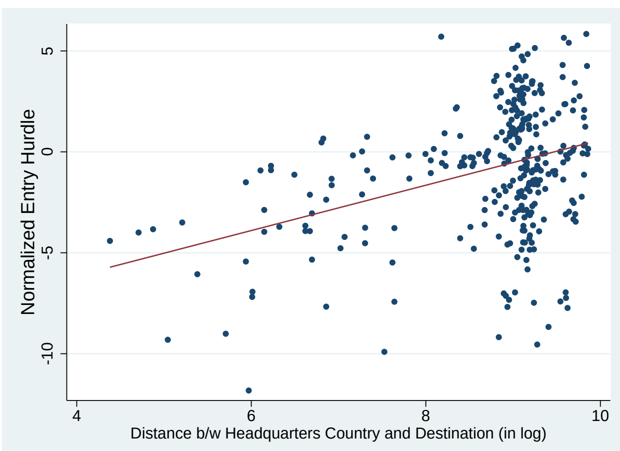


Figure 4: Entry Hurdles with Distance between Headquarters and Destination

(Note: Entry hurdle is defined as the cutoff of the sales in China above which a firm located in China would export to a certain market. Entry hurdle $H_{d,CHN,i}$ is normalized by the destination market size and the destination distance from China, i.e. $H_{d,CHN,i} - \log(X_d) - \log(dist_{d,CHN})$ where X_d is the GDP of country d and $dist_{d,CHN}$ is the distance between China and country d. The distance in X-axis is the geographic distance between the headquarters country and the destination country.)

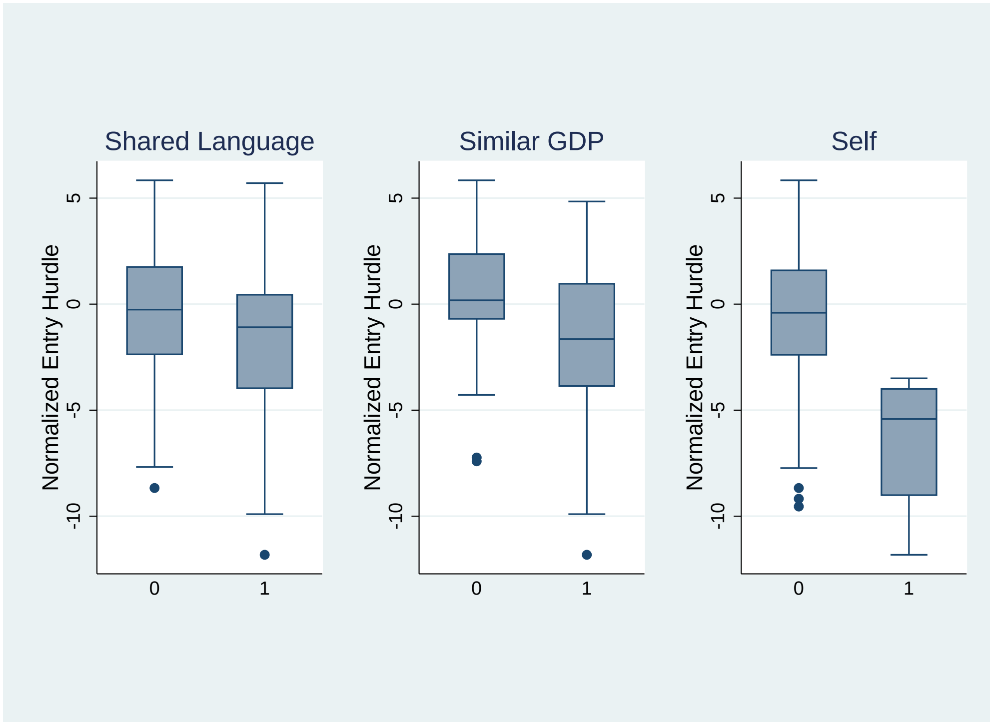


Figure 5: Entry Hurdles with Cultural & Economic Distances

(Note: Entry hurdle is defined as the cutoff of the sales in China above which a firm located in China would export to a certain market. Entry hurdle $H_{d,CHN,i}$ is normalized by the destination market size and the destination distance from China, i.e. $H_{d,CHN,i} - \log(X_d) - \log(dist_{d,CHN})$ where X_d is the GDP of country d and $dist_{d,CHN}$ is the distance between China and country d. Cultural distance refers to whether the headquarters country and the destination use the same language. Economic distance refers to whether the headquarters country and the destination have similar GDP per capita. "Self" refers to whether the headquarters country is the destination country.)

4.1.2 Estimating γ_{di}

γ_{di} can be recovered from export sales characterized by Equation (7). Substituting $\varphi_i(\nu)$ in Equation (7) with $x_{nni}(\nu)$ leads to

$$\begin{aligned} \frac{x_{dni}(\nu)}{x_{nni}(\nu)} &= -(\sigma-1)\log(\gamma_{di}) + \iota_{ni} + \kappa_{dn} + \log(\xi^*_{dn}(\nu)), \\ \log(\eta^*_{dn}(\nu)) &\geq H_{dni} - \log(x_{nni}(\nu)), \end{aligned} \tag{25}$$

where $\xi^*_{dn}(\nu) = \xi_{dn}(\nu)/\xi_{nn}(\nu)$ and $\iota_{ni} = (\sigma-1)\log(\gamma_{ni})$.

