Spatial Linkages and Offshoring Location Choice

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Abstract

We argue that a firm's offshoring location choice not only depends on a location's production costs, but also on its spatial linkages with other parts of the global value chain. A location that is closer to upstream suppliers and downstream markets should attract more offshoring activities. To validate this conjecture, we use detailed processing trade data for 29 Chinese provinces. We find that three types of spatial linkages affect a province's attractiveness as an offshoring location: a province's distance to its closest seaport, the proximity of this seaport to international suppliers, and the proximity of this seaport to international markets.

Keywords: offshoring, global value chain, economic geography, China, processing trade.

INTRODUCTION

Falling trade and communication costs have brought about important changes in how firms spatially organize their production activities. Stages of production or "tasks" that firms used to perform in close proximity to one another can now more easily be separated geographically without a substantial drop in efficiency (Blinder, 2006; Leamer & Storper, 2001; Zaheer & Manrakhan, 2001). Firms have sought to take advantage of this trend by slicing up their value chains and relocating tasks to the location that has the lowest production costs. These offshoring decisions have led to a rise in "global value chains" (GVCs), with many countries involved in the production of individual goods (Gereffi, Humphrey & Sturgeon, 2005; Grossman & Rossi-Hansberg, 2009).

The spatial distribution of tasks within GVCs, however, remains far less dispersed than would be expected in a globalized or "flat" world. Trade in intermediate goods is mainly conducted intra-regionally (Athukorala & Yamashita, 2006; Curran & Zignago, 2011), and distance-related trade costs are found to be an especially important determinant for bilateral trade flows within GVCs (Baldwin and Taglioni, 2011; Gamberoni, Lanz & Piermartini, 2010; Gangnes, Ma & Van Assche, 2011). These facts seem to suggest that most value chains are regional instead of global. Yet few studies have analyzed why this may be the case, and more generally, what determines the spatial organization of tasks within GVCs.

Building on the new economic geography (NEG) literature, Amiti (2005) and Baldwin & Venables (2011) argue that the tension between comparative advantage and agglomeration forces lies at the heart of location decisions in GVCs. On the one hand, comparative advantage forces induce firms to establish value chain tasks in the location that has the lowest production costs. On the other hand, this effect is moderated by the benefits of agglomerating adjacent value chain stages close to one another, such as reduced transportation costs, increased timeliness, and fewer coordination problems. The authors suggest that, when choosing how to organize their value chains spatially, firms need to constantly keep these two forces into balance.

This theory has important implications for understanding the choice of an offshoring location. It suggests that the attractiveness of an offshoring location is not only driven by location-specific characteristics that can provide a comparative advantage such as local labor costs, transportation infrastructure and institutional quality, but also by the location's spatial linkages with upstream and downstream stages within the same GVC. All else equal, a location that is geographically closer to adjacent value chain stages should be a more attractive offshoring site. Furthermore, the theory implies that a change in agglomeration forces (i.e. change in distance-related trade costs) can entice firms to rethink the spatial organization of their GVC, even if location-specific characteristics remain unaltered. Indeed, Harrigan & Venables (2006) argue that the adoption of just-in-time production techniques should pressure firms to relocate their production of goods closer to home, and Evans & Harrigan (2005) find evidence of this in the textile industry. Rubin (2009) and Rubin & Tal (2008) use a similar discourse to argue that the rise in oil prices between 2000 and 2008 has enticed many firms to abandon far away production for closer locations.

Surprisingly, there have been few studies that test the role of spatial linkages in GVCs empirically (Beugelsdijk, McCann, & Mudambi, 2010). Data limitations may be one reason for this absence. There are few known datasets that capture the spatial organization of GVCs. A number of studies have used as a proxy the spatial dispersion of a multinational firm's subsidiaries (Defever, 2011; Hanson, Mataloni, & Slaughter, 2005; Rugman, Li, & Oh, 2009), yet this gives a potentially biased picture since many multinationals outsource a large portion of their GVC activities to external firms (Contractor, Kumar, Kundu, & Pedersen, 2010; Mudambi, 2008).

In this paper, we aim to shed new light on the determinants of location choice within GVCs by taking advantage of a unique database on China's processing trade regime for the period 1997-2008. Under this customs regime, firms located in China are granted duty exemptions on imported inputs *as long as they are used solely for export purposes*. By definition, the only firms that can take advantage of this regime locate in China for efficiency-seeking reasons, thus allowing us to focus on the determinants of offshoring location choice across Chinese provinces. Furthermore, for each Chinese province, the dataset provides information on the source country of foreign inputs used by its processing plants, as well as the destination country of the processed goods. This attribute allows us to generate a spatial mapping of trade flows (both intra-firm and at arm's length) between three sequential nodes of GVCs: the production location of processing inputs, the processing location in China, and the consumption location of processed goods.

We use the processing trade data to estimate whether a province's spatial proximity to international suppliers and international markets within GVCs affects its attractiveness as an offshoring location. We distinguish between the effects of three types of spatial linkages: (1) a province's distance to its closest seaport (*distance to port*); (2) the proximity of this seaport to international suppliers (*supplier access*); and (3) the vicinity of the seaport to international markets (*market access*). Our econometric analysis finds supporting evidence that all three types of spatial linkages affect offshoring location choice in China. A province's *distance to port* reduces its attractiveness as an offshoring location, while the port's *supplier access* and *market access* increases the amount of offshoring that gravitates to a province. These results are robust to the inclusion of a wide set of location-specific control variables, as well as to various robustness checks.

Our analysis has important implications for both business leaders and academics. For managers, it highlights the importance of considering the spatial organization of the entire value chain when deciding where to offshore manufacturing activities. For international business scholars, it provides new insights into the implications of semi-globalization on international strategy (Buckley and Ghauri, 2004; Ghemawat, 2003; Ricart, Enright, Ghemawat, Hart, & Khanna, 2004; Rugman and Verbeke, 2005).

HYPOTHESIS DEVELOPMENT

The rise of GVCs has profoundly affected the organization of international business (Baldwin, 2011). Thanks to reductions in communication, transportation and other trade barriers, many firms have sliced up their supply chains and have dispersed their production activities across multiple countries (*offshoring*). At the same time, they have outsourced large portions of their supply chain activities to external firms (*outsourcing*). As a result, the production process of numerous manufacturing goods now involves many firms that are located in various countries across the globe.

The complex configuration of GVCs has been documented for a number of electronics products. Using "teardown" reports from industry analysts, Dedrick, Kraemer, & Linden (2010), Kraemer, Linden, & Dedrick (2011) and Ali-Yrkkö, Rouvinen, Seppälä, & Ylä-Anttila (2011) have reconstructed the GVC structures of the Apple iPhone, the Apple iPod and for the Nokia N95 Smartphone, respectively. They find that Apple and Nokia have held on to high-value activities at the upstream (design) and downstream (marketing) ends of the value chain and have kept them in advanced economies. Conversely, they have outsourced low-value manufacturing activities in the middle of the value chain to external companies and these activities have been offshoring to various developing economies primarily in East Asia.[i]

The large spatial dispersion of tasks has generated a renewed interest in the determinants of location choice within GVCs (Beugelsdijk, Pedersen & Petersen, 2009; Beugelsdijk et al., 2010; Buckley and Ghauri, 2004). Contractor et al. (2010) and Mudambi & Venzin (2010) focus on the role of *organizational linkages* on offshoring location choice. The two studies consider the configuration of GVCs as a multidimensional strategy where a firm simultaneously chooses what to outsource and what to offshore. They show that the optimal location choice of a GVC task is therefore not only affected by comparative advantage forces, but is also influenced by its *organizational linkages* with other tasks within the same GVC. Jensen & Pedersen (2011) and

Liu, Feils, & Scholnick (2011) indicate that the role of organizational linkages on offshoring location choice is moderated by the characteristics of a task.

