

Ma, Alyson; Van Assche, Ari; Hong, Chang

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Global production networks and the People's Republic of China's processing trade

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Global Production Networks and the People's Republic of China's Processing Trade

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Abstract

This paper unveils a systematic pattern in the People's Republic of China's (PRC) processing trade. In a cross-section of the PRC's provinces, the average distance traveled by processing imports (import distance) is negatively correlated with the average distance traveled by processing exports (export distance). To explain this pattern, we set up a three-country industry-equilibrium model in which heterogeneous firms from two advanced economies, East and West, sell their products in each other's markets. Each firm can use two modes to serve the foreign market. A firm can directly export its products from its home country. Alternatively, it can indirectly export to the foreign market by assembling its product in a third low-cost economy, PRC, which is located in the vicinity of East. Our model established two theoretical predictions relating the PRC's geographical location to its processing trade patterns. First, the PRC's processing exports are negatively affected by both an increase in import distance and an increase in export distance. Second, the PRC's processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance than its processing exports to non-Asian economies. We found empirical support for both predictions.

JEL Classification: F12, F14, F23

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1. INTRODUCTION

The People's Republic of China's (PRC) rapid emergence as an export powerhouse has attracted much attention in both academic and policy circles. In the past 20 years, the PRC's exports have grown at an annualized rate of 19%, more than twice the rate of growth of world exports. As a result, the PRC has surpassed Japan and the United States to become the world's second largest exporter after Germany.

To a large extent, the PRC's dramatic export rise can be attributed to its relatively low labor costs coupled with its aggressive export promotion policies (Lardy 2002; Huang 2003; Branstetter and Lardy 2006; Amiti and Freund 2008). In the mid-1980s, the PRC installed a processing trade regime that grants firms duty exemptions on imported raw materials and other inputs as long as they are used solely for export purposes. Many foreign firms have taken advantage of this regime to slice up their value chain and move their labor-intensive final-assembly plants to the PRC. As a result, the share of processing exports (i.e., exports conducted under the processing regime) in the PRC's total exports has risen from 30% in 1988 to 55% in 2005. Currently, processing exports account for more than half of the PRC's total export value.

An often overlooked feature of the PRC's processing trade regime is its heavy reliance on imported inputs from neighboring East Asian economies for its exports. According to a recent estimate by Koopman, Wang, and Wei (2008), only 20% of the PRC's processing export value is produced in the PRC, while the remaining 80% consists of the value of imported inputs. These inputs are primarily imported from the PRC's more advanced East Asian neighbors such as Japan, Republic of Korea, and Taipei,China (Dean, Lovely, and Mora forthcoming). This import pattern suggests that the PRC's geographic location within the East Asian region may have played an important role in the rapid growth of its processing trade.

In this paper, we use detailed data on processing trade collected by the General Administration of Customs of the People's Republic of China to analyze the role of the PRC's geographic location in its processing trade patterns (see Feenstra et al. [2004] for a description of the data). This PRC Customs Statistics data set is particularly useful because by its nature, the processing trade regime requires all imported inputs to be used for export purposes. As a result, the data provides for each location a unique mapping of the source economy of imported inputs and the destination economy of its processed exports. This feature enabled us to analyze the roles of both import and export distance in the PRC's processing trade patterns.¹

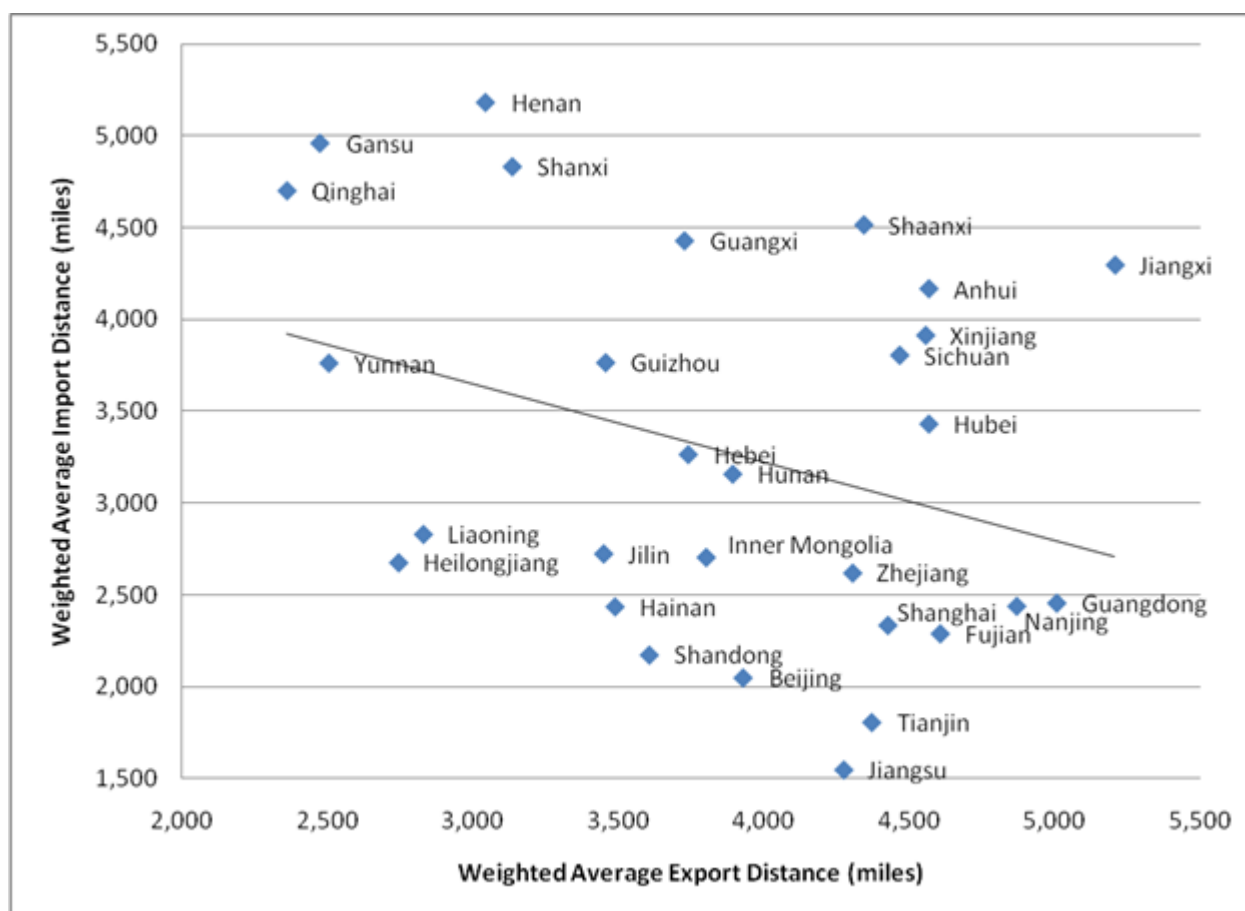
A cursory glance at the processing trade data reveals a distinctive geographical pattern related to the PRC's processing trade. Using a cross-section of 29 PRC provinces² for 2005, we show in Figure 1 that the average distance traveled by processing imports (import distance) is negatively correlated with the average distance traveled by processing exports (export distance).³ A similar association between export and import distance can be found for all years from 1997 to 2005.

¹ This exercise cannot be conducted with regular trade data because imports are not necessarily used as inputs in the production of exports, but can also be consumed locally.

² In this paper, "province" encompasses all of the PRC's first-tier administrative divisions: provinces, municipalities, and autonomous regions. We have excluded the Xizang Autonomous Region (also known as Tibet Autonomous Region) and Ningxia from our analysis because they had no processing trade in at least one year of our data sample. Furthermore, we treat Hong Kong, China; Macau, China; and Taipei,China as foreign economies.

³ The sample correlation coefficient of -0.3274 is statistically significant at the 10% level. Note that the data used for this figure are adjusted for transshipments through Hong Kong, China. See Section 3 for further details.

Figure 1: Weighted Average Export Distance versus Weighted Average Import Distance, 2005



Source: Authors' calculations based on People's Republic of China Customs Statistics.

In this paper, we set up a three-country industry-equilibrium model with heterogeneous firms to explain this pattern. In our framework, a continuum of heterogeneous firms from two advanced economies, *East* and *West*, sell their products in each other's markets. Each firm can use two modes to serve the other market. A firm can produce its variety at home and directly export it to the foreign economy. Alternatively, it can indirectly export its variety to the foreign economy by assembling it in a third low-cost economy, *PRC*. By assuming that *PRC* is located in the geographical proximity of *East*, our model provides an explanation for the negative correlation between export and import distance for the *PRC*'s processing trade: the inputs that *PRC* imports from the nearby *East* are processed into final goods and exported to the far-away *West*. Conversely, the inputs that *PRC* imports from the far-away *West* are processed into final goods and exported to the nearby *East*.