To estimate γ_{di} for all (d, i) pairs, I link γ_{di} to the observed gravity variables:

$$\log(\gamma_{di}) = \rho_{\gamma,1} \log(dist_{di}) + \rho_{\gamma,2} lang_{di} + \rho_{\gamma,3} sgdp_{di} + \rho_{\gamma,4} self_{di}, \tag{26}$$

where $dist_{di}$ is the distance between d and i, $lang_{di}$ is a dummy for d and i speaking the same language, $sgdp_{di}$ is a dummy for d and i having similar GDP per capita, and $self_{di}$ is a dummy for $d = i$. Let $\rho_\gamma = (\rho_{\gamma,1}, \rho_{\gamma,2}, \rho_{\gamma,3}, \rho_{\gamma,4})$ and $D_{di} = (\log(dist_{di}), lang_{di}, sgdp_{di}, self_{di})'$. Now I turn to estimate ρ_γ from Equation (25).

The selection effect of the exporters may bias the OLS estimator for ρ_γ. Note that γ_{di} is a component of the entry hurdle, H_{dni}. Therefore, if $cov(\eta^*, \xi^*) \neq 0$, the selection of the exporters will bias the OLS estimator for ρ_γ. It is straightforward to show that if $cov(\eta^*, \xi^*) > 0$ then the OLS estimator of ρ_γ is biased towards 0.

To correct the selection bias I estimate the following equation:

$$\log(\frac{x_{dni}(\nu)}{x_{nni}(\nu)}) = -(\sigma - 1)\rho_\gamma D_{di} + \iota_{ni} + \kappa_{dn} + m(H_{dni} - \log(x_{nni}(\nu)) + u_{dni}(\nu), \tag{27}$$

where $m(.)$ is a general-form function, H_{dni} is the estimated entry hurdle, and $u_{dni}(\nu)$ is an exogenous measurement error. Note that ι_{ni} and κ_{dn} are captured, respectively, by a headquarter country fixed effect and a destination fixed effect.

ρ_γ can be consistently estimated from equation (27) by semi-parametric regression[12]. Irarrazabal, Moxnes, and Opromolla (2013) estimates the sales equation similar to equation (25) by MLE. The semiparametric regression is more robust to the distributional assumptions for shocks η and ξ.

Table 3 presents the estimation results for semi-parametric regression. ρ_γ is statistically significant and with the expected signs. The estimates suggest that the MNEs' advantage in export is strongly biased towards their headquarters: the variable export cost of an affiliate to its headquarters country is, ceteris paribus, 32% lower than to any other country. I also estimate equation (25) without correcting entry selection. The OLS estimator tends to bias ρ_γ towards 0, which implies $cov(\eta^*, \xi^*) > 0$.

[12] In practice I use Robinson (1988) double residual semi-parametric regression estimator. The details are in the appendix.

	Semi-parametric	OLS
$(\sigma-1)\rho_{\gamma,1}$: $\log(dist_{di})$	0.13***	0.033*
	(0.019)	(0.02)
$(\sigma-1)\rho_{\gamma,2}$: $lang_{di}$	-0.1**	-0.07**
	(0.04)	(0.04)
$(\sigma-1)\rho_{\gamma,3}$: $sgdp_{di}$	-0.4***	0.005
	(0.15)	(0.16)
$(\sigma-1)\rho_{\gamma,4}$: $self_{di}$	-1.2***	-0.56***
	(0.1)	(0.08)
# obs.	17814	17814
R-sq	0.2	0.08

Table 3: The Estimates on γ_{di}: Semi-parametric vs OLS

4.1.3 Imputing the Fixed Export Cost

With the estimated entry hurdle H_{dni} and iceberg headquarters gravity term γ_{di}, I can compute the fixed export cost E_{dni} directly through $\log(E_{dni}) = H_{dni} - (\sigma-1)\log(\gamma_{di}) + \iota_{ni} + \kappa_{dn} - \log\sigma - \log w_d$. This can only recover E_{dni} for 311 (d,i) pairs. The remaining E_{dni} have to be imputed from the observed gravity variables. I parameterize E_{dni} as

$$\log(E_{dni}) = \rho_{E,1}\log(D_{di}) + \rho_{E,2}\log(D_{dn}) + v_{dni}, \quad d \neq n, n = CHN, \tag{28}$$

where v_{dni} is an exogenous measurement error.

I estimate Equation (28) by OLS estimator. The result is presented in Table 4. Similar to γ_{di}, the estimates of E_{dni} shows that the MNEs' advantage in export is strongly biased towards their headquarters. The fixed export cost of an affiliate to its headquarters country is, ceteris paribus, 80% lower than to any other country. Moreover, doubling the distance between the headquarters and the destination would increase the fixed export cost by 10%.

4.1.4 Shock Parameters

I have gotten $\sigma^2_{\eta^*} = \sigma^2_\eta + \sigma^2_\xi = 4.93^2$. Using the normality of $\log(\eta)$ and $\log(\xi)$, I estimate $(\sigma_\eta, \sigma_\xi, \sigma_{\xi\eta})$ from equation (25) by MLE. The estimation details are presented in the appendix. The estimates are shown in Table 5. The correlation between $\log(\eta)$ and

Dependent Variable: $\log(E_{dni})$								
$\log(dist_{di})$	$lang_{di}$	$sgdp_{di}$	$self_{di}$	$\log(dist_{dn})$	$lang_{dn}$	$sgdp_{dn}$	R-sq.	N. of Obs
.1*	-.4	-.95***	-1.6***	-.18	-.88***	.25	.47	311
(.065)	(.12)	(.15)	(.44)	(.11)	(.20)	(1.1)		

Table 4: Imputing Fixed Export Costs E_{dni}: Gravity and Headquarters Gravity

$\log(\xi)$ is close to 1, which implies that the variation of idiosyncratic demand shocks is much higher than the variation of entry shocks. The estimates also imply a positive correlation between $\log(\eta^*)$ and $\log(\xi^*)$, which confirms the direction of bias caused by selection of the exports.