Less attention, however, has been paid to the role of *spatial linkages* with other GVC activities on the optimal location of a task (Beugelsdijk et al., 2010). This is perhaps surprising given the recent focus in the field of international business field on semi-globalization and its impact on international strategy (Buckley and Ghauri, 2004; Ghemawat, 2003; Ricart et al., 2004; Rugman and Verbeke, 2005).

The aim of this paper is to investigate whether spatial linkages between GVC activities affect a firm’s choice in deciding where to locate a manufacturing activity. To set up our research design, we in this section review the traditional location-specific drivers of offshoring location choice in manufacturing as identified by the existing literature. Furthermore, we review how spatial linkages should affect the offshoring location choice. The literature review will lead to our two research hypotheses.

Location-specific factors

The international business literature has identified a number of location-specific variables that drive a firm’s offshoring location choice. The first is labor costs, which is generally cited as the principal motive for firms to offshore manufacturing activities, and especially to labor-abundant countries such as China (Farrell, 2005; Lewin, 2005). According to Banister & Cook (2011), hourly compensation costs in China’s manufacturing is only 4 percent of those in the United States in 2008, thus creating an important incentive for firms to arbitrage labor cost differences by offshoring to China.

Another factor affecting the offshoring location choice may be the availability of human capital (Bunyaratavej, Hahn & Doh, 2007; Farrell & Grant, 2005; Graf & Mudambi, 2005; Jensen & Pedersen, 2011). Access to better educated and trained personnel should be necessary for firms to manage their offshoring activities, and to coordinate them with other GVC stages. Furthermore, human capital should be an important input for firms specializing in more sophisticated offshoring activities.[ii]

Accessibility to local suppliers should also enhance a location's attractiveness as an offshoring destination. It should allow firms to save on transport costs and costly delays, therefore reducing production costs and increasing flexibility. Furthermore, it can lead to important factor market externalities and technology spillovers (Ellison, Glaeser & Kerr, 2010). Accessibility to local suppliers has been found to be a strong driver for a firm's FDI location decision (Fontagné & Mayer, 2005). Amiti & Javorcik (2008), for example, find that intra-provincial supplier access is among the most important determinants of multinational firms' FDI location choice in China.

The quality of a location's transportation infrastructure should also improve the attractiveness of an offshoring location, by enhancing a firm's ability to rapidly and cheaply link with other GVC stages (World Trade Organization, 2011). Holl (2004) finds that access to good transportation infrastructure in Spain plays an important role in manufacturing plant location. Gamberoni et al. (2010) show that a location's ability to export on time is at least an as important source for comparative advantage as factor costs in the export of intermediate goods.

Offshoring location choice should depend on a location's institutional quality as well (Liu, Feils & Scholnick, 2011). Locations with a good governance infrastructure that strengthens the freedom of transaction, secures property rights and ensures transparency in government and legal processes should improve the attractiveness of doing business in the location (Globerman & Shapiro, 2003).

In sum, there are a variety of sources of location-specific variables that may improve a location's attractiveness as an offshoring destination. This leads to our hypothesis 1:

Hypothesis 1: *Ceteris paribus, (i) lower wages, (ii) a larger share of educated workers, (iii) a better access to local suppliers, (iv) a superior transportation infrastructure, and (v) a better governance increases the number of offshoring activities that will gravitate to that location.*

Spatial linkages

A key insight from the New Economic Geography (NEG) literature is that spatial linkages may also affect a firm's offshoring location choice. Krugman & Venables (1995) show that since spatial interactions are costly due to trade costs, firms should try to save on these trade costs by locating their production activities in the proximity of their upstream suppliers and downstream markets. They use this argument to explain the high regional concentration of manufacturing activity around the world. Amiti (2005) and Baldwin & Venables (2011) build on this reasoning to show that the tension between comparative advantage and agglomeration forces lies at the heart of location decisions in GVCs. While comparative advantage forces (i.e. location-specific variables) might entice firms to offshore an activity to the location that has the lowest production costs, trade costs moderate this effect and can induce firms to keep the activity closer to other GVC activities. This leads to the following hypothesis:

Hypothesis 2: *Ceteris paribus, the closer a location is to (i) international upstream suppliers and (ii) international downstream markets, the larger the number of offshoring activities that will gravitate to that location.*

To our knowledge, no empirical studies have directly tested this hypothesis in the context of GVC. Rugman, Li, & Oh (2009) find that multinational firms' assets are distributed regionally rather than globally, yet it is unclear if these assets are all part of the same GVC. Hanson et al. (2005) show that distance is an important determinant of U.S. firms' decisions in which foreign subsidiary to process their goods. And Defever (2011) shows that, after controlling for location-specific characteristics, proximity to other subsidiaries positively affects a firm's location choice. However, a downside of these studies is that they solely focus on the location of activities within the same multinational firm. This gives an incomplete and potentially biased picture of the spatial organization of GVCs since many multinationals outsource a large portion of their manufacturing activities to external firms (Mudambi, 2008).

PROCESSING TRADE REGIME

In this paper, we exploit a unique dataset that allows us to measure the amount of offshoring in various locations that occur both at arm's length and intra-firm. Specifically, we use a data set collected by the *General Administration of Customs of the People's Republic of China* on China's processing trade regime. Under this regime, firms located in China are granted duty exemptions on imported raw materials and other inputs as long as they are used solely for export purposes.

The processing trade data has a number of advantages. First, firms can only use the regime if they locate a processing activity in China for efficiency-seeking (vertical) reasons. Indeed, by definition, processing plants may not sell any output on the Chinese market, thus ruling out market-seeking (horizontal) motives for locating processing activities in China. Furthermore, since processing plants need to export all their output, a province's exports value equals the total sales value of processing activities in the province. These characteristics of the dataset imply that we can use the value of processing exports by a province as a proxy for the amount of offshoring activities that are located in the province.

Second, the processing trade data not only captures offshoring activities conducted by subsidiaries of multinational firms, but also those that have been outsourced to external firms. Indeed, the dataset captures the universe of international trade activities conducted by processing plants in China, both intra-firm and at arm's length. As we have explained above, this characteristic allows us to obtain a more accurate spatial mapping of activities within GVCs.