The model allows us to develop two theoretical predictions relating the *PRC*'s geographical location to its processing trade patterns. First, we expect that the *PRC*'s processing exports are negatively affected by both an increase in import distance and an increase in export distance. Second, we predict that the *PRC*'s processing exports to the nearby East Asian economies are more sensitive to export distance and less sensitive to import distance than its processing exports to non-Asian economies that are located further away.

Using the *PRC*'s bilateral processing trade data, we find support for the theoretical predictions of the model. Specifically, our empirical analysis provides some evidence that the *PRC*'s processing exports are negatively affected by both import and export distance. Furthermore, it provides strong evidence that processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance than processing

exports to non-Asian Organisation for Economic Co-operation and Development (OECD) countries.

Our theoretical model builds on an emerging theoretical literature on export platform foreign direct investment (FDI), i.e., on multinational firms that process their final goods in a foreign subsidiary for export to a third-country market.⁴ Yeaple (2003) and Ekholm, Forslid, and Markusen (2007) examined theoretically the determinants of export platform FDI by setting up a model with two similar advanced “Northern” countries and a third Southern country in which the final good can be assembled at lower cost. Both studies analyzed how firms’ choices of using the South as an export platform depend on trade costs, factor-cost differentials, and the fixed costs associated with foreign investment. Grossman, Helpman, and Szeidl (2006) introduced intra-industry firm heterogeneity in this type of setting and examined the role of different types of complementarities on export platform activities. Our theoretical framework complements these three studies in two ways. First, we use elements of Helpman, Melitz, and Yeaple’s (2004) model structure to derive a closed-form solution of an export platform’s bilateral processing exports. Second, we introduce more realistic assumptions about trade costs by exploiting the empirical regularity that export-platform countries are generally located in the geographical proximity of large markets. For example, the PRC lies in the vicinity of developed East Asia; Mexico neighbors the United States. This allows us to develop new theoretical predictions that relate an export platform’s bilateral exports to both export and import distance.

Our empirical analysis is related to Hanson, Mataloni, and Slaughter’s (2005) study on the determinants of global production networks. Their study used firm-level data on United States multinational firms to examine the determinants of trade in processing inputs between parent firms and their foreign affiliates. Among other findings, they showed that a foreign affiliate’s demand for imported processing inputs is affected by trade costs, wages for less-skilled labor, and host-country policies. In line with their findings, we provide empirical evidence that the PRC’s processing exports depend on trade costs on both the import and export sides.

This paper is organized as follows. In the following section, we set up the theoretical model and derive our two main hypotheses. In Section 3, we describe the data. We describe the methods of analysis in Section 4. We report and interpret the empirical findings in Sections 5 and 6, respectively, and we provide concluding comments in the closing section.

2. THEORETICAL MODEL

To motivate the empirical analysis, we set up an industry-equilibrium model in which *Eastern* firms can use two channels to export their products to the *West*, and vice versa.⁵ Via one channel, they can produce their goods at home and directly export them to the other region. Via the other channel, they can indirectly export to the other region by using low-cost *PRC* as a final assembly platform. As we shall see below, the model will provide a theoretical explanation for the negative correlation between the average distance traveled by the PRC’s processing imports and the average distance traveled by its processing exports. In addition, it will allow us to identify two testable hypotheses related to the PRC’s processing trade patterns.

Consider an industry-equilibrium model encompassing three economies.⁶ There are two advanced economies (East and West) that are fully symmetric with high wages and large markets for the industry’s output. In addition, there is a third economy (PRC) that has low

⁴ Yeaple (2003) uses the term “complex integration strategy.”

⁵ The structure of our model closely follows that of Helpman, Melitz, and Yeaple (2004).

⁶ We conduct our analysis for a single industry, but it is straightforward to embed our model in a general equilibrium framework with many industries.

wages, no market for the industry's output, and that is geographically located closer to East than to West. In this model, the only role that the PRC plays is thus that it is a potential low-cost location in the vicinity of East for processing final goods. The assumption that the PRC does not have a market for the industry's output is harmless because, by the very nature of the processing trade regime, processed goods are not allowed to be sold in the PRC market.

A continuum of firms in East and West has the know-how to produce a single differentiated product. These are the only active firms in the industry because we assume that the knowledge is nontransferable to domestic firms in the PRC. Each advanced-economy firm needs to produce its intermediate good at home, but can process its final good in any of the three economies.

All consumption of the differentiated products takes place in the East and West. Specifically, in each advanced economy $i \in \{E, W\}$, a representative consumer allocates an amount of expenditure Y^i to the industry. Within the industry, the consumer has a utility function that exhibits constant elasticity of substitution $\varepsilon = 1/(1 - \alpha)$. Maximizing the utility function subject to the consumer's expenditure generates the demand function that a firm faces in advanced economy i :

$$q^i = A^i p^{-\varepsilon}, \quad (1)$$

where the demand level A^i is exogenous from the point of view of the individual firm.⁷ In this case, the monopolistically competitive firm charges the following price for its product:

$$p^i = \frac{c}{\alpha}, \quad (2)$$

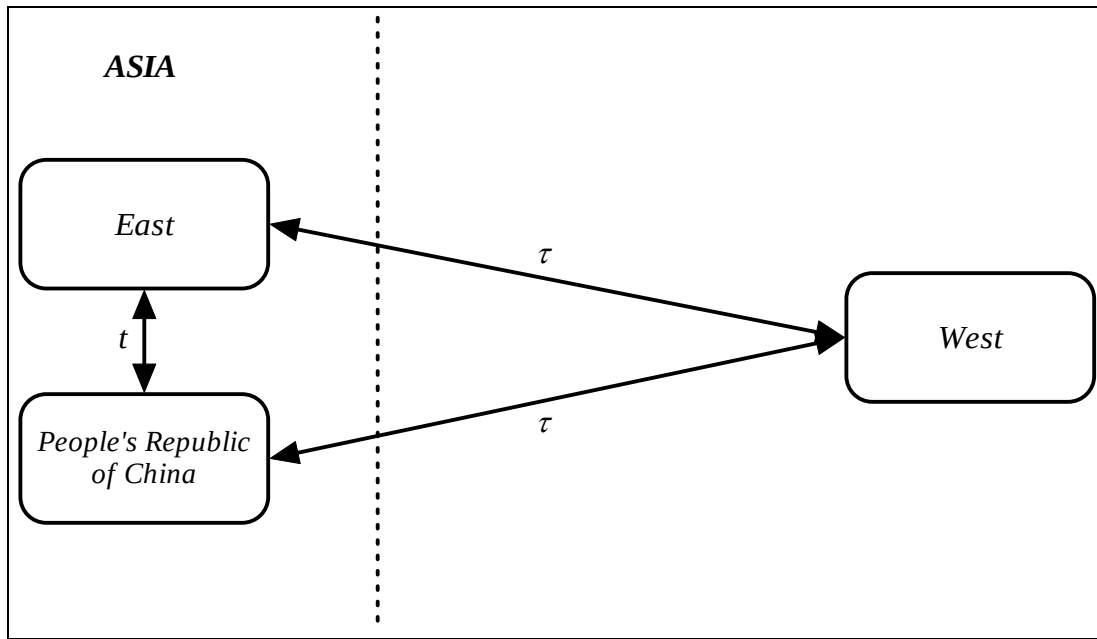
where c denotes the firm's marginal unit production cost and $\frac{1}{\alpha}$ represents the markup factor.

We distinguish the economies in several ways. First, wage rates are higher in the advanced economies than in the PRC; in particular, $w^E = w^W = 1 > w^C = w$. Second, the PRC is located closer to East than to West, while West is equidistant to both East and PRC. Denote τ^{ij} as the melting-iceberg trade cost of shipping goods from economy i to economy j , where $\tau^{ii} = 1$ and $\tau^{ij} = \tau^{ji} > 1$ for $i \neq j$. We assume that trade costs increase linearly with distance so that $\tau^{EC} = t < \tau^{WC} = \tau^{WE} = \tau$ (see Figure 2).⁸ These locational assumptions reflect the notion that the PRC acts as the low-cost processing platform in the vicinity of East. To see this, note the differential impact that an increase in trade costs t and τ play in our model. A rise in t increases trade costs only between East and PRC, thus making it less attractive to indirectly export through the PRC. Conversely, a rise in τ increases the trade costs between West and PRC as well as West and East, thus reducing the incentives for both direct and indirect exports.

⁷ As is well known, $A^i = Y^i / \left[\int_0^{n^i} p^i(v)^{1-\varepsilon} dv \right]$, where n^i is the number (measure) of varieties available in economy i and $p^i(v)$ is the price of variety v .

⁸ A debate has recently emerged on whether trade costs are truly a linear function of distance (e.g., Brun et al. 2005; Coe, Subramanian, and Turrini 2007). In this paper, we follow the standard approach in gravity regressions of using distance as a proxy for trade costs.