MLE		
σ_ξ	σ_η	$\rho_{\xi\eta}$
3.55***	3.42***	.94**
(.019)	(.0002)	(.37)

Table 5: The Estimates on Shock Parameters

(Note: $\rho_{\xi\eta} = \sigma_{\xi\eta}/(\sigma_\xi\sigma_\eta)$.)

4.2 Model-fit for Micro Data

In this section I test the fit of my model of firm exports for micro data patterns. To generate model predictions, I take the sales of each MNE in China as given and simulate (ξ, η) for all affiliate-destination pairs. Then the export entry and sales can be derived from equation (23) and (25). To evaluate the effects of the MNEs' advantage in export on the model fit, I impose all MNEs in China to have the same export costs as Chinese firms, i.e. $\gamma_{di} = \gamma_{d,CHN}$ and $E_{d,CHN,i} = E_{d,CHN,CHN}$ and re-simulate my model. Apparently by imposing MNEs to have the same export costs as Chinese firms, I eliminate headquarters gravity in my model.

Figure 6 presents the model fit for the number of MNEs exporting to their headquarters countries. The result suggest that my baseline model with headquarters gravity fits the data tightly in this dimensions while the model without headquarters gravity severely underes-

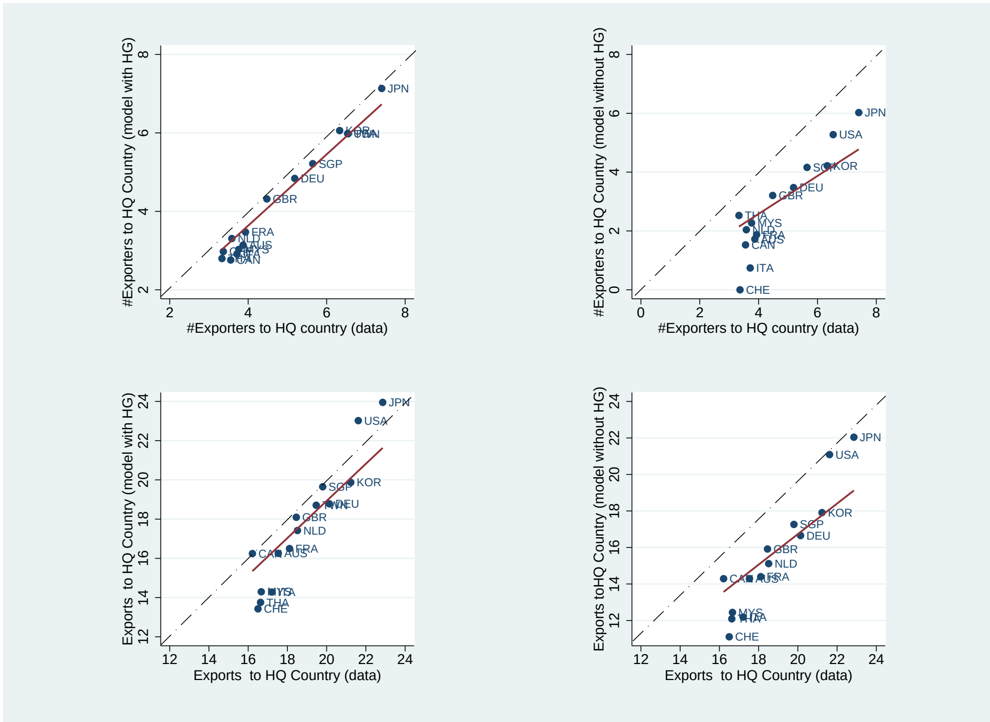


Figure 6: Number of Exporters and Exports to Headquarters Countries: Model vs Data

(Note: The left column is the fit of the baseline model while the right column is the fit of the model without headquarters gravity in which $\gamma_{di} = \gamma_{d,CHN}$ and $E_{d,CHN,i} = E_{d,CHN,CHN}$. The upper row is the fit for the number of exporters while the lower row is the fit for the export values. All values are in log.)

timate the number of MNEs in China that export to their headquarters countries. Similar results hold for MNEs' exporting values to their headquarters countries.

4.3 The Magnitude of Headquarters Gravity

The estimates of γ_{di} and E_{dni} show how the MNEs' export costs depend on their headquarters locations. In this section I illustrate the effects of headquarters locations on the export costs of MNEs in China.

I start with computing the average differences in export costs between MNEs in China and Chinese local firms. For $i \neq d$, I compute the average iceberg headquarters gravity term weighted by export share $\log(\bar{\gamma}_{MNE}) = \sum_{d,i \neq CHN} \frac{X_{d,CHN,i}}{\sum_{l,k} X_{l,CHN,k}} \log(\gamma_{di})$. Similarly for Chinese local firm $\log(\bar{\gamma}_{CHN}) = \sum_d \frac{X_{d,CHN,CHN}}{\sum_l X_{l,CHN,CHN}} \log(\gamma_{d,CHN})$. Then I can compute the average difference by $\Delta_\gamma = \frac{\bar{\gamma}_{CHN} - \bar{\gamma}_{MNE}}{\bar{\gamma}_{CHN}}$. By exactly the same procedure I can get the average difference for the fixed cost Δ_E.

The results suggest the MNEs' advantage in export is substantial: $\Delta_\gamma = 0.28$ and $\Delta_E = 0.82$. However, this advantage in export is not distributed evenly across destinations. By the estimates of headquarters gravity, we have known that this advantage is strongly biased towards headquarters countries. I now turn to summarize the MNEs' advantage in export by destination, showing the MNEs' comparative advantage in exporting to some destinations.

