The Impact of Trade Costs on Horizontal and Vertical FDI Locations—Evidence from Taiwanese FDI in China

Chinchih Chen*
London School of Economics

December 2014

Abstract

This paper investigates the impact of trade costs on the pattern of foreign direct investment (FDI). I aim at providing new empirical evidence on the relative effect of trade costs on the location choices between horizontal and vertical FDI. The paper exploits a novel source of data, a panel dataset of Taiwanese public-listed firms' affiliates in Chinese provinces with detail information on location, ownership, and four-digit ISIC Rev.4 between 2002 and 2011. I identify each affiliates as a horizontal or vertical FDI on the basis of the input-output linkage of each parent-affiliate industry pair. By using the fixed effects estimator, the results show a negative and significant impact on the number of new vertical FDI relative to the horizontal FDI.

JEL: F23 F14

Keywords: foreign direct investment, horizontal and vertical FDI, trade cost

* Contact: Department of Geography