Figure 2: Locational Assumptions



The production of a final good variety involves two distinct stages: intermediate good production and final good processing. Intermediate goods need to be produced in the firm's home economy j at cost $aw^j = a$, where a equals the firm's labor-per-unit-output coefficient. The final good can be processed in any economy $l \in \{E, W, C\}$ at an extra ad valorem cost w^l . The combination of production costs and melting-iceberg trade costs then implies that the unit cost of producing an intermediate good in economy j , processing it into a final good in economy l , and delivering the final goods to economy i equals:

$$c^{ji} = a\tau^j w^l \tau^i. \quad (3)$$

To interpret this unit cost function, suppose that a firm with labor-per-unit-output coefficient a conducts both production stages in East and sells its output domestically.⁹ From equation (3), its unit cost then amounts to a . If it conducts both production stages in East and then exports the final goods to West, the unit cost equals $a\tau$. If the firm produces its intermediate goods in East, processes its final goods in the PRC, and delivers them to West, the unit cost amounts to $atw\tau$. Because $w < 1$ and $t, \tau > 1$, it is clear that the attractiveness of conducting processing activities in the PRC depends on the tradeoff between lower wages and higher trade costs.

Our model features intra-industry firm heterogeneity as developed by Melitz (2003). To set up its headquarters in advanced economy i , a firm needs to bear a fixed cost of entry F_e , measured in labor units. With this fee, the entrant acquires the design for a differentiated product and draws a labor-per-unit-output coefficient of a from a cumulative Pareto distribution $G(a)$ with shape parameter z . Upon observing this draw, the firm decides either to exit the industry or to start producing. If it decides to produce, it bears an additional fixed cost f_D of initiating production operations. There are no other fixed costs when the firm sells only in the domestic market. If the firm chooses to export to the foreign market, however, it bears an additional fixed cost f_X of forming a distribution and servicing network in the foreign economy. Finally, if it sets up a processing plant abroad, it bears one additional fixed cost f_P .

⁹ We rely on this specific functional form because it ensures that the derivation is symmetric for advanced economies *East* and *West*. The key theoretical predictions of our model do not hinge on this specific functional form.

We take on the following simplifying assumption:

Assumption 1: $(t^2w)^{\varepsilon-1} > 1 > (tw)^{\varepsilon-1} > f_X/(f_P + f_X)$.

Assumption 1 ensures that (i) at least one firm from advanced economy i processes its final goods in the PRC for export to advanced economy $j \neq i$; ¹⁰ and (ii) no firm from advanced economy i sets up a processing plant in the PRC to export back to its own market in economy i . ¹¹ Assumption 1 and the unit cost function in equation (2) ensure that, despite the PRC's relative proximity to East, the analyses for economies East and West are completely symmetric. Below, we conduct the analysis for advanced economy i . We call firms from economy i "domestic" firms and firms from the other advanced economy j "foreign" firms.

In advanced economy i , there are three types of firms that sell their final goods: type- D domestic firms that conduct both production stages in economy i and sell their output domestically; type- X foreign firms that produce both stages in the advanced economy j and export their final goods to economy i ; and type- P foreign firms that produce their components in advanced economy j , process their final goods in the PRC, and then export to economy i . Using equations (1) to (3), we can derive the operating profits that the three types of firms face:

$$\pi_D^i = a^{1-\varepsilon} B^i - f_D, \quad (4)$$

$$\pi_X^i = (a\tau)^{1-\varepsilon} B^i - f_X - f_D, \quad (5)$$

$$\pi_P^i = (a\tau tw)^{1-\varepsilon} B^i - f_P - f_X - f_D, \quad (6)$$

where $B^i = (1 - \alpha)A^i/\alpha^{1-\varepsilon}$.

We depict these profit functions in Figure 3. In this figure, $a^{1-\varepsilon}$ is represented on the horizontal axis. Because $\varepsilon > 1$, this variable increases monotonically with labor productivity $1/a$, and can be used as a productivity index. ¹² All three profit functions are increasing with this productivity index: more productive firms are more profitable in all three activities. For a given productivity level, type- D firm profits are always higher than the other two firm-types because type- D firms invoke both a lower fixed cost and a lower marginal cost (due to assumption 1). Type- X firms face a lower fixed cost but a higher marginal cost than type- P firms. These profit functions imply that domestic firms with a productivity level below $(a_D^i)^{1-\varepsilon}$ expect negative operating profits and exit the industry, while firms with productivity levels above this cutoff become type- D firms. Foreign firms with productivity levels below $(a_X^i)^{1-\varepsilon}$ do not sell their products in advanced economy i ; foreign firms with productivity between $(a_X^i)^{1-\varepsilon}$ and $(a_P^i)^{1-\varepsilon}$ become type- X firms; while those with a higher productivity become type- P firms. Using equations (4) to (6), the cutoff coefficients $(a_D^i)^{1-\varepsilon}$, $(a_X^i)^{1-\varepsilon}$, and $(a_P^i)^{1-\varepsilon}$ are determined by:

$$(a_D^i)^{1-\varepsilon} B^i = f_D \quad (7)$$

$$(\tau a_X^i)^{1-\varepsilon} B^i = f_X \quad (8)$$

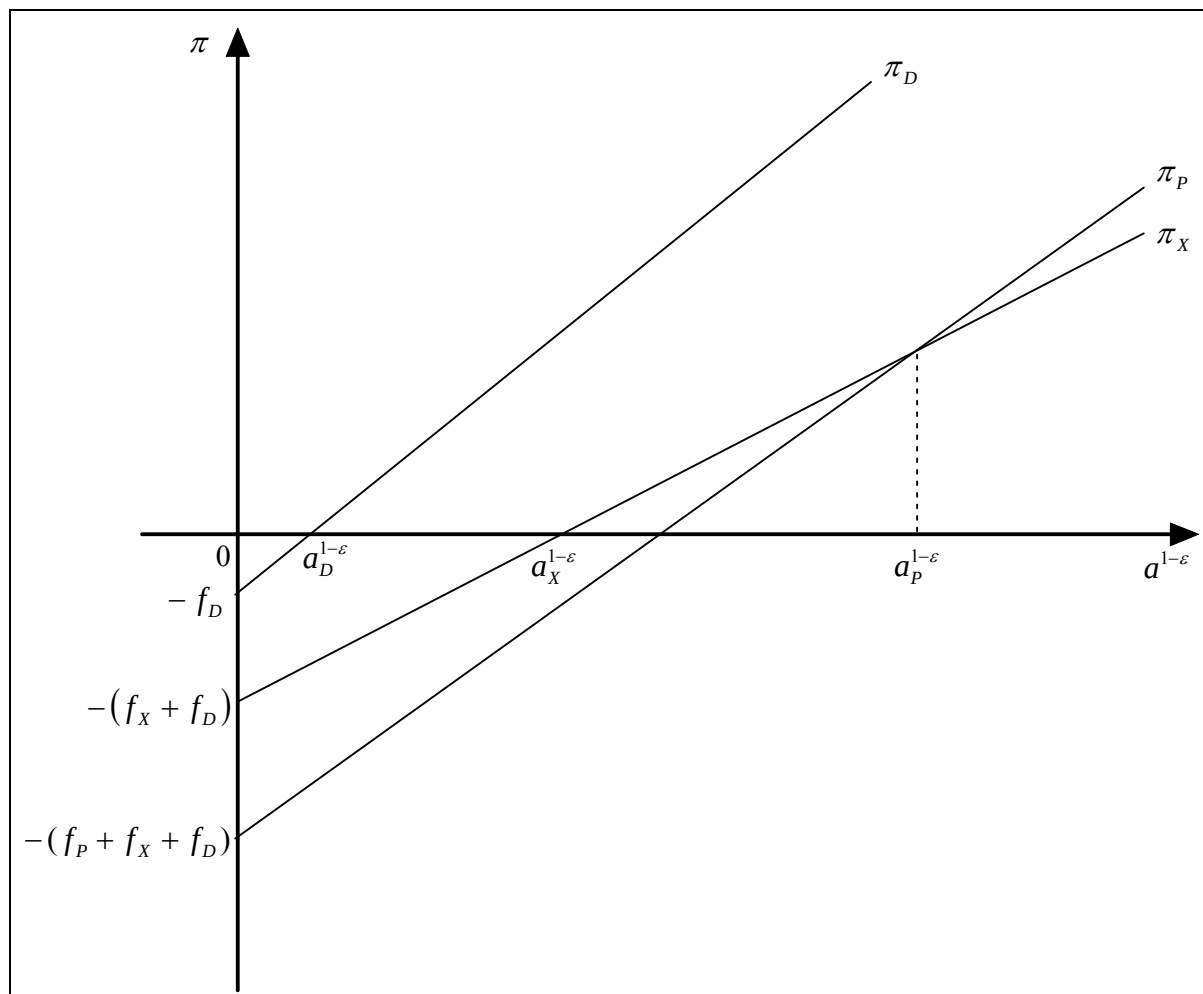
$$(\tau a_P^i)^{1-\varepsilon} B^i ((tw)^{1-\varepsilon} - 1) = f_P \quad (9)$$

¹⁰ As will become clear below, assumption 1 ensures that the unit cost of a type- P firm is sufficiently lower than that of a type- X firm so that $a_X^i > a_P^i$.