The average iceberg headquarters gravity term by destination can be computed by $\log(\bar{\gamma}_{MNE,d}) = \sum_{i \neq CHN} \frac{X_{d,CHN,i}}{\sum_k X_{d,CHN,k}} \log(\gamma_{di})$. Then $\Delta_{\gamma,d} = \frac{\gamma_{d,CHN} - \bar{\gamma}_{MNE,d}}{\gamma_{d,CHN}}$. $\Delta_{E,d}$ is derived analogously. The results are illustrated by Figure 7. MNEs in China are shown to have strong advantage in exporting to developed countries such as Japan, Korea, Germany, and the U.S. Apparently this is due to these developed countries are Chinese major MP sources. In contrast, Chinese local firms have comparative advantage in exporting to developing countries such as India and Poland. This comparative advantage, as I elaborate below, has distributional implications for Chinese manufacturing exports.

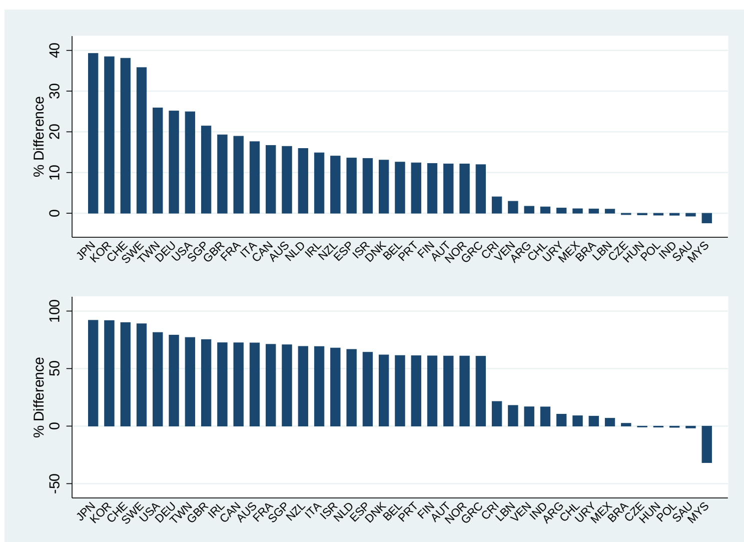


Figure 7: Differences in Export Costs between MNEs in China and Chinese Firms

(Note: The upper panel is the percentage differences in iceberg export costs by destination, $\Delta_{\gamma,d} = \frac{\gamma_{d,CHN} - \bar{\gamma}_{MNE,d}}{\gamma_{d,CHN}}$. The lower panel is the percentage differences in fixed export cost by destination, $\Delta_{E,d} = \frac{E_{d,CHN,CHN} - \bar{E}_{MNE,d}}{E_{d,CHN}}$.)

4.4 The Value of MNEs' Access to Export Markets

In the previous section I show that MNEs in China face substantially lower export costs than Chinese firms. This could be a reason for Chinese firms to acquire MNEs in China. By doing this, Chinese firms would get access to MNEs' brand names and networks in foreign markets. If a Chinese firm gets access to export markets by acquiring a MNEs in China, how much will its export expand? With my estimated headquarters gravity, I conduct the following exercise.

Suppose by acquiring a US multinational affiliate in China, the export costs of a Chinese firm reduce from $\gamma_{d,CHN}$ and $E_{d,CHN,CHN}$ into, respectively, $\min\{\gamma_{d,USA}, \gamma_{d,CHN}\}$ and $\min\{E_{d,CHN,USA}, E_{d,CHN,CHN}\}$.[13] I take the Chinese firm's sales in China, Chinese wage, and the destination market size as given. Then I simulate (ξ, η) for all firm-destination pairs. Equation (23) and (25) deliver the export destinations and export sales for each Chinese firm.

I can then compute how much, on average, the exports of a Chinese firm will expand if it gets access to international markets as a US MNE in China. Figure 8 shows that the exports of the Chinese firm to the U.S. can increase by about 40 percent. Its overall exports can increase by 13 percent. By getting access to brand names and international networks of the U.S. MNE, the Chinese firm can substantially expand its market share in the U.S. and other foreign countries.

5 Calibrating the general equilibrium model

In this section I calibrate the rest of the structural parameters in the general equilibrium model. This enables us to compute the general equilibrium outcomes and to conduct counterfactual analysis in next section. The key remaining parameters include the dispersion parameter of productivity (θ) and bilateral trade and MP frictions. The world I target to

[13] To focus on market access, I abstract other gains from acquisition such as technologies and management know-how.