Third, for each province, the dataset provides the source countries of processing inputs, as well as the destination countries of processing exports. These attributes allow us to estimate the spatial linkage of each province's processing activities with both its upstream international suppliers and with its downstream international markets within GVCs.[iii]

Finally, the dataset allows us to study the role of spatial linkages on offshoring location choice by investigating variations in offshoring activity across Chinese provinces. This provides us with a controlled environment that rules out effects of country-wide macro-economic shocks such as exchange rate movements, country risk, trade policy etc. on offshoring location choice. Furthermore, the relatively large cultural homogeneity across Chinese provinces naturally controls for the role of cultural differences.

Characteristics of China's processing trade

China's processing trade regime is an important driver of the country's overall trade performance. Between 1997 and 2008 the share of processing exports in China's total manufacturing exports has fluctuated between 48% and 60%, while the share of processing imports in total imports has hovered around 45%. In other words, about half of China's international trade in manufacturing is related to offshoring activities within GVCs.

Two characteristics illustrate the high level of integration of processing plants in GVCs. First, the processing plants in China heavily rely on imported inputs to produce their exports. Koopman, Wang & Wei (2008) estimate that, in 2006, the domestic content share of processing exports in manufacturing was merely 11.7%, implying that imported inputs accounted for 88.3% of the processing export value. As a comparison, the domestic content share of non-processing exports in manufacturing stood at a much higher 82.3% of the export value.

Second, processing exports are predominantly conducted by foreign-invested enterprises (FIEs).[iv] Between 1997 and 2008, the share of processing exports conducted by FIEs has increased from 64% in 1997 to 85% in 2008 (see Figure 1). In contrast, FIEs' share of non-processing exports has consistently remained below 30%.

[Figure 1 about here]

To analyze the role of spatial linkages on offshoring location choice, it is instructive to analyze the geographical patterns of processing trade. To investigate this, however, it is important to first correct for an important bias in the data. While Hong Kong is China's most important trade partner, most processing trade with Hong Kong consists of re-exports through the administrative region. This can significantly affect the analysis since it biases the *true* source country of processing inputs and the *true* destination country of processing exports that are shipped through Hong Kong. To estimate the true country of origin of processing imports re-exported through Hong Kong and the true destination country of processing exports re-exported through Hong Kong, we link the processing trade data to a data set from the *Hong Kong Census and Statistical Office* on Hong Kong re-exports and use a procedure developed by Ma, Van Assche & Hong (2009). All data presented in the paper are adjusted for Hong Kong re-exports.

The adjusted data illustrate a clear triangular trade pattern in China's processing trade. On the one hand, China heavily sources its foreign inputs from its neighboring East Asian countries, with 78% of processing imports in manufacturing originating from within East Asia in 2007 (left-panel of Table 1). On the other hand, the majority of processing exports are destined to the West, with the share of processing exports destined to Western countries rising to 58% in 2007 (right-panel of Table 1). Ma & Van Assche (2010) provide econometric evidence that this is indeed due to the importance of trade costs within GVCs.

[Table 1 about here]

Variations across provinces

The aggregate patterns hide important variations in processing exports across provinces. Figure 2 shows that the three coastal provinces Guangdong, Jiangsu and Shanghai are responsible for more than three quarters of China's processing exports in 2007, while the share of internal provinces is negligible. This suggests that a province's distance to a seaport may affect its attractiveness as a processing location.

[Figure 2 about here]

Across seaports, there is also an important variation in the composition of source countries for processing imports and destination countries for processing exports. To illustrate this, we have in figure 3 linked each province to its closest major seaport.[v]

[Figure 3 about here]

Table 2 shows that the three Northern seaports (Dalian, Tianjin and Qingdao) more intensively import processing inputs from Northeast Asia. All three ports receive more than 50% of their imports from Japan and Korea, which is higher than the share of China's overall imports sourced from this region. Conversely, the Southern seaports Shanghai, Xiamen and Shenzhen more intensively import processing inputs from South East Asia, with 40% or more of inputs sourced from this region.

[Table 2 about here]

On the export side, Northern ports export a larger portion of their processed goods within East Asia, while Southern ports export more intensively to the West (table 3).

[Table 3 about here]

These stylized facts suggest that firms' offshoring location choice may not only be affected by a province's distance to port, but also by the proximity of the seaport to international suppliers and the proximity of the seaport to international markets. In testing our hypothesis 2, we will therefore divide a province's distance to international suppliers into two components: the domestic distance to its closest seaport (*distance to port*) and the international distance from the port to the international suppliers. Similarly, we will divide a province's distance to international markets into the domestic *distance to port* and the international distance from the port to international markets.

DATA AND METHODOLOGY

To analyze the impact of spatial linkages on offshoring location choice in China, we estimate the following log-linear model:

$$ln(X_{it}) = a + b_1 ln(Pdist_i) + b_2 ln(SA_{it}) + b_3 ln(MA_{it}) + Z_{it}B + u_{it}, \quad (1)$$

where $ln(X_{it})$ denotes the natural log level of processing exports by province *i* in year *t*; $ln(Pdist_i)$ is the natural log of a province *i*'s distance to its closest major seaport; $ln(SA_{it})$ is the proximity of the seaport used by province *i* to upsteam international suppliers (i.e. supplier access); $ln(MA_{it})$ is the proximity of the seaport used by province *i* to downstream international markets (i.e. market access); Z_{it} is a vector of location-specific control variables; and u_{it} is a stochastic error.

In our analysis, we include all first level administrative divisions in Mainland China except Tibet, which has very little processing exports and Chongqing, which only became a directly administered city in 1997, and for which data only became available in 2001. This gives us 29 locations comprising 26 provinces and 3 directly administered cities. Throughout the paper, we refer to all these administrative divisions as provinces.

In this section, we provide an overview of our measures of spatial linkages and location-specific variables. We list all our data sources in appendix 1, and present summary statistics in Table 4.

[Table 4 about here]

Spatial linkages

Distance to port. A province's access to international suppliers and international markets depends on the internal trade costs within China. A province that is located further from a major Chinese seaport should face additional trade costs to transport its goods to and from the port, thus reducing its attractiveness as an offshoring location. To estimate *distance to port*, we use Google Maps to calculate the shortest driving distance between a province's capital and its closest major Chinese seaport.

Supplier access. To measure the proximity of a province's seaport to international suppliers, we rely on a theory-consistent econometric procedure pioneered by Redding & Venables (2004). The microeconomic foundations for the procedure are derived from a theoretical trade-and-geography model and the empirical application has been used widely in the fields of international economics and economic geography.[vi] The theoretical model can be applied straightforwardly to the setting of processing locations in China (Ma, 2006), and we therefore do not replicate the theoretical model in this paper. Following Redding & Venables (2004) we will call the proximity of a province's seaport to international suppliers "supplier access".

Supplier access is estimated in two steps. In the first step, for each year between 1997-2008 we estimate a standard log-linear gravity equation on the log of a Chinese province *i*'s bilateral processing imports from source country j, $ln(M_{ij})$:

$$ln(M_{ij}) = \alpha + \beta_j ctry_j + \gamma_i prov_i + \delta ln(dist_{ij}) + \varepsilon_{ij}, \quad (2)$$

where $ctry_j$ are country fixed effects; $prov_i$ are province fixed effects; $dist_{ij}$ reflects the distance along maritime routes between country *j* and the seaport closest to province *i*; and ε_{ij} is a stochastic error.