¹¹ $(t^2w)^{\varepsilon-1} > 1$ implies that the unit cost of conducting both production stages at home for domestic sales is lower than offshoring final assembly to the PRC for re-import. While this assumption is not realistic, it significantly reduces the complexity of our analysis. Furthermore, relaxing this assumption is unlikely to change the two key theoretical predictions of our model.

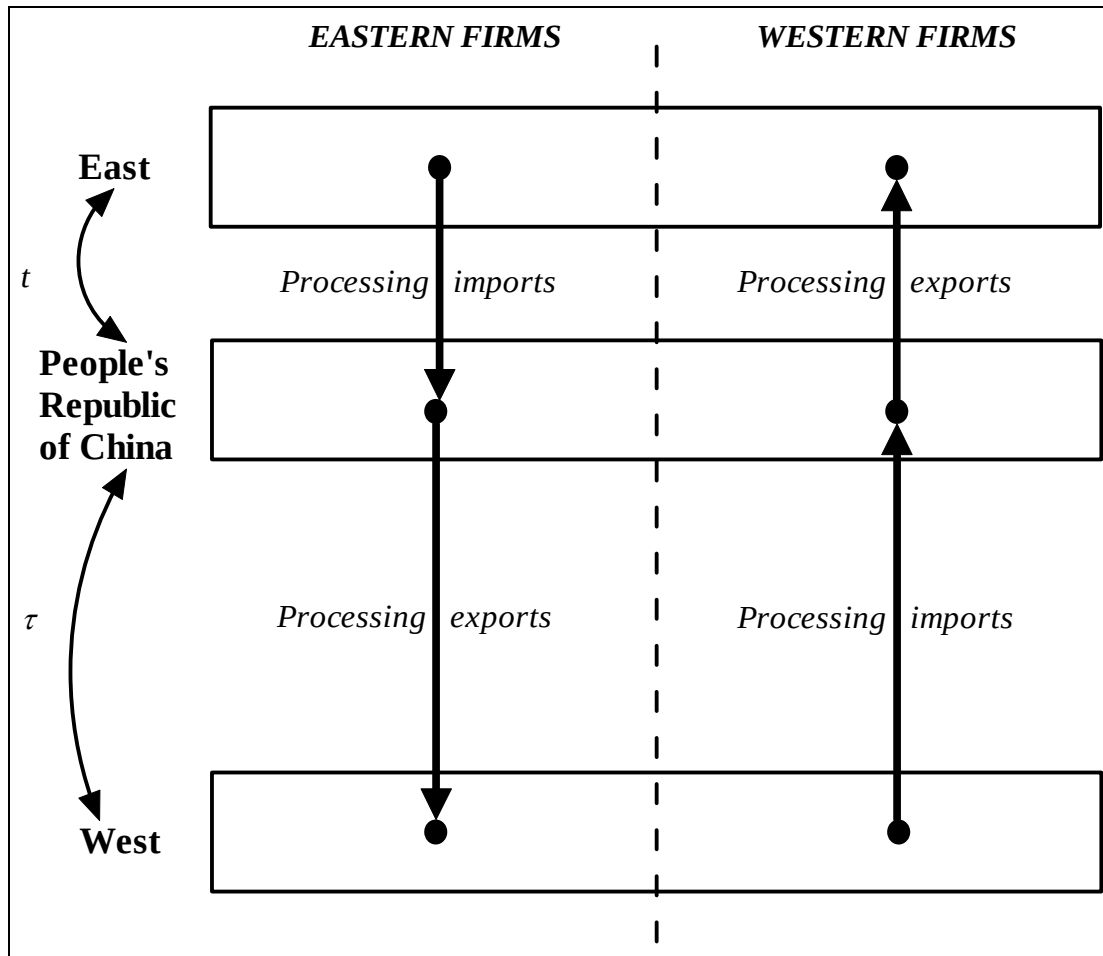
¹² This graphical approach of presenting the results is adopted from Helpman, Melitz, and Yeaple (2004).

Figure 3: Profits Functions for Type-D Domestic Firms, Type-X Foreign Firms, and Type-P Foreign Firms



Free entry ensures equality between the expected operating profits of a potential entrant and the entry cost F_e . The free entry condition together with equations (7) to (9) provide implicit solutions for the cutoff coefficients a_D^i , a_X^i , and a_P^i , and the demand levels B^i in every economy.

If we take into account the PRC's bilateral trade patterns for Eastern and Western firms, and the locational assumptions shown in Figure 2, our theoretical model fits the stylized facts of the PRC's processing trade well. In line with Figure 1, our theoretical model predicts a negative correlation between the distance from which the PRC's inputs are imported (import distance) and the distance to which the PRC's final goods are exported (export distance). The inputs that the PRC imports from the nearby East are processed into final goods and exported to the far-away West. Conversely, the inputs that the PRC imports from the far-away West are processed into final goods and exported to the nearby East (Figure 4).

Figure 4: People's Republic of China's Processing Trade Patterns

Furthermore, we can use our model to derive a number of testable hypotheses related to the PRC's processing trade. In Appendix 1, we demonstrate that the bilateral export value of the PRC to advanced economy i can be expressed as:

$$\Omega_P^i(t, \tau) = \frac{Y^i}{1 + \sigma_{D,P}^i(t, \tau) + \sigma_{X,P}^i(t, \tau)}, \quad (10)$$

where Ω_P^i denotes the total industry sales of type- P firms in economy i , $\sigma_{X,P}$ captures the relative market share of type- X firms to type- P firms in economy i ; and $\sigma_{D,P}$ captures the relative market share of type- D firms to type- P firms in economy i . Equation (10) provides the intuitive result that, all else equal, an increase in the relative market share of type- D firms to type- P firms in advanced economy i reduces the PRC's exports to i . Similarly, an increase in the relative market share of type- X firms to type- P firms in advanced economy i reduces the PRC's exports to i .

In Appendix 1, we also derive that:

$$\sigma_{X,P}(t, \tau) = (tw)^{\varepsilon-1} \left[\left(\frac{f_P}{f_X} \cdot \frac{(tw)^{\varepsilon-1}}{1 - (tw)^{\varepsilon-1}} \right)^{\frac{z - (\varepsilon-1)}{\varepsilon-1}} - 1 \right], \quad (11)$$

$$\sigma_{D,P}(t, \tau) = (\pi tw)^z \left(\frac{f_P}{f_X} \cdot \frac{1}{1 - (tw)^{\varepsilon-1}} \right)^{\frac{z - (\varepsilon-1)}{\varepsilon-1}}. \quad (12)$$

It is straightforward to calculate from equations (11) and (12) that:

$$\frac{\partial \sigma_{X,P}}{\partial t} \geq \frac{\partial \sigma_{X,P}}{\partial \tau} = 0, \quad (13)$$

$$\frac{\partial \sigma_{D,P}}{\partial t} \geq \frac{\partial \sigma_{D,P}}{\partial \tau} \geq 0. \quad (14)$$

Equation (13) suggests that a rise in t increases the relative market share of type- X firms to type- P firms, $\sigma_{X,P}$, while a rise in τ leaves $\sigma_{X,P}$ unaffected. The differential impact of t and τ is related to our notion that the PRC is the low-cost processing platform in the vicinity of East. On the one hand, an increase in t only raises the trade costs related to using the PRC as an export platform. As a result, it reduces the attractiveness of indirect exports through the PRC, thus inducing some foreign firms to substitute indirect exports for direct exports. This leads to an increase in the relative market share of type- X firms to type- P firms. On the other hand, an increase in τ raises the trade costs for both direct and indirect exports. In our model, it therefore leaves the relative market share of type- X firms to type- P firms unchanged. Similarly, equation (14) indicates that a rise in both t and τ increases the relative market share of type- D domestic firms to type- P foreign firms, $\sigma_{D,P}$, but that the effect of an increase in t is larger. Combined with equation (10), these results suggest that an increase in both t and in τ has a negative impact on the PRC's exports to economy i , Ω_P^i , but that the effect of an increase in t is larger.

Note that t and τ play a different role in the PRC's processing exports to East and West. When exporting to West, t reflects the trade costs related to import distance and τ reflects the trade costs related to export distance. Conversely, when exporting to East, t reflects the trade costs related to export distance and τ reflects the trade costs related to import distance. This leads to two hypotheses relating import and export distance to the PRC's processing exports:

Hypothesis 1: *Ceteris paribus, PRC's processing exports are negatively affected by both an increase in import distance and an increase in export distance.*

Hypothesis 2: *Ceteris paribus, PRC's processing exports to East are (i) more sensitive to export distance and (ii) less sensitive to import distance than its processing exports to West.*

In the two sections that follow, we present the data and methods that we use to test these hypotheses.