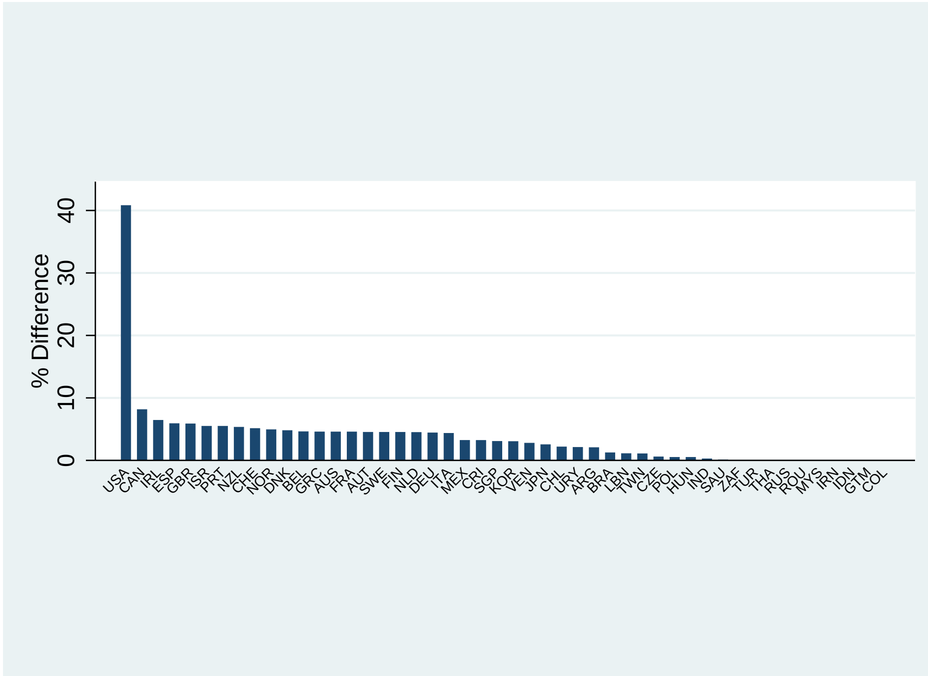


Figure 8: Export Expansion from Acquisition

(Note: Here I consider a Chinese firm acquires a U.S. MNE affiliate in China. I assume that by doing this the export costs of the Chinese firm is reduced from $\gamma_{d,CHN}$ and $E_{d,CHN,CHN}$ into, respectively, $\min\{\gamma_{d,USA}, \gamma_{d,CHN}\}$ and $\min\{E_{d,CHN,USA}, E_{d,CHN,CHN}\}$.)

consists of 28 economies in 2001.[14]

In the following subsections, I first calibrate θ from the domestic sales of Chinese local firms. Then I calibrate bilateral trade and MP frictions by matching the model-generated trade and MP flows to their data correspondents.

5.1 Calibrating θ and L_i

The dispersion parameter of firm productivity, θ, is calibrated from the dispersion of the domestic sales for Chinese local firms.

Let $\alpha = \frac{\theta}{\sigma-1}$. The model shows that the domestic sales for Chinese local firms is

$$\log(x_{nnn}(\nu)) = \tilde{\gamma}(\nu) + \log \xi(\nu) + \Xi_n, \tag{29}$$

[14]These economies are Australia, Austria, Belgium & Netherlands, Brazil, Canada, Switzerland, China, Germany, Denmark, Spain, Finland, France, Britain, Indonesia, India, Ireland, Italy, Japan, Korea, Mexico, Malaysia, Poland, Portugal, Singapore, Sweden, Thailand, Taiwan, and the U.S.

where $\Xi_n = A_n \bar{m}(w_n^{\beta} P_n^{1-\beta})^{1-\sigma}(\gamma_n^{min})^{\sigma-1}$, $\tilde{\gamma}$ follows an exponential distribution with parameter α, and $\log \xi$ follows a left-truncated normal distribution.

For the domestic sales I ignore the selection of exporters, assuming $\log \xi$ is symmetrically distributed[15]. The property of exponential distribution gives that

$$mean(\log(x_{nnn})) - median(\log(x_{nnn})) = \frac{1-\log(2)}{\alpha}. \tag{30}$$

Therefore, $\frac{\theta}{\sigma-1} = 1.39$. Since $\sigma = 4$, $\theta = 4.17$.

L_i comes directly from ILO database for 2001. I use the variable "paid employment in manufacturing" as the measure of country size in the model. There are two reasons for me to use this measure. First it is a comparable measures for manufacturing employment in all 28 countries I am interested. Second I will use the manufacturing wage in ILO database to calibrate the technology levels. This "paid employment in manufacturing" is compatible with my wage measures.

5.2 Calibrating $(\tau_{dn}, \zeta_{ni}, f_{ni}, T_i)$

I calibrate the general equilibrium model to match aggregate bilateral trade flows and MP sales. The data moments are summarized in Table 6.

Moments	Definition	Data Source	Model
π_{dn}^{tr}	Export Share	UNCOMTRADE	$\sum_i X_{dni} / \sum_{d,i} X_{dni}$
π_{ni}^{mp}	MP Share	Ramondo et al. (2015)	$\sum_d X_{dni} / \sum_{d,i} X_{dni}$
π_{ni}^{aff}	Affiliate Share	Ramondo et al. (2015)	J_{nni}/J_{iii}
w_i	manufacturing wage	ILO database	w_i

Table 6: Data moments for calibrating the general equilibrium model

The aggregate bilateral trade flows come from UNCOMTRADE database. Since this paper is about manufacturing exports, I keep trade flows with 2-digit HS code between 16 and 97 (excluding 25, 26, 27). The bilateral MP sales and numbers of affiliates come from Ramondo et al. (2015). The manufacturing wages come from ILO database. It will be

[15] The imputed entry hurdle for local firms in the domestic market, H_{nnn}, is very low. Therefore assuming $\log \xi$ is symmetrically distributed will not change the result much.

targeted in order to back out technology level T_i.

I have normalized bilateral trade flows and MP sales as shares of the total production of the exporting countries. Moreover, the number of bilateral affiliates is normalized as a share of total firms in the source countries. Targeting on shares instead of levels prevents my calibration work from dealing with current account imbalance in the data.

Given the estimated $(\theta, \sigma, \beta, \sigma_\eta, \sigma_\xi, \sigma_{\xi\eta})$ and $(\gamma_{di}, E_{dni}, L_i)$, I calibrate $(\tau_{dn}, \zeta_{ni}, f_{ni}, T_i)$ by the following algorithm. This algorithm can be widely used in calibrating gravity models.