Our bilateral distance measure, $dist_{ij}$, is compiled from a dataset on maritime shipping maps from www.searates.com. This dataset provides the distance in nautical miles along maritime shipping routes from each of the six largest Chinese seaports to the largest ports of countries around the world, thus providing a more accurate proxy for transportation costs than the traditionally used measure of distance between capital cities.[vii]

Note that the specification of (2) is well-known to be more general than the standard gravity model in which country and province fixed effects would be replaced by country/province variables such as GDP per capita, population size, real wages, landlocked status and institutional features (Redding & Venables, 2004). The inclusion of province and country fixed effects is important to control for multilateral resistance (Baldwin & Taglioni, 2006; Feenstra, 2004).[viii]

From equation (2), the coefficient δ provides an estimate of the magnitude of the trade-cost frictions related to distance.[ix] Furthermore, the coefficient on the country dummy β_j determines the supplier capacity of country *j*, with a higher coefficient indicating that a country is a more important supplier of processing inputs to China.

In a second step, we use these estimated coefficients to compute a province's supplier access as the trade-cost weighted sum of its source countries' supplier capacities using the following formula:[x]

$$SA_{it} = \sum_j \left(exp(ctry_{jt})\right)^{\widehat{\beta}_{jt}} {dist_{ij}}^{\widehat{\delta}_t} \quad (3)$$

where $\left(exp(ctry_{jt})\right)^{\widehat{\beta}_{jt}}$ is the supplier capacity of country *j* in year *t*, and $dist_{ij}{}^{\widehat{\delta}_t}$ is the estimated bilateral trade cost between province *i* and country *j* in year *t*. From equation (3), provinces that are consistently closer to countries with large supplier capacities will therefore have a larger supplier access SA_{it}.

Market access. Redding & Venables (2004) propose a similar estimation procedure to measure a location's proximity to international markets, i.e. market access. In a first step, we estimate a yearly gravity equation on the log of a Chinese province *i*'s bilateral processing exports to country *j* , $ln(X_{ij})$:

$$ln(X_{ij}) = \zeta + \eta_j ctry_j + \theta_i prov_i + \vartheta ln(dist_{ij}) + \varepsilon_{ij} \qquad (4)$$

where $prov_i$ are province fixed effects; $ctry_j$ are country dummies; $dist_{ij}$ reflects the distance along maritime routes between the port through which province *i* exports and country *j*; and ε_{ij} is a stochastic error. The parameter estimate of the destination country dummy η_{jt} determines country *j*'s market capacity, while the distance coefficient ϑ estimates the trade-cost frictions related to distance.

Similar to the construction of the supplier access variable, the parameter estimates from equation (4) are in a second step used to define our market access as an appropriately distance-weighted measure of destination countries' market capacities using the following equation:

$$MA_{it} = \sum_j \left(exp(ctry_{jt})\right)^{\widehat{\eta}_{jt}} dist_{ij}{}^{\widehat{\vartheta}_t}. \qquad (5)$$

From equation (5), provinces that are consistently closer to countries with large market capacities will have a larger market access MA_{it}.

Location-specific variables

Local supplier access. The availability of local suppliers in a province plausibly should increase with the size and concentration of its economic activity. To measure local supplier access, we follow Amiti & Javorcik (2008) and Leamer (1997) in using the GDP share of a province *i* weighted by its circular area: $\frac{GDP_{it}}{GDP_{CHINA,t}} * \left(\frac{area_i}{\pi}\right)^{-1}$, where $GDP_{CHINA,t}$ is China's GDP in year *t*, $area_i$ is province *i*'s area in square kilometres, and π is a mathematical constant. Note that this measure, which we will call *distance-weighted GDP share,* is both an indicator of the size and of the density of economic activity in the province. Large and sparsely populated provinces will have a smaller local supplier access than small and densely populated provinces.

Government efficiency. We follow the methodology proposed by Cole, Eliott, & Zhang (2008) and Tang & Tang (2004a,b) to quantify the government efficiency of a province in each year. The government efficiency index aggregates 39 separate indicators that cover the quality of a province's public services, public goods, government size and national welfare (see appendix 3 for more details). A higher index number implies that a province has greater government efficiency.

Other variables. We use the *average wage of staff and workers in manufacturing* as a measure of unskilled labor costs in a province. To measure the abundance of skilled workers in a province, we use the *share of population with a secondary education*. To measure transportation infrastructure, we use the *number of river berths* and *number of sea berths* in a province.

RESULTS

The empirical results from our estimation of equation (1) are presented in Table 5. The natural log of processing exports by province *i* in year *t* is our dependent variable. Similar to other studies, we find that market access and supplier access are highly correlated within years, thus creating a collinearity problem (Amiti & Javorcik, 2008; Redding & Venables, 2004; Knaap, 2006). We therefore estimate the model separately for supplier access and market access. All specifications include year-fixed effects to control for macro supply-and-demand shocks that are common to all provinces. Moreover, all standard errors are clustered at the port-year level.[xi]

[Table 5 about here]

Since we use gravity equations to estimate supplier and market access, the residuals of these gravity equations may affect the residual in equation (1). As Head & Mayer (2006) point out, this invalidates the standard errors, but it has no impact on the estimated coefficient. To correct for this, we follow Redding & Venables (2004) and Fally, Paillacar, & Terra (2010) and use bootstrap to obtain unbiased confidence intervals. We present the OLS results in columns (1)-(3) of Table 5, and the bootstrap results in columns (4) and (5). We only discuss the bootstrap results, which are our preferred specifications.

The results generally confirm hypothesis 1. The positive and significant coefficient on the percent of the population with a secondary degree suggests that access to more educated personnel is necessary to successfully engage in offshoring activities. The positive and significant coefficient on a province's distance-weighted GDP share indicates that greater access to local suppliers increases the number of offshoring activities that gravitate to a location. A superior transportation infrastructure is also found to be an important driver of offshoring location choice, with the number of sea and river berths in a province positively affecting processing exports. Furthermore, we find that better-quality government efficiency positively affects the attractiveness of a province as an offshoring location.

The only counterintuitive result is that manufacturing wages negatively affect processing exports. While puzzling, this result is in line with the findings of other micro-data studies which show that firms seem insensitive to local wages in choosing a location for foreign investment (see Liu, Lovely & Ondrich, 2010 for an overview). It also follows Bunyaratavej, Hahn & Doh's (2007) finding that a country is more likely to be a destination of services offshoring as the average wage of a country increases. One reason for this result may be that average manufacturing wages do not take into account productivity effects. Wages are comparable only if labor productivity is properly controlled because high wages could either be a sign of expensive labor cost or an indicator of productive labor forces.

More importantly, our results confirm hypothesis 2. We find that distance to port, supplier access and market access all significantly affect offshoring location choice in China. The coefficient on the distance-to-port variable is negative and significant, suggesting that provinces located further from a major seaport are less attractive as offshoring locations. Furthermore, the coefficients on supplier access (column 4) and market access (column 5) are positive and significant (with the latter at the 10 percent level), implying that provinces that are closer to upstream suppliers and downstream markets are more attractive offshoring locations.