3. DATA AND SETTING

To test our two hypotheses, we use bilateral trade data between PRC provinces and their foreign trading partners for the period 1997–2005 compiled by the General Administration of Customs of the People's Republic of China. For each bilateral trade, this data set provides

information on the economy of origin and destination and the type of trade (ordinary versus processing).

For the purposes of the present analysis, we focus solely on processing trade. The summary statistics provided in Table 1 show the importance of processing trade in the PRC's overall trade. Between 1997 and 2005, processing exports consistently accounted for approximately 55% of total PRC exports (column 4), while processing imports consisted of 39–49% of total PRC imports (column 5). In addition, column 3 of Table 1 illustrates the high foreign content in the PRC's processing exports. Between 1997 and 2005, approximately two thirds of the PRC's processing export value corresponded to the value of the imported components embodied in these exports.¹³

Table 1: Summary Statistics on People's Republic of China's Processing Trade, 1997–2005

Year	Processing Exports (bn US\$)	Processing Imports (bn US\$)	Processing Trade Surplus as Share of Processing Exports	Share of Processing Exports in Total Exports	Share of Processing Imports in Total Imports
1997	99.6	70.1	29.6	54.5	49.4
1998	104.3	68.5	34.3	56.8	48.9
1999	110.9	73.6	33.6	56.8	44.4
2000	137.6	92.6	32.7	55.2	41.1
2001	147.0	94.0	36.1	55.4	38.6
2002	179.6	122.3	31.9	55.3	41.4
2003	241.2	162.9	32.5	55.2	39.5
2004	327.2	221.5	32.3	55.3	39.5
2005	415.2	273.8	34.1	54.7	41.5

US = United States.

Source: Authors' calculations based on People's Republic of China Customs Statistics.

In Table 2, we list the primary source economies of the PRC's processing imports and destination economies of the PRC's processing exports in 2005. The table unveils two interesting facts related to the PRC's processing trade. First, columns 1 and 3 of Table 2 show that, despite Hong Kong, China's relatively small economic size, it is the PRC's largest source of processing imports and the second largest destination market for its processing exports. A key reason why Hong Kong, China is such an important trading partner is that a large portion of the PRC's processing imports and exports are transshipped through Hong Kong, China (Feenstra, Hanson, and Lin 2004). Because the PRC's Customs Administration does not necessarily know the original source economy of imports and destination economy of exports transshipped through Hong Kong, China, they record Hong Kong, China as the trade partner. To account for these transshipments, we used a data set from the Government of the Hong Kong Special Administrative Region Census and Statistics Department on the economy's re-exports to identify the original source and final destination of these transshipments (see Appendix 2 for details). A comparison of columns 1 versus 2 and columns 3 versus 4 in Table 2 illustrates the significant impact that adjusting for transshipments through Hong Kong, China has on the PRC's processing trade with its major trading partners. More specifically, it almost doubles the share of processing imports originating from the PRC's major trading partners (other than Hong Kong, China) and increases by a quarter the share of processing exports destined for these same economies.

¹³ This estimate of the import content share of the PRC's processing exports is slightly lower than that of Koopman, Wang, and Wei (2008) because they also took into account indirect import content in their estimation.

Table 2: Origin and Destination of People's Republic of China's Processing Imports and Exports, 2005

	Share of Processing Imports Originating from		Share of Processing Exports Destined for	
	Unadjusted for Hong Kong, China	Adjusted for Hong Kong, China	Unadjusted for Hong Kong, China	Adjusted for Hong Kong, China
	Transshipments	Transshipments	Transshipments	Transshipments
East Asia	88.16	77.24	47.19	31.93
Hong Kong, China	48.01	—	22.89	—
Japan	10.45	20.09	11.73	14.15
Korea, Rep. of	11.33	21.78	3.93	4.87
Singapore	3.15	6.05	2.57	3.59
Taipei, China	9.39	18.06	2.24	2.96
Malaysia	1.95	3.75	1.40	1.87
Thailand	1.24	2.39	0.82	1.43
Philippines	1.83	3.53	0.51	1.05
Viet Nam	0.09	0.18	0.41	0.74
Indonesia	0.47	0.90	0.48	0.71
Macau, China	0.27	0.51	0.21	0.55
OECD	8.17	15.71	47.9	61.26
United States	3.51	6.75	25.21	31.08
EU-19	3.30	6.35	18.83	24.96
Canada	0.33	0.63	1.31	1.73
Australia	0.73	1.40	1.17	1.58
Mexico	0.05	0.09	0.66	0.88
Turkey	0.03	0.05	0.29	0.40
Switzerland	0.06	0.11	0.21	0.32
New Zealand	0.09	0.18	0.12	0.18
Norway	0.07	0.14	0.10	0.13
Iceland	0.01	0.01	0.00	0.00
Rest of the World	3.67	7.05	4.92	6.81

EU = European Union; OECD = Organisation for Economic Co-operation and Development.

Source: Authors' calculations based on People's Republic of China Customs Statistics.

The second interesting fact Table 2 reveals is that the main source economies for the PRC's processing imports differ from the primary destination economies for processing exports. For the supply of its processing imports, the PRC relies heavily on its neighbor economies, with 77.2% of its processing imports originating from within East Asia (after adjusting for Hong Kong, China transshipments). Conversely, the majority of the PRC's processing exports are destined for countries outside of East Asia, with 61.3% sent to the non-Asian OECD countries. Overall, more than 90.0% of the PRC's processing trade is with the listed East Asian and OECD economies. In our regression analysis below, we will restrict our data sample of export destination economies to the 10 East Asian economies (excluding Hong Kong, China) and the 28 non-Asian OECD economies listed in Table 2.

In Table 3, we list by province the weighted average distance of the economies from which the PRC imports its processing inputs (import distance) and to which the PRC ships its processing exports (export distance). The table demonstrates that in a cross-section of 29

PRC provinces, export distance is negatively correlated with import distance (see Figure 1). In addition, Table 3 shows that adjusting for transshipments through Hong Kong, China significantly increases import and export distance. In 2005, for example, the weighted average distance of Guangdong province's processing exports and imports increased by 1,723 and 2,174 miles, respectively, after Hong Kong, China transshipments were taken into account.

Table 3: Weighted Average Export and Import Distance by Province, 2005

	Weighted Average Export Distance			Weighted Average Import Distance		
	Unadjusted	Adjusted	Difference	Unadjusted	Adjusted	Difference
Jiangxi	4,021	5,207	1,186	3,320	4,296	976
Guangdong	3,282	5,005	1,723	283	2,457	2,174
Ningxia	4,731	4,869	138	2,439	2,439	0
Fujian	4,186	4,666	480	1,375	2,290	915
Anhui	4,278	4,567	289	4,128	4,167	39
Hubei	4,145	4,567	422	3,140	3,431	291
Xinjiang	4,543	4,556	13	3,908	3,913	5
Sichuan	3,499	4,422	923	3,507	3,805	298
Shanghai	4,047	4,403	356	2,162	2,337	175
Tianjin	4,162	4,356	194	1,679	1,807	128
Shaanxi	3,860	4,345	485	4,344	4,514	170
Zhejiang	4,133	4,304	171	2,453	2,620	167
Jiangsu	3,772	4,276	504	1,406	1,549	143
Beijing	3,624	3,928	304	1,893	2,049	156
Hunan	3,164	3,893	729	2,856	3,158	302
Inner Mongolia	2,665	3,802	1,137	2,236	2,705	469
Hebei	3,650	3,740	90	3,210	3,265	55
Guangxi	2,734	3,727	993	2,941	4,428	1,487
Shandong	3,435	3,598	163	2,119	2,174	55
Guizhou	2,869	3,456	587	3,474	3,766	292
Jilin	3,376	3,450	74	2,651	2,724	73
Hainan	2,206	3,405	1,259	1,964	2,436	472
Shanxi	2,895	3,137	242	4,693	4,830	137
Henan	2,533	3,046	513	5,148	5,180	32
Liaoning	2,696	2,902	206	2,770	2,830	60
Heilongjiang	2,496	2,724	228	2,588	2,616	28
Yunnan	1,667	2,505	838	3,214	3,762	548
Gansu	2,261	2,475	214	4,956	4,959	3
Qinghai	1,905	2,362	457	4,700	4,700	0
Average	3,339	3,854	514	2,950	3,283	333

Source: Authors' calculations using People's Republic of China Customs Statistics.