Guess $(\tau_{dn}^0, \zeta_{ni}^0, f_{ni}^0, T_i^0)$. Compute (w_i, X_i, P_i) using the iterative algorithm described above. Then compute the model-generated moments, $\tilde{w}_i$, $\tilde{\pi}_{dn}^{tr}$, $\tilde{\pi}_{ni}^{mp}$, and $\tilde{\pi}_{ni}^{aff}$, and their gap with the data moments. If the gap is below tolerance, stop. Otherwise increase τ_{dn} if the trade share in the model is higher than in data. Similar rules apply for ζ_{ni} and f_{ni}. Increase T_i if the wage in the model is lower than in data. Stop until converge.

To see the validity of my calibration, I compare the calibrated bilateral frictions with the bilateral distances. I also compare the calibrated technology levels with the total factor productivities from Penn World Table for 2001. The results are shown in Figure 9. The calibrated trade costs increase with the distance between importing and exporting countries. The calibrated iceberg and fixed MP costs increase with the distance between the headquarters and host countries. And the calibrated technology levels are in line with the TFP measures from outside database. Note that the developing countries such as China, India, Indonesia, and Thailand have technology levels much lower than developed countries. So MNEs in these countries are on average much more productive than local firms. This productivity advantage, as I elaborate below, is quantitatively important for MNEs' contribution to the host countries' exports.

Figure 7 summarizes the structural parameters in the baseline model that will be used for counterfactual experiments.

5.3 Additional Model Validity

In this section I provide additional model validity using the data moments that my calibration never targets to. OECD database has provided the MNE affiliates' export share in 5 OECD countries. I compute the equilibrium with the calibrated parameters and compare

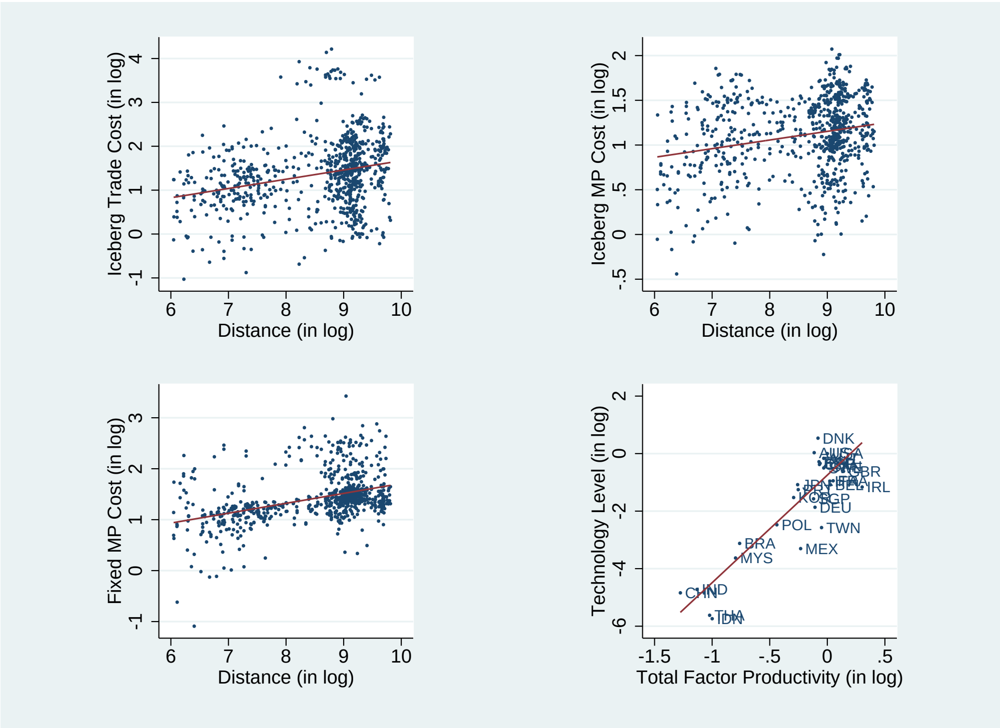


Figure 9: The Calibrated $(\tau_{dn}, \zeta_{ni}, f_{ni}, T_i)$

(The parameters are calibrated by the algorithm described above. The distance is the geographic bilateral distance between the importing and the exporting countries (compared with trade costs) and between the source and host countries (compared with MP costs). The TFP comes from Penn World Table for 2001.)

Outsourced			
Parameter	Definition	Target/Source	Value
σ	Elasticity of Substituion	Arkolakis et al. (2015)	4
β	Value-added Share	Median VA share in ASCM	0.35
θ	Dispersion of Firm Productivity	Dispersion of firm sales	4.17
L_i	Manufacturing Labor	ILO (2001)	-
Headquarters Gravity Parameters			
Parameter	Definition	Target/Source	Value
γ_{di}	Iceberg HG term	Exports given sales in China	Figure 3
E_{dni}	Fixed HG term	Export entry and exports	Figure 4
Standard Gravity and Technology			
Parameter	Definition	Target/Source	Value
τ_{dn}	Iceberg Trade costs	Export as a share of production	-
ζ_{ni}	Iceberg MP costs	Inward MP as a share of production	-
f_{ni}	Fixed MP costs	MP affiliates as a share of total firms	-
T_i	Level of productivity	Wage from ILO (2001)	-
Shock Parameters			
Parameter	Definition	Target/Source	Value
σ_ξ	Standard error for demand shock	Relation b/w sales in China and exports	3.55
σ_η	Standard error for demand/entry shock	Relation b/w Sales in China and export entry	3.42
$\rho_{\xi\eta}$	Correlation between ξ and η	Relation b/w export entry and exports	0.94

Table 7: The Structural Parameters in the Baseline Model

the moments generated by the model with the data.