A potential problem with our estimates for market access is that it is likely to be endogenous. Specifically, a positive shock in a province's processing exports can plausibly affect the gravity coefficients in equation (4), thus affecting market access. To control for this, we use two different proxies for market access that should not be endogenous. First, we use market access in 1996, i.e. in the year before our sample period. The results are presented in column 1 of table 6. The initial-year proxy yields a positive coefficient for market access (once again at the 10 percent level), confirming that market access is a determinant of firms' offshoring location choice between Chinese provinces. Note that the coefficient is smaller than in the baseline OLS and bootstrap specifications.

[Table 6 about here]

Second, we follow Fally et al. (2010) and consider Harris' (1954) measure of market potential as an alternative proxy for market access. This measure is computed as the sum of the GDP of the countries *j* to which China exports processed goods to, weighted by the inverse of bilateral distance from the seaport closest to a province *i*: $\sum_j \frac{GDP_{jt}}{dist_{ij}}$. As is shown in column 2 of table 6, the coefficient on Harris Market Potential is positive and highly significant, confirming that market access affects a province's attractiveness as an offshoring location.

In sum, our results suggest that spatial linkages are an important determinant of offshoring location across Chinese provinces. This result is robust to the inclusion of a wide set of location-specific control variables, robustness checks and alternative measures of market access.

CONCLUSION

In this paper, we have examined if spatial linkages with other activities within GVCs affects a firm's offshoring location choice. Using data from China's processing trade regime for 29 Chinese provinces between 1997 and 2008, we indeed find supporting evidence that three types of spatial linkages affect offshoring location choice in China: (1) a province's distance to a major Chinese seaport; (2) the seaport's proximity to international suppliers; and (3) the seaport's vicinity to international markets. These results are robust to the inclusion of a wide set of location-specific control variables, as well as to alternative measures of international market access.

These results have important implications for international business. They imply that while location-specific factors such as factor costs, governance and transportation infrastructure are important decision factors for choosing an offshoring location, managers should also consider the spatial organization of the entire value chain.

There are a number of limitations of our research that point to future research directions. First, we have conducted our analysis using aggregated processing manufacturing exports, which might hide important variations across industries. The spatial organization of GVCs may vary considerably across industries. A province such as Guangdong, for example, is known to specialize in the assembly of electronics products, while Jiangsu specializes in textiles (Long & Zhang, 2011). And similar agglomeration patterns may also occur in the production of processing inputs and the consumption of processed goods. In this paper, we did not conduct our analysis at the industry level since it is difficult to identify the input-output linkage of imported processing inputs and exported processed goods at the industry level in the processing trade data. A fruitful area for future work will be to verify the role of spatial linkages on offshoring location choice using more disaggregated datasets.

Second, while our analysis has provided new insights into the interaction between place (comparative advantage) and space (agglomeration) on location decisions within GVCs, data limitations have required us to ignore the impact of organization (ownership and control). This is limiting since the location decision of GVC activities is likely to depend on the interaction of all three factors (Beugelsdijk et al., 2010). Spatial linkages, for example, may be more important within firm boundaries than at arm's length, adding an additional dimension of complexity in a firm's offshoring location choice.

Appendix 1: Data sources

Variable	**Definition/Source**
Processing exports	Data from *China Custom Statistics* in US$, linked to Hong Kong re-exports data from *Hong Kong Census and Statistical Office.*
Distance	Maritime distance in nautical miles between Chinese seaport and port in destination country from www.searate.com
Distance to Port	Google map – driving distance in km between capital city of a province and its major seaport.
Wage	Average wage of staff and workers in manufacturing (yuan), from *China's Statistical Yearbook.*
% population with secondary degree	Secondary enrolment divided by population from *China's Statistical Yearbook*
# river berths	Number of river berths in a province, from *China Data Online*
# sea berths	Number of sea berths in a province from *China Data Online*
Distance-weighted GDP of a province	Data on Provincial GDP (yuan) and area (square km) from *China Statistical Yearbook*
Government efficiency	39 indices compiled from *China Statistical Yearbook* (see appendix 4 for more details)
Harris Market Potential	Data on countries' GDP from *World Development Indicators;* distance data from www.searates.com

Appendix 2: Estimation of supplier access and market access

This appendix presents the intermediate results needed to estimate market and supplier access. The table below shows the distance coefficients from estimating equations (2) and (4). The results show that the distance coefficient is generally larger for processing imports than processing exports.

Table: Distance coefficients, 1997-2008

	Processing Exports	Processing imports
1997	-0.2617**	-0.7127***
	[0.108]	[0.129]
1998	-0.2129**	-0.4536***
	[0.107]	[0.142]
1999	-0.2578**	-0.7378***
	[0.120]	[0.163]
2000	-0.2924***	-0.5424***
	[0.107]	[0.197]
2001	-0.3828***	-0.6180***
	[0.120]	[0.215]
2002	-0.4260***	-0.5756***
	[0.151]	[0.191]
2003	-0.3737**	-0.8485***
	[0.188]	[0.192]
2004	-0.3155*	-0.5527**
	[0.164]	[0.231]
2005	-0.6114***	-0.8390***
	[0.175]	[0.182]
2006	-0.4700***	-0.7552***
	[0.174]	[0.203]
2007	-0.3615**	-0.6600***
	[0.170]	[0.217]
2008	-0.3174*	-0.6451***
	[0.166]	[0.236]

Notes: Robust standard errors adjusted for region clusters are in parentheses. * means significant at 10%; ** means significant at 5%; *** means significant at 1%.

The next table ranks the major seaports by their supplier access and market access for the years 1997, 2002 and 2007. For supplier access, Xiamen has consistently ranked the highest and Tianjin the lowest. Shanghai and Shenzhen have seen their rank go up, at the expense of Qingdao and Dalian. For market access, Shanghai has consistently ranked the highest and Tianjin the lowest. Shenzhen has seen its rank go up at the expense of Qingdao and Dalian.

Table: Chinese ports' rank in supplier and market access, from high to low, various years

Rank	Supplier Access			Market Access		
	1997	2002	2007	1997	2002	2007
1	Xiamen	Xiamen	Xiamen	Shanghai	Shanghai	Shanghai
2	Qingdao	Shanghai	Shanghai	Xiamen	Xiamen	Xiamen
3	Shanghai	Shenzhen	Shenzhen	Qingdao	Qingdao	Shenzhen
4	Dalian	Qingdao	Qingdao	Dalian	Dalian	Qingdao
5	Shenzhen	Dalian	Dalian	Shenzhen	Shenzhen	Dalian
6	Tianjin	Tianjin	Tianjin	Tianjin	Tianjin	Tianjin

Authors' calculations.