4. METHODS OF ANALYSIS

To test our two main hypotheses, we estimated a standard gravity model using the processing trade data described in the previous section. The dependent variable in the model is the natural log of processing exports from a PRC province i to a destination

economy j in year t ($\ln EX_{ijt}$). We included three independent distance variables in our analysis: the natural logs of export distance, import distance, and internal distance. We measured export distance ($ExDist_{ij}$) as the arc distance between the PRC port closest to province i and the destination economy j . To measure import distance ($ImDist_{ij}$), we needed to take into account that multiple inputs from various economies are used in the production of a specific export good. As a consequence, we measured import distance using the following formula:

$$ImDist_{it} = \sum_j \frac{IM_{ijt}}{\sum_j IM_{ijt}} \cdot ExDist_j, \quad (15)$$

where IM_{ijt} is province i 's imports from economy j in period t ; and $ExDist_{ij}$ is the arc distance between the PRC port closest to province i and source economy j . Finally, we followed Feenstra, Hanson, and Lin (2004) by measuring internal distance ($IDist_i$) as the distance between a province and its closest major PRC port, where distance is given by train time between the two destinations.

To investigate whether the PRC's processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance than its processing exports to Western countries, we introduced a dummy variable, $East_j$, that equals 1 if the economy of destination is an East Asian one and 0 if the destination market is a non-Asian OECD country. We then introduced interaction terms between $East_j$ and our two distance variables $\ln ExDist_{ij}$ and $\ln ImDist_{it}$ as independent variables in our model.

Finally, we added a number of standard control variables that may affect the relationship between distance and processing exports. Specifically, we used data from, respectively, the *China Statistical Yearbook* and from the World Bank's World Development Indicator database to include controls for GDP per capita ($GDPpc_{it}$) and population size (Pop_{it}) for PRC provinces and destination markets. We also used data from the *China Statistical Yearbook* to add a control for PRC provincial wages ($wage_{it}$).

In summary, we estimated the following equation:

$$\begin{aligned} \ln EX_{ijt} = & \beta_0 + \beta_1 \ln cGDPpc_{it} + \beta_2 \ln GDPpc_{jt} + \beta_3 \ln cPop_{it} + \beta_4 \ln Pop_{jt} \\ & + \beta_5 \ln Wage_{it} + \beta_6 \ln ExDist_{ij} + \beta_7 \ln IDist_i + \beta_8 \ln ImDist_{it} + \beta_9 Market_j \\ & + \beta_{10} East_j \cdot \ln ExDist_{ij} + \beta_{11} East_j \cdot \ln ImDist_{it} + \lambda_t + \mu_{ijt} \end{aligned} \quad (16)$$

where EX_{ijt} is the volume of exports from province i to economy j in period t ; $cGDPpc_{it}$ and $cPop_{it}$ are the GDP per capita and population of province i in period t ; $GDPpc_{jt}$ and POP_{jt} are the GDP per capita and population of the target economy j in period t ; $Wage_{it}$ is province i 's wage in period t ; $ExDist_{ij}$ is export distance between province i and economy j ; $IDist_i$ is internal distance; $ImDist_{it}$ is the weighted import distance for province i in period t ; $East_j$ is a dummy variable that equals 1 if the destination economy is an East Asian one, and is 0 otherwise; λ_t is the time effect; and μ_{ijt} is a white noise disturbance term.

Hypothesis 1 will be confirmed if $\ln ExDist_{ij}$ and $\ln ImDist_{it}$ both have a negative effect on processing exports. Hypothesis 2 will be validated if (i) the coefficient on the interaction term between $East_j$ and $\ln ExDist_{ij}$ is significantly negative and (ii) the coefficient on the interaction term between $East_j$ and $\ln ImDist_{it}$ is significantly positive.

5. RESULTS

Table 4 presents our estimation results of equation (16), which are ordinary least squares (OLS) coefficient estimates with robust standard errors in columns 1 to 5 and instrumental variables (IV) estimates in column 6. Column 1 includes the independent variables that are

generally used in gravity equations. Column 2 adds import distance $\ln ImDist_{it}$ as an independent variable. Column 3 includes the dummy variable $East_j$ and the interaction terms. Columns 4 and 5 show the estimation results for the subsamples of East Asia and OECD countries, respectively; whereas column 6 includes the full sample for the IV estimation.

Table 4: Benchmark and IV Regression Results, 1997–2005

Dependent Variable: Log of Bilateral Processing Exports						
	OLS				IV	
	All		East Asia	OECD	All	
	(1)	(2)	(3)	(4)	(5)	(6)
GDP Per Capita (province)	1.046***	0.921***	0.955***	0.850***	0.998***	0.872**
(<i>IncGDPpc</i>)	(0.041)	(0.043)	(0.040)	(0.068)	(0.048)	(0.386)
GDP Per Capita (country)	0.841***	0.840***	0.986***	0.787***	1.140***	0.985***
(<i>lnGDPpc</i>)	(0.014)	(0.014)	(0.016)	(0.018)	(0.026)	(0.017)
Population (province)	1.306***	1.282***	1.297***	1.223***	1.349***	1.278***
(<i>IncPop</i>)	(0.023)	(0.023)	(0.022)	(0.037)	(0.025)	(0.081)
Population (country)	1.020***	1.020***	0.973***	0.660***	1.124***	0.973***
(<i>lnPop</i>)	(0.013)	(0.013)	(0.013)	(0.018)	(0.015)	(0.013)
Wage (province)	2.934***	3.013***	2.955***	2.724***	3.071***	2.997***
(<i>lnWage</i>)	(0.091)	(0.093)	(0.089)	(0.145)	(0.107)	(0.248)
Export Distance	−1.161**	−1.161***	0.271*	−0.301***	−0.161	0.307
(<i>lnExDist</i>)	(0.021)	(0.021)	(0.127)	(0.041)	(0.127)	(0.230)
Internal Distance	−0.478**	−0.431***	−0.432***	−0.417***	−0.447***	−0.400***
(<i>lnIDist</i>)	(0.011)	(0.014)	(0.013)	(0.021)	(0.016)	(0.150)
Import Distance	—	−0.507***	−0.670***	−0.353***	−0.588***	−1.023
(<i>lnImDist</i>)		(0.069)	(0.074)	(0.106)	(0.081)	(1.591)
East	—	—	3.290**	—	—	3.417
(<i>East</i>)			(1.305)			(2.389)
East*Export Distance	—	—	−0.660***	—	—	−0.700***
(<i>East*lnExDist</i>)			(0.131)			(0.251)
East*Import Distance	—	—	0.510***	—	—	0.536***
(<i>East*lnImDist</i>)			(0.093)			(0.165)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,044	8,044	8,044	2,390	5,654	8,043
R ²	0.752	0.755	0.774	0.777	0.777	0.773

* means significant at 10%; ** means significant at 5%; *** means significant at 1%.

GDP = gross domestic product; IV = instrumental variables; OECD = Organisation for Economic Co-operation and Development; OLS = ordinary least squares.

Note: Robust standard errors are in parentheses.

The results generally provide support for Hypotheses 1 and 2. Let us first examine the evidence for Hypothesis 1. Specifically, in column 2, both coefficients on import distance and export distance are negative and statistically significant. In column 3, the coefficient on import distance remains negative and statistically significant, but the coefficient on export distance is positive. Comparing columns 4 and 5, the results suggest that import and export distance both have a negative impact on processing exports to East Asian economies;

import distance has a negative impact on processing exports to non-Asian OECD countries, but export distance is an insignificant determinant of processing exports to non-Asian OECD countries.

We also find strong evidence in favor of Hypothesis 2. Specifically, in column 3 the coefficient on $East_j * \ln ExDist_i$ is negative and statistically significant, while the coefficient on $East_j * \ln ImDist_i$ is positive and statistically significant. In line with Hypothesis 2, this suggests that processing exports destined for East Asian economies are more sensitive to export distance and less sensitive to import distance than processing exports destined for non-Asian OECD countries. The coefficients on import and export distance in columns 4 and 5 are also in line with Hypothesis 2. Namely, the absolute value of the coefficient on $\ln ExDist$ is larger for processing exports to East Asian economies than to non-Asian OECD countries; whereas the absolute value of the coefficient on $\ln ImDist$ is smaller for processing exports to East Asian economies than to non-Asian OECD countries.

The other coefficients in columns 2 to 5 all take on the expected signs. Processing exports are larger for more populated provinces and those with higher GDP per capita, higher wages, and lower internal distance. In addition, processing exports are greater for destinations that are more populated and have a higher GDP per capita. Finally, the positive coefficient on the dummy variable $East_j$ suggests that there are extra trade costs related to interregional trade.

By comparing the other coefficients in columns 4 and 5, we are able to identify additional differences between processing exports to East Asian versus non-Asian OECD economies. The results show that the coefficients on $\ln GDPpc_{it}$, $\ln GDPpc_{jt}$, $\ln Pop_{it}$, $\ln Pop_{jt}$, $\ln Wage_{it}$, and $\ln IDist_i$ are in absolute value all larger for the subsample of non-Asian OECD countries than for the subsample of East Asian economies.¹⁴ This implies that processing exports to non-Asian OECD countries tend to concentrate in more populated provinces with higher GDP per capita, higher wages, and smaller internal distance than processing exports to East Asian economies. Moreover, processing exports to non-Asian OECD countries are mainly shipped to richer and larger destination markets.