Moreover, to examine how important the headquarters gravity is for my model-fit, I re-calibrate the model ignoring headquarters gravity, i.e. $\gamma_{di} = 1$ and $E_{dni} = 1$ for all (d, n, i) and re-calibrate the model to match the bilateral trade and MP shares. By construction, the baseline model and the model ignoring headquarters gravity should generate the same production share of MNEs. But their predictions for the MNEs' export shares could be different.

The outsample predictions are shown in Table 8. The baseline model fits the MNEs' export shares in several OECD countries. The model ignoring headquarters gravity tends to underestimate the MNEs' export shares. Therefore, headquarters gravity is the key for my model to fit the exports of multinational affiliates.

% Exports			
	Data	Baseline model	Model ignoring HG
FRA	40.6	46.6	20.9
IRL	90.6	89.0	68.8
ITA	23.4	35.7	13.4
NLD	64.2	66.6	39.7
SWE	45.1	57.5	28.6

Table 8: Model-fit for MNEs' Export Share in OCED Countries
(Note: %Exports refers to the MNEs' export share in the host countries. The data shown in this table come from OECD database. The model ignoring headquarters gravity comes from setting $\gamma_{di} = 1$ and $E_{dni} = 1$ for all (d, n, i) and re-calibrating the model to match the bilateral trade and MP shares.)

6 Counterfactual Analysis

In this section I conduct counterfactual experiments to quantify impacts of MNEs on exports and income distribution of the host countries. To achieve this, I consider two counterfactual scenarios. First I impose MNEs in China to have the same export costs as Chinese firms. Second I shut down MNEs in China by raising Chinese inward MP costs to infinity. By these two exercises I quantify the overall impacts of MNEs in China on Chinese exports and welfare as well as the impacts of MNEs' lower export costs and higher productivities. Note that in this paper I am primarily interested in implications for China. But apparently my multi-country general equilibrium framework can apply for policy discussions in other countries.

6.1 To Promote Exports, Promote Multinationals

As I have mentioned, I first impose MNEs in China to have the same export costs as Chinese firms, i.e. $\gamma_{di} = \gamma_{d,CHN}$ and $E_{d,CHN,i} = E_{d,CHN,CHN}$ for $d \neq CHN$.[16] Second I shut down MNEs in China by letting $\zeta_{CHN,i} = \infty$.

Changes in Chinese manufacturing exports from the baseline economy to counterfactual

[16]Headquarters gravity implies Chinese local firms having advantage in serving Chinese market. In this counterfactual scenario I do not allow MNEs in China to incur the same trade cost to China with Chinese local firms. Otherwise it gives MNEs additional advantage in serving China.

economies are presented in Table 9. Note that the micro data shows that in 2001 MNEs in China account for 68 percent of Chinese manufacturing exports. The counterfactual experiment shows that shutting down MNEs in China would decrease Chinese manufacturing exports by 49 percent. Shutting down MNEs in China would induce the entry of Chinese local firms. But these new entrants are less productive and with higher export costs than MNEs in China. Consequently, Chinese manufacturing exports would fall dramatically if MNEs exit Chinese market.

My model implies that a firm's export performance is determined by its productivity and its export costs. Therefore, my model allows me to decompose MNEs' impacts on exports into their lower export costs and their higher productivities. Imposing MNEs in China to have the same export costs with Chinese firms would decrease Chinese manufacturing exports by 23.3 percent. So half of the MNEs' contribution to Chinese exports is due to their lower export costs. The remaining half is due to their higher productivities. In sum, both the technologies and the access to export markets brought by MNEs are quantitatively important for Chinese export booms.

Furthermore, the impacts of MNEs' lower export costs are not evenly distributed across destinations. Their impacts are strongly biased towards their headquarters countries. Table 9 shows that if MNEs in China have the same export costs as Chinese firms, Chinese manufacturing exports to OECD countries would decrease by 32 percent while Chinese manufacturing exports to non-OECD countries would increase by 27 percent. This trade switching effect is mainly due to the fact that most MNEs in China come from rich OECD countries. In contrast, shutting down MNEs in China would decrease Chinese exports to both OCED and non-OEDC countries. This is mainly due to the MNEs' productivity effect. Unlike those highly productive MNEs in China, Chinese local firms can hardly penetrate the developing countries which often have high trade barriers.

Figure 10 illustrates impacts of MNEs' lower export costs on Chinese exports by destination. If MNEs in China lose their advantage in export, China would lose a large fraction of its exports to developed countries such as Japan, Britain, Germany, and the U.S. Chinese exporters would then switch into the developing countries such as India, Indonesia, and Thailand. Headquarters gravity does not only affect Chinese export scales but also shapes

% Changes in Chinese Manufactuing Exports			
	Total	To OECD	To non-OECD
No HG	-23.3	-31.9	27.4
No MP	-49.4	-55.9	-11.6

Table 9: The Impacts of MNEs in China on Chinese Exports

(Note: No HG refers to the counterfactual scenario in which MNEs in China have the same export costs with Chinese local firms. No MP refers to the counterfactual scenario in which $\zeta_{CHN,i} = \infty$. %Change are counterfactual levels relative to the baseline level.)

the geographical patterns of Chinese exports.