Appendix 3: computation of government efficiency

To measure government efficiency, we follow Cole et al. (2009) and Tang & Tang (2004a,b) by first collecting the 39 indices listed in the table below from *China Statistical Yearbook*. Next, we used the following three steps to create the overall index of provincial government efficiency:

1. Each index is standardized using the following formula: $STD_{ij} = \frac{X_{ij}-\bar{X}_j}{S_j}$, where STD_{ij} is the standardized value of index *j* in province *i*, X_{ij} is the original value of the index *j* in province *i*, $\bar{X}$ is the mean value of *X*; S is the standard error of the mean.
2. The mean is used to average the STD values for each province within each sub-factor. The resulting STD value for each sub-factor is once again averaged, standardized, and normalized.
3. The weighted mean is then used to aggregate the sub-factors and each of the four factors. The weights of each sub-factor and factor follows Tang and Tang (2004b) and Cole et al. (2009) and are presented in the table below. This allows us to compute the aggregated STD values and corresponding ranks for our 29 provinces for the period 1997-2008.

Factors	Sub Factors	Indices
Government public services (17 indices, weight = 0.4)	Education, science & technology, culture, and public health services (11 indices, weight = 0.55)	1. Per capita government expenditures for science & technology promotion (*yuan*) 2. Rate of products with excellent quality (%) 3. Patent (inventions, utility models and design) applications granted (item/100,000 persons) 4. Per capita transaction value in technical market (*yuan*) 5. Inverse of student-teacher ratio of primary schools 6. Inverse of student-teacher ratio of secondary schools 7. Inverse of illiterate and semi-illiterate rate (%) 8. Share of government appropriation for education in GDP 9. Institutions for culture and art (unit/100,000 persons) 10. Beds in health institutions (unit/100,000 persons) 11. Employees in health institutions (person/100,000 persons)
	Public security services (2 indices, weight = 0.15)	12. accidents (traffic, fires, and pollution, case/100,000 persons) 13. Losses in accidents (*yuan*)
	Meteorological services (2 indices, weight = 0.15)	14. Agro-meteorological services stations (unit/100,000 persons) 15. Earthquake monitoring stations (unit/100,000 persons)
	Social security services (2 indices, weight = 0.15)	16. Urban community welfare facilities (unit/10,000 persons) 17. Rural social security network (unit/10,000 persons)
Government public goods (11 indices, weight = 0.3)	Social infrastructure (5 indices, weight = 0.5)	18. State budgetary appropriation in capital construction and innovation (100 million *yuan*) 19. Local-central government projects ratio of investment in capital construction and innovation (%) 20. Ratio of projects completed and put into use in capital construction and innovation (%) 21. Treatment efficiency of industrial wastewater, waste gas and solid wastes 22. Ratio of area of nature reserves and provincial area (%)
	City infrastructure (5 indices, weight = 0.5)	23. Rate of access to gas (%) 24. Public Transportation Vehicles per 10,000 persons in cities (unit) 25. Per capita area of paved roads (sq.m) 26. Per capita green area (sq.m) 27. Public toilets per 10,000 persons (unit)
Government Scale (5 indices, weight = 0.2)		28. Inverse of ratio of workers in government agencies and total pop. (person/10,000 persons) 29. Inverse of ratio of workers in government agencies and total employed persons (%) 30. Inverse of ratio of government consumption and final consumption (%) 31. Inverse of ratio of government expenditures and GDP (%) 32. Inverse of the share of penalty and confiscatory income and income from administrative fees in total government revenue.
National Scale (5 indices, weight = 0.1)		33. Per capita annual net income of rural households (*yuan*) 34. Per capita annual disposable income of urban households (*yuan*) 35. Inverse of Engle coefficients of rural households (%) 36. Inverse of Engle coefficients of urban households (%) 37. Inverse of CPI (preceding year = 100) 38. GDP per capita (*yuan*) 39. Ratio of expenditure on policy-related subsidies and government expenditure (%)

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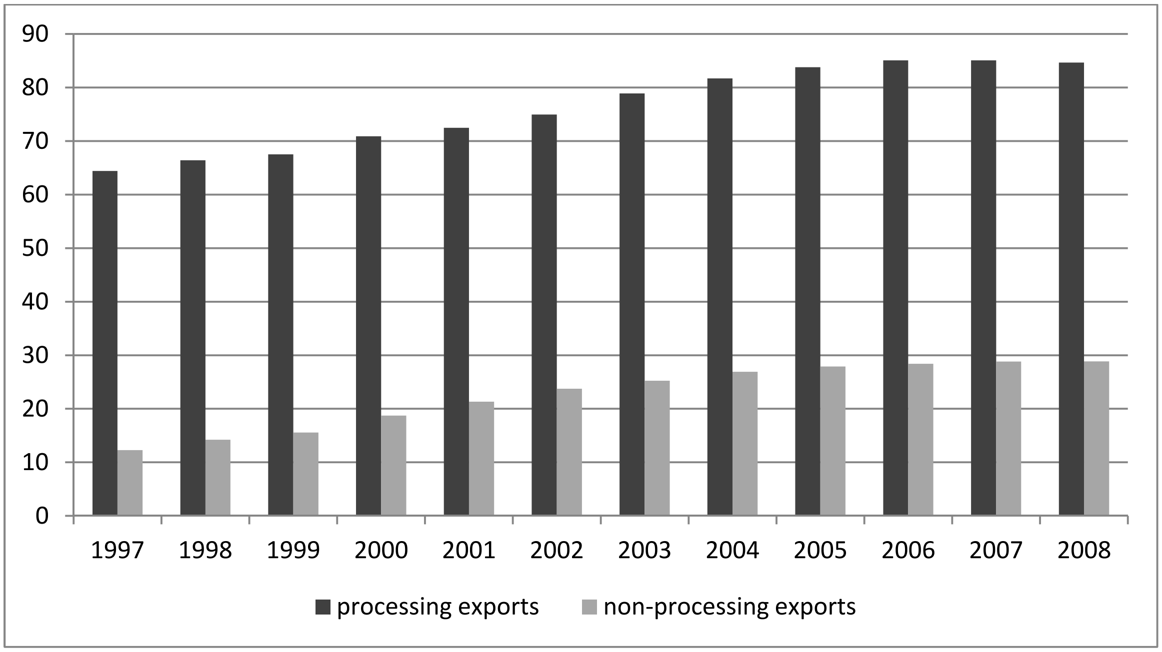
Figure 1

Share of China's manufacturing exports conducted by foreign-invested enterprises, 1997-2008



Source: authors' calculations, using China's Customs Statistics.