6. ROBUSTNESS CHECKS

6.1 IV Estimation

A potential endogeneity problem may exist in our empirical framework in that unobserved factors that are correlated with processing exports also influence import distance. For example, locations that are considered ideal for processing activities due to their proximity to the destination market may simultaneously be favorable because of their closeness to suppliers in the destination market. In order to account for this potential issue, we adopted an IV approach in which we used “supplier access” as an instrument for import distance $ImDist_i$. Supplier access is an economic geography concept proposed by Redding and Venables (2004) to measure a location’s access to foreign sources of input supply. To measure supplier access, the authors developed a two-stage least square (2SLS) procedure to estimate for each location an appropriately distance-weighted measure of the location of its import supply. This approach was adapted by Ma (2006) to PRC data.

To estimate supplier access, in stage one, we estimate a gravity equation of PRC processing imports by province with year and economy dummies. The estimated coefficients from the gravity equation are then used in stage 2 to calculate the supplier access variable by applying the following equation:

¹⁴ A positive coefficient on $\ln Wage$ is in line with previous studies. Using data from 1996 to 1999 to examine the effect of labor costs on FDI location, Gao (2002) also obtained a positive coefficient on the OLS estimation of real wages.

$$S\hat{A}_{it} = \sum_{j=1}^J e^{\hat{\eta}_{jt}} * IDist_i^{\hat{\lambda}_{1t}} * ExDist_{ij}^{\hat{\lambda}_{2t}}, \quad (17)$$

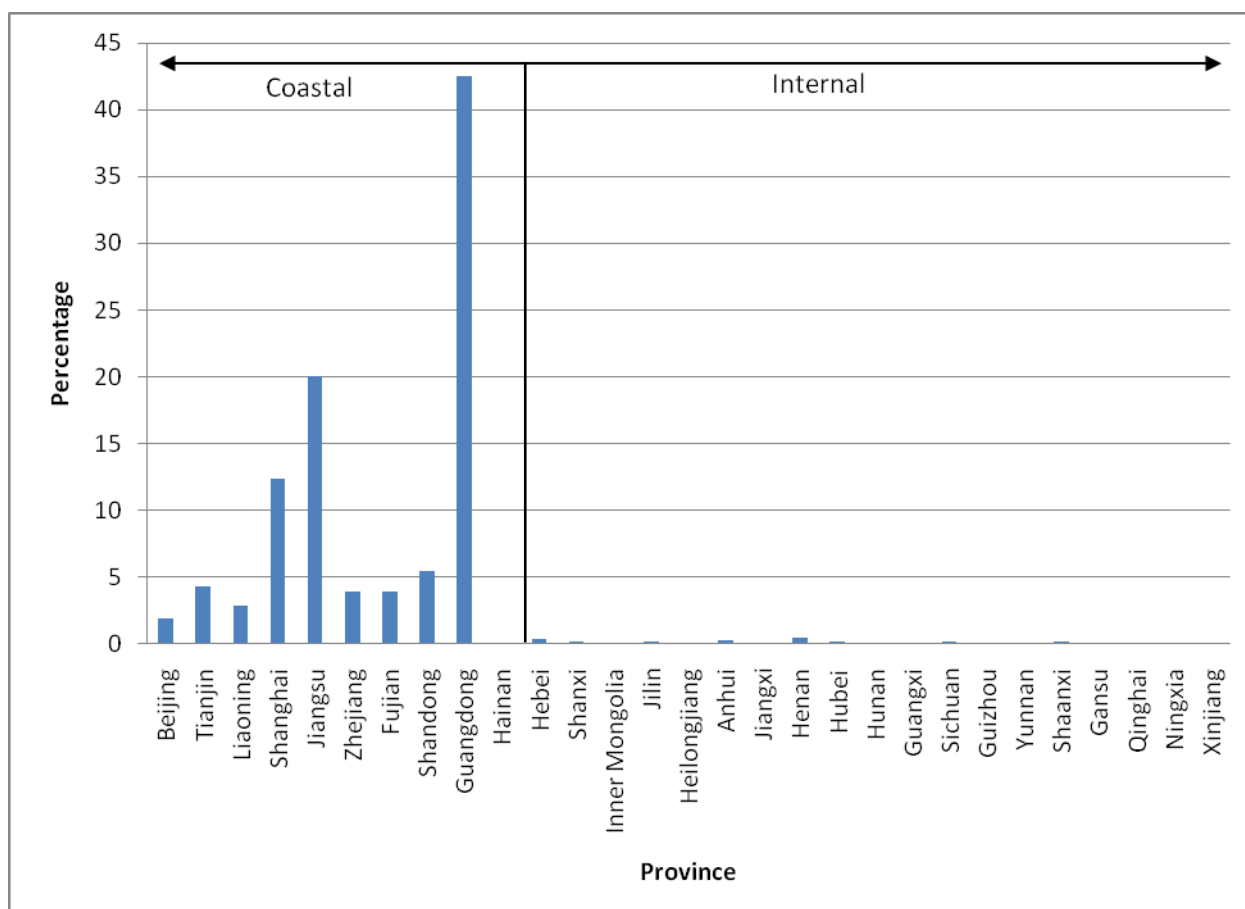
where $S\hat{A}_{it}$ denotes province i 's supplier access in year t , $\hat{\lambda}_{1t}$ and $\hat{\lambda}_{2t}$ are the coefficients on internal and external distances, respectively, and $\hat{\eta}_{jt}$ denotes the economy dummy.

Column 6 of Table 4 shows the estimated results using the IV method. Our instrument passes the Stock-Yogo weak identification test at the 10% level and is correctly specified according to the Hansen test. Moreover, the IV estimation using the full sample yields results that are similar to those in the benchmark specification provided in column 3. Specifically, there is strong evidence for Hypothesis 2 in that the coefficient on $East_j * \ln ExDist_i$ is negative and statistically significant, while the coefficient on $East_j * \ln ImDist_{it}$ is positive and statistically significant. However, contrary to the benchmark results, the coefficients on $\ln ExDist_{it}$, $\ln ImDist_{it}$, and $East_j$ are insignificant.

6.2 County-Level Estimation

Another potential estimation issue arises from the presence of industrial clustering in particular regions and the level of aggregation in our analysis. Low-import-distance and high-export-distance provinces may be specialized in different industries than high-import-distance and low-export-distance provinces. In line with this, there might be structural differences between the coastal and internal provinces in their share of processing trade. As is shown in Figure 5, in 2005, about 97% of processing exports and 98% of processing imports were conducted by the 10 coastal provinces listed in the figure. Guangdong alone accounted for approximately 43% of the total processing trade in that year.

Figure 5: Share of Processing Trade by Province, 2005



Source: Authors' calculations based on People's Republic of China Customs Statistics.

Ideally, we should control for locational differences between provinces and across industries by disaggregating our analysis at the industry and county level. However, we are limited by the lack of available data. Specifically, it is not possible to disaggregate the analysis at the industry level because we do not have the necessary input-output information regarding the combination of inputs that are used to produce specific exports. For example, semiconductors can be used to produce both cars and computers. The processing trade data identifies the value of semiconductors that are imported by a certain location but not in which industry they are put to use. Furthermore, conducting a full analysis at the county level is not possible because we are limited by the available number of explanatory variables; most notably, county-level information on GDP per capita, population, and wages is not available.

To at least partially address these estimation issues we re-estimated equation (16) at the county level with the inclusion of county fixed effects to take into account the unobserved heterogeneity across counties. Moreover, we included year dummies and interaction variables between county and year to capture changes over time. We restricted the analysis to the counties in the coastal provinces to control for a potential structural difference between processing activities in coastal and internal provinces. The results presented in column 1 of Table 5 continue to support Hypothesis 2. In particular, an increase in export distance leads to a larger decrease in processing exports destined for the East Asian economies. By contrast, processing exports shipped to East Asia are less sensitive to import distance than those exported to non-Asian OECD countries.

Table 5: County Regression Results, 2000–2005

Dependent Variable: Log of Bilateral Processing Exports by Coastal Counties			
	Total	Foreign-Invested Enterprises	Domestic Firms
	(1)	(2)	(3)
GDP per capita (county)	1.024*** (0.008)	1.051*** (0.009)	0.821*** (0.011)
Population (county)	0.977*** (0.006)	0.963*** (0.007)	0.967*** (0.008)
Export distance	−0.077 (0.066)	−0.127* (0.078)	−0.090 (0.094)
East	1.966*** (0.636)	2.696*** (0.747)	0.387 (0.899)
East*Export Distance	−0.232*** (0.069)	−0.199*** (0.081)	−0.158* (0.097)
East*Import Distance	0.201** (0.035)	0.062 (0.040)	0.269*** (0.044)
Year Dummy	Yes	Yes	Yes
County Dummy	Yes	Yes	Yes
Year*County Dummy	Yes	Yes	Yes
Observations	38,050	28,259	23,192
R ²	0.744	0.748	0.667

* means significant at 10%; ** means significant at 5%; *** means significant at 1%.