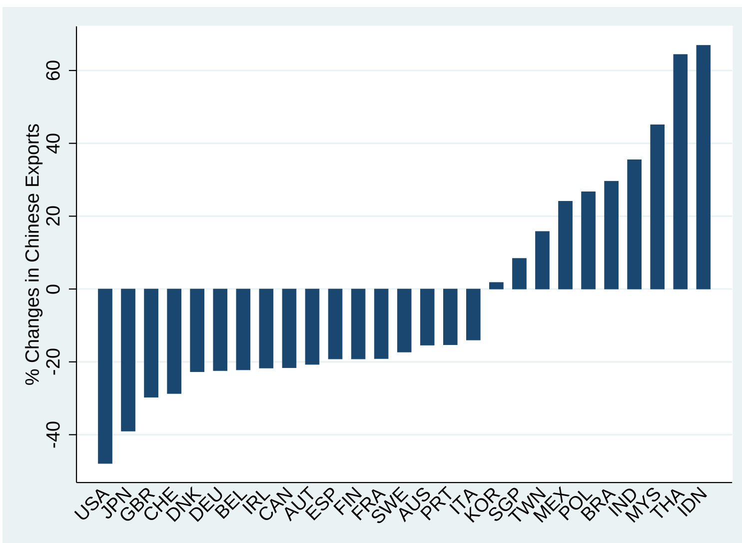


Figure 10: The Impacts of Headquarters Gravity on Chinese Exports by Destination

(Note: % Change refers to the percentage change from the calibrated economy to the counterfactual economy. Here counterfactual refers to the case that MNEs' in China have the same export costs as Chinese firms.)

In sum, the counterfactual analysis shows that MNEs in China are responsible for a substantial fraction of Chinese export booms. Both their higher productivities and lower export costs are quantitatively important for the impacts of MNEs in China on Chinese exports. An effect way to promote exports is to attract FDI, especially FDI from large markets.

6.2 Distributional Implications of Headquarters Gravity

The multi-country general equilibrium model allows me to examine the welfare and distributional implications of headquarters gravity. Again I impose MNEs in China to have the same export costs as Chinese firms and examine how the welfare and income distribution in China will change. Since my model assumes CES preference, I can measure the welfare by real GDP per capita.

$$W_i = \frac{w_i + \Pi_i/L_i}{P_i}. \tag{31}$$

Note that the GDP consists of two parts: the workers' wage and the firms' profits. The income distribution discussed here refers to the income allocation between nominal wage and profits. The fundamental difference between wage and profits is that the wage can only be earned in the country the labor lives in but the profits can come from multinational production. The MNEs' advantage in export affect international trade and production patterns and thus affect the distribution of wage and profits in all the countries.

Table 10 shows the welfare and distributional effects in China and the U.S. The results for all 28 countries can be found in the appendix. If MNEs in China have the same export costs as Chinese firms, the welfare in China would decrease by 0.1 percent. This tiny gain, however, is associated with a substantial distributional effect. Imposing MNEs in China to have the same export costs with Chinese firms would decrease Chinese nominal wage by 8.8 percent. Losing access to international markets would greatly decrease Chinese labor demand, making Chinese workers worse-off. In contrast, eliminating the MNEs' advantage in export would shelter Chinese local firms from the MNEs' competition, increasing their nominal profits by 1.4 percent. Moreover, the entry of Chinese local firms would decrease Chinese price level since these new entrants have advantage in serving Chinese market.

The export costs of MNEs in China also have welfare and distributional implications for the U.S. Imposing MNEs in China to have the same export costs as Chinese firms would decrease the U.S. welfare by 0.28 percent. But the distributional effect in the U.S. is opposite with the one in China. The import competition from China would decrease if MNEs in China do not have advantage in export. This will benefit the U.S. workers. In the other hand, the

U.S. MNEs would lose since without headquarters gravity these firms can no longer utilize Chinese cheap labor to serve the U.S. market.

	% Changes			
	Welfare	Wage	Profit	Price
China	-0.10	-8.83	1.35	-6.22
The U.S.	-0.28	0.07	-0.28	0.23

Table 10: Welfare and Distributional Implications of Headquarters Gravity

(Note: % Change refers to the percentage change from the calibrated economy to the counterfactual economy. Here counterfactual refers to the case that MNEs' in China have the same export costs as Chinese firms. The results for all 28 countries are presented in the appendix.)

7 Conclusion

This paper quantifies the impacts of MNEs on the host countries' exports, decompose these impacts into MNEs' higher productivities and lower export costs, and examines the distributional implications of MNEs' lower export costs. The key feature of my model is that it allows a MNE's export costs to each market to depend on how similar this market is to its production locations (gravity) and to its headquarters location (headquarters gravity). By introducing headquarters gravity into a standard multi-country general equilibrium framework, I characterize the multinational sales flows in a way that is consistent with micro data patterns. The model allows me to examine the impacts of headquarters gravity on aggregate trade patterns and welfare implications.

The estimates from Chinese micro data showed that headquarters gravity is substantial, which makes the export costs of MNEs in China much lower than Chinese local firms. MNEs' lower export costs are quantitatively important for Chinese exports. Counterfactual analysis suggests that shutting down MNEs in China would decrease Chinese manufacturing exports by about 50 percent, about half of which is due to MNEs in China having lower export costs than Chinese firms. Finally, the lower export costs of MNEs in China can benefit Chinese workers by improving their access to international markets but hurt the U.S. workers by intensifying import competition from China.

This paper may be extended in several ways. One possibility is to introduce multiple sectors in the model. The motivation of this extension is a simple observation that foreign firms in China produce a very different set of goods with Chinese local firms. Therefore MNEs in China do not only affect Chinese export scales and directions, but also affect the composition of Chinese exports. This extension would provide micro foundation to Alviarez (2015) who finds that multinational production is disproportionately allocated to industries where local firms exhibit comparative disadvantage. A second direction is to disentangle the demand and supply factors on headquarters gravity. Headquarters gravity could be driven by lower penetration costs or by higher demands in markets closer to headquarters. This extension requires detailed quantity and price data similar to Cosar et al. (2015). A third direction is to incorporate imports of multinational affiliates into the model. Foreign firms are known to use more imported intermediates than local firms. Combining imports and exports could give us more precise estimates on MNEs' welfare implications.

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