Figure 2

Share of processing trade in manufacturing by province, 2007

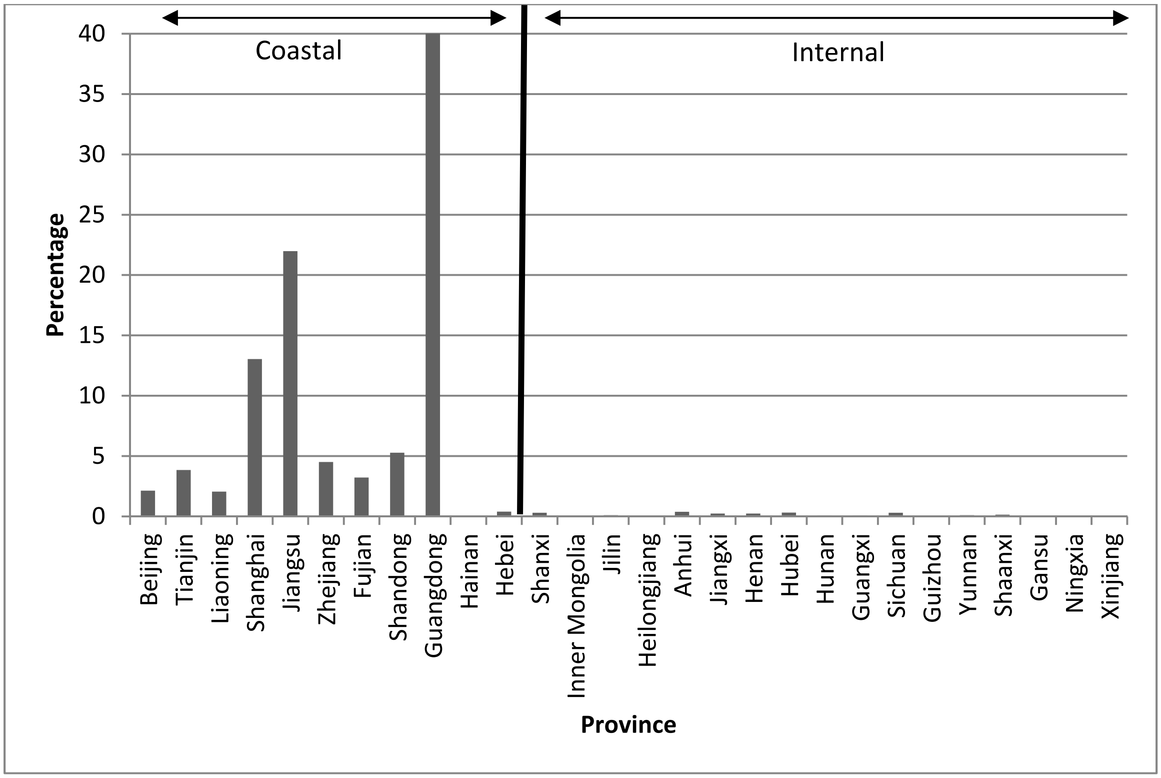


Figure 3

Identification of the six Chinese seaports and linkage with the provinces

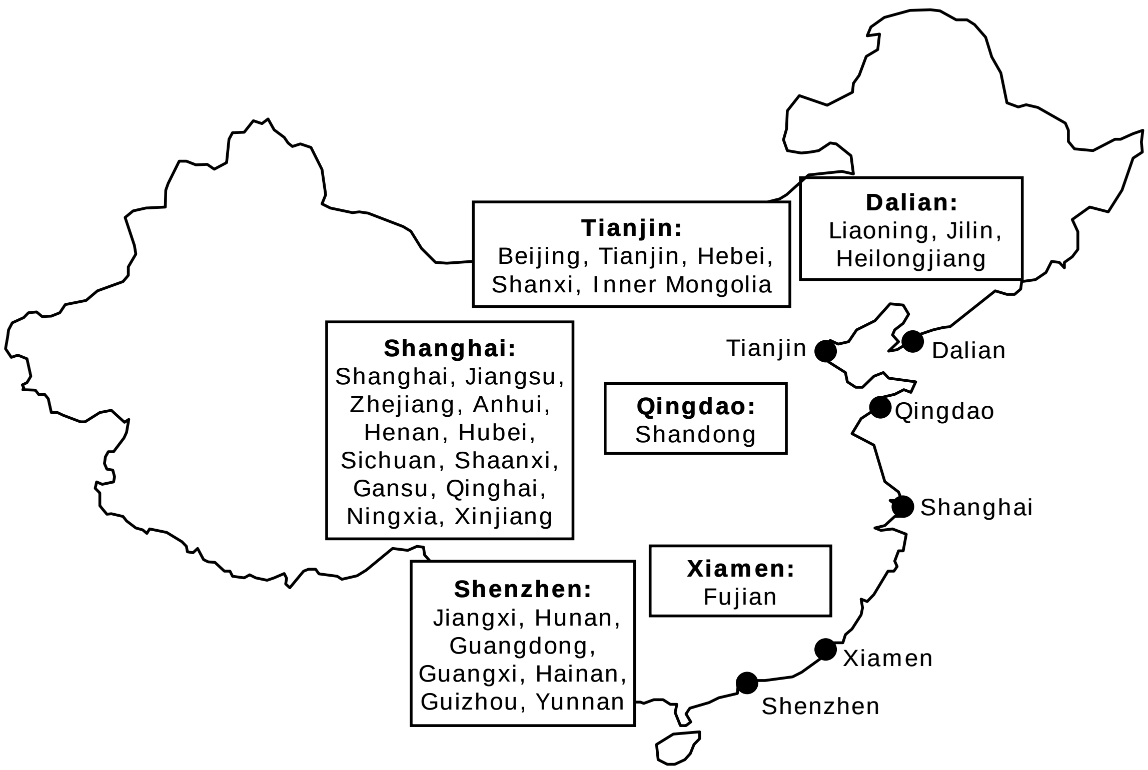


Table 1

The origin and destination of China's processing imports and exports

	Share of processing imports originating from (%)		Share of processing exports destined to (%)	
	1997	2007	1997	2007
East Asia	**72.1**	**77.6**	**34.9**	**28.8**
Japan	28.7	22.4	18.0	10.9
South Korea	16.0	16.5	5.0	5.0
Taiwan	18.1	21.6	2.2	2.4
Macau	0.4	0.3	0.6	0.3
ASEAN-10	8.8	16.9	9.1	10.1
West	**20.4**	**17.2**	**52.3**	**58.2**
United States	0.6	0.6	1.8	1.7
Canada	10.2	7.9	29.6	28.5
Mexico	0.2	0.3	0.4	1.2
EU-27	9.4	8.4	20.6	26.8
ROW	**7.5**	**5.2**	**12.8**	**13.0**

Authors' calculations using China's Customs Statistics Data. Data are adjusted for Hong Kong re-exports.

Table 2

Share of processing imports originating from a country/region, by major port, 2007

	Dalian	Tianjin	Qingdao	Shanghai	Xiamen	Shenzhen	Total
North East Asia	**66.7**	**52.1**	**61.4**	**38.1**	**28.4**	**34.8**	**38.9**
Japan	42.7	20.3	18.3	21.3	19.6	23.5	22.4
South Korea	24.0	31.8	43.1	16.8	8.9	11.2	16.5
South East Asia	**12.4**	**21.7**	**21.0**	**42.5**	**48.3**	**39.5**	**38.5**
Taiwan	4.2	10.0	5.4	23.6	36.4	23.0	21.6
ASEAN-10	8.2	11.7	15.6	19.0	12.0	16.5	16.9
West	**14.7**	**21.9**	**11.7**	**15.4**	**19.2**	**18.7**	**17.2**
NAFTA	5.8	10.7	7.2	8.3	9.2	9.4	8.8
EU-27	9.0	11.2	4.5	7.2	10.1	9.3	8.3
Rest of the World	6.2	4.3	5.9	3.9	4.0	7.0	5.5

Authors' calculations using China's Customs Statistics Data. Data are adjusted for Hong Kong re-exports.