GDP = gross domestic product.

Note: Robust standard errors are in parentheses.

We further disaggregated the county-level analysis for the coastal region to differentiate between processing exports by foreign-invested enterprises (FIEs) and domestic firms. We present the results of this analysis in columns 2 and 3 of Table 5. In line with Hypothesis 2, we find that for both domestic firms and FIEs, processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance. But the coefficient on the interaction between *East* and *ImDist_i* is not significant for FIEs. A comparison of the coefficients in columns 2 and 3 of Table 5 suggests that processing exports by foreign firms are more sensitive to GDP per capita and export distance. Furthermore, processing exports shipped to East Asia by foreign firms are more sensitive to export distance and less sensitive to import distance than those shipped by domestic firms. This latter result may suggest that FIEs are primarily used by Western global production networks to process goods destined for larger and richer East Asian consumer markets; domestic firms are used by Eastern production networks to process inputs from neighboring East Asian economies for goods destined for Western markets. Overall, the results from estimating at the county level for coastal provinces provide support for Hypothesis 2.

7. CONCLUSION

This paper has unveiled an interesting pattern in the People's Republic of China's (PRC) processing trade. In a cross-section of PRC provinces, the average distance traveled by processing imports (import distance) is negatively correlated with the average distance traveled by processing exports (export distance). To explain this pattern, we have built on the recent literature on export-platform foreign direct investment to set up a three-economy industry-equilibrium model in which heterogeneous firms from two advanced economies, *East* and *West*, sell their products in each other's markets. Each firm can use two modes to serve the foreign market. It can directly export its products from its home economy. Alternatively, it can indirectly export to the foreign market by assembling its product in a third low-cost economy, *PRC*. By assuming that *PRC* is located in the geographical proximity of *East*, our model provides an explanation for the negative correlation between export and import distance for the PRC's processing trade: the inputs that *PRC* imports from the nearby *East* are processed into final goods and exported to the far-away *West*. Conversely, the inputs that *PRC* imports from the far-away *West* are processed into final goods and exported to the nearby *East*. Our model has also established two theoretical predictions relating the PRC's geographical location to its processing trade patterns. First, the PRC's processing exports are negatively affected by both an increase in import distance and a rise in export distance. Second, the PRC's processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance than its processing exports to non-Asian economies.

Using data on the PRC's processing trade, our empirical analysis has found support for the theoretical predictions of the model. Specifically, we found some evidence that the PRC's processing exports are negatively affected by import and export distance. Furthermore, we found a strong confirmation that processing exports to East Asian economies are more sensitive to export distance and less sensitive to import distance than processing exports to non-Asian Organisation for Economic Co-operation and Development (OECD) countries. The empirical evidence is consistent with the claim that the PRC's attractiveness as a labor-intensive offshoring location is driven by, among other factors, its geographic location. Production networks centered in East Asia consider the PRC's proximity to input suppliers in the East Asian region to be a driving factor of their offshoring decisions. Conversely, production networks centered in the West deem the PRC's vicinity to East Asian markets as a main determinant of their offshoring decisions. This paper provides new insights into the PRC's role in world trade, which is of major concern to policymakers.

One limitation of our theoretical analysis is our assumption that downstream production stages are more footloose than upstream production stages. That is, we follow the literature

on export-platform foreign direct investment by assuming that advanced country firms decide where to locate final assembly activities while taking the location of intermediate good production as a given. This assumption may not hold in all industries. In some cases, it may be that upstream activities are more footloose than downstream production stages. Contrary to our model, advanced-economy firms then may decide to move their upstream production stages to East Asia in order to be located in the vicinity of downstream production stages in the PRC. As our empirical analysis may also support this scenario, further empirical research is therefore required to analyze the relative footlooseness of the PRC's processing activities.

APPENDIX 1: THEORETICAL MODEL

In this appendix, we derive equations (10), (11), and (12) of the text. We start with the derivation of equation (10). In our model, three types of firms sell their products in advanced economy i : type- D domestic firms, type- X foreign firms, and type- P foreign firms. The representative consumer spends amount Y^i on industry output:

$$Y^i = \Omega_D^i + \Omega_X^i + \Omega_P^i, \quad (\text{A-1})$$

where Ω_D^i , Ω_X^i , and Ω_P^i denote the total industry sales of type- D firms, type- X firms, and type- P firms, respectively. If we divide both sides of the equation by Ω_P^i and rearrange, we obtain equation (10):

$$\Omega_P^i = \frac{Y^i}{1 + \sigma_{D,P}^i + \sigma_{X,P}^i}, \quad (\text{A-2})$$

where

$$\sigma_{D,P}^i = \frac{\Omega_D^i}{\Omega_P^i}, \quad (\text{A-3})$$

$$\sigma_{X,P}^i = \frac{\Omega_X^i}{\Omega_P^i}. \quad (\text{A-4})$$

Next, we need to derive industry sales for the three firm-types: Ω_D^i , Ω_X^i , and Ω_P^i . Denote a firm's type with subscript $k \in \{D, P, X\}$. Using equations (2) and (3) of the text, the revenue that a firm with type k receives in advanced economy i equals:

$$R_k^i = \frac{B^i c_k^{1-\varepsilon}}{1-\alpha}, \quad (\text{A-5})$$

where unit cost c_k^i is given by equation (3) of the text. Using the unit cost function in equation (3) and the cutoffs presented in equations (7) to (9) of the text, we can then aggregate the industry sales of firms with type k to be:

$$\Omega_D^i = \frac{B^i V(a_D)}{1-\alpha}, \quad (\text{A-6})$$

$$\Omega_X^i = \frac{B^i \tau^{1-\varepsilon} [V(a_X) - V(a_P)]}{1-\alpha}, \quad (\text{A-7})$$

$$\Omega_P^i = \frac{B^i (\tau \tau w)^{1-\varepsilon} V(a_P)}{1-\alpha}, \quad (\text{A-8})$$

where

$$V(a) = \int_0^a x^{1-\varepsilon} dG(x). \quad (\text{A-9})$$

Inserting equations (A-6) to (A-8) into (A-3) and (A-4) yields:

$$\sigma_{D,P}^i = (\tau \tau w)^{\varepsilon-1} \frac{[V(a_D)]}{V(a_P)}, \quad (\text{A-10})$$

$$\sigma_{X,P}^i = (\tau w)^{\varepsilon-1} \left(\frac{[V(a_X)]}{V(a_P)} - 1 \right). \quad (\text{A-11})$$

In the text, we have assumed that firms randomly draw a labor-per-unit-output coefficient of a from a cumulative Pareto distribution $G(a)$ with shape parameter z . In that case, Helpman,

Melitz, and Yeaple (2004) showed that $V(a)$ is also Pareto with the shape parameter $z - (\varepsilon - 1)$. The Pareto distribution implies that

$$\frac{V(a_1)}{V(a_2)} = \left(\frac{a_1}{a_2}\right)^{z-(\varepsilon-1)} \quad (\text{A-12})$$

for every a_1 and a_2 in the support of the distribution of a . Inserting equation (A-12) into equations (A-10) and (A-11) and using the cutoff conditions in equations (7) to (9) then yields equations (11) and (12).

APPENDIX 2: ADJUSTMENT FOR TRANSSHIPMENTS THROUGH HONG KONG, CHINA

A2.1 Export Side

1. X_{izkt} = exports from province i to Hong Kong, China by Harmonized Series at the 2-digit level (HS-2) category k at time t .
2. s_{zjkt} = share of Hong Kong, China's re-exports from the People's Republic of China (PRC) to economy j by HS-2 category k at time t .
3. $T_{ijkt} = s_{zjkt} * X_{izkt}$ = province i 's exports to Hong Kong, China that are re-exported to economy j by HS-2 category k at time t .
4. Add T_{ijkt} to X_{ijkt} to obtain province i 's total exports to economy j for category k at time t .

A2.2 Import Side

1. M_{izkt} = province i 's imports from Hong Kong, China by HS-2 category k at time t .
2. r_{zjkt} = share of Hong Kong, China's re-exports from economy j to PRC by HS-2 category k at time t .
3. $V_{ijkt} = r_{zjkt} * M_{izkt}$ = province i 's imports from Hong Kong, China that are re-exports from economy j by HS-2 category k at time t .
4. Add V_{ijkt} to M_{ijkt} to obtain province i 's total imports from economy j for category k at time t .

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