Table 3

Share of processing export destined for a country/region, by major port, 2007

	Dalian	Tianjin	Qingdao	Shanghai	Xiamen	Shenzhen	Total
North East Asia	**42.3**	**16.7**	**28.7**	**15.9**	**23.8**	**12.2**	**15.9**
Japan	31.0	8.9	11.2	11.4	21.0	8.8	10.9
South Korea	11.2	7.8	17.4	4.4	2.8	3.3	5.0
South East Asia	**15.6**	**14.7**	**6.2**	**12.2**	**8.8**	**13.4**	**12.5**
Taiwan	1.1	1.7	0.7	3.1	2.1	2.2	2.4
ASEAN-10	14.5	13.1	5.5	9.1	6.6	11.2	10.1
West	**29.7**	**49.1**	**48.4**	**59.5**	**56.6**	**61.3**	**58.2**
NAFTA	15.0	24.5	27.8	30.8	33.5	34.0	31.3
EU-27	14.7	24.7	20.5	28.6	23.1	27.3	26.9
Rest of the World	12.4	19.4	16.7	12.5	10.8	13.1	13.4

Authors' calculations using China's Customs Statistics Data. Data are adjusted for Hong Kong re-exports.

Table 4

Summary Statistics, 1997-2008

Variable	No. obs.	Mean	Standard dev.	Minimum	Maximum
Ln(processing exports)	347	20.54	2.26	13.56	26.25
Ln(supplier access)	347	2.94	1.40	1.19	5.95
Ln(market access)	347	4.90	1.22	1.73	6.38
Ln(distance to port)	347	2.49	1.71	0.00	4.87
Ln(distance-weighted GDP share)	347	4.69	1.25	1.89	7.01
Share of pop. with sec. education	347	6.46	1.59	0.27	11.94
Government efficiency	347	0.09	2.02	-6.88	7.37
Ln(# river berths)	347	0.94	1.99	0.00	7.69
Ln(# sea berths)	347	1.38	2.11	0.00	6.56

Table 5

Regression results, 1997-2008

Dependent variable: log of processing exports by province *i* in year *t*					
		OLS		Bootstrap	
	(1)	(2)	(3)	(4)	(5)
Ln(supplier access)		2.12**		2.12**	
		[0.73]		[0.96]	
Ln(market access)			3.91*		3.91†
			[1.79]		[2.28]
Ln(distance to port)	-0.39***	-0.38***	-0.40***	-0.38***	-0.40***
	[0.06]	[0.05]	[0.06]	[0.05]	[0.06]
Ln(distance-weighted GDP share)	0.65***	0.68***	0.67***	0.68***	0.67***
	[0.08]	[0.08]	[0.08]	[0.08]	[0.08]
Ln(wage)	1.18***	1.15***	1.14***	1.15**	1.14**
	[0.30]	[0.30]	[0.30]	[0.34]	[0.34]
% population with secondary degree	0.09**	0.08**	0.08**	0.08**	0.08**
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Government efficiency	0.19***	0.18***	0.18***	0.18***	0.18***
	[0.03]	[0.03]	[0.04]	[0.03]	[0.03]
Ln(# river berths)	0.07***	0.04*	0.05**	0.04*	0.05*
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
Ln(# sea berths)	0.15***	0.15***	0.14***	0.15***	0.14***
	[0.04]	[0.03]	[0.04]	[0.03]	[0.04]
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	347	347	347	347	347
R^2	0.84	0.84	0.84	0.84	0.84

Notes: Coefficients are reported with standard errors robust to heteroskedasticity that are clustered by year-port. In Columns (1)-(3), we present OLS estimates. In columns (4) and (5) we use bootstrap. ***, **, * and † denote significance at the 0.1%, 1%, 5% and 10% levels, respectively. Coefficients on constant and year fixed effects not reported.

Table 6

Regression results with alternative measures for market access, 1997-2008

Dependent variable: log of processing exports by province *i* in year *t*		
	(1)	(2)
Ln(market access, 1996)	2.28†	
	[1.26]	
Ln(Harris market potential)		1.09***
		[0.11]
Ln(distance to port)	-0.40***	-0.37***
	[0.06]	[0.06]
Ln(distance-weighted GDP share)	0.68***	0.55***
	[0.08]	[0.06]
Ln(wage)	1.15***	1.39***
	[0.32]	[0.32]
% population with secondary degree	0.09**	0.08**
	[0.03]	[0.03]
Government efficiency	0.18***	0.19***
	[0.04]	[0.03]
Ln(# river berths)	0.05**	0.06**
	[0.02]	[0.02]
Ln(# sea berths)	0.14***	0.17***
	[0.04]	[0.04]
Year fixed effects	Yes	Yes
Observations	347	347
R^2	0.84	0.86

Notes: Coefficients are reported with robust standard errors. The standard errors are clustered by year-port. ***, **, * and † denote significance at the 0.1%, 1%, 5% and 10% levels, respectively. Coefficients on constant and year fixed effects not reported.

[i] Mudambi (2008) refers to this as the smile of value creation.
[ii] This argument has recently been backed up by theoretical work by Costinot (2009) that shows that more educated workers are complementary sources of traditional comparative advantage forces in complex industries.
[iii] Such mapping of GVCs cannot be conducted with regular international trade data since imports are not necessarily used solely for export purposes, but can also be consumed domestically.
[iv] Foreign-invested enterprises include wholly foreign-owned enterprises, Sino-foreign contractual joint ventures with more than 25% foreign ownership, and Sino-foreign equity joint ventures with more than 25% foreign ownership. Note that in China's Customs Statistics, companies from Hong Kong, Macau and Taiwan are considered foreign firms.
[v] To identify the ports, we have solely considered seaports that the American Association of Port Authorities lists among the 25 busiest ports in 2009. We have dropped Guangzhou and Ningbo due to their proximity to Shenzhen and Shanghai, respectively. Provinces were linked to their nearest large seaport.
[vi] Numerous studies have used Redding & Venables' (2004) estimation procedure to analyze the impact of a country's market access and supplier access on wages (see Redding, 2010 for an overview). Recently, a number of studies have used it to analyze the role of supplier access and market access on a firm's FDI locational choice. (Head & Mayer, 2004; Mayer, Méjean & Nefussi, 2010).
[vii] Since the dataset from searates.com only provides the distances between major seaports, we were required to exclude land-locked countries from our analysis. This is at a relatively low loss of generality since our sample accounts for more than 95% of China's processing exports and processing imports, respectively.
[viii] The multilateral resistance term takes into account that bilateral trade flows not only depend on the bilateral trade costs between the home and host country, but also on the average trade costs across all other countries.
[ix] For completeness, we present the estimated distance coefficients in appendix 3.
[x] The specific functional form of equation (3) is derived from Redding & Venables (2004) theoretical model.
[xi] Since the supplier and market access variables vary by port rather than province, clustering is done at the port-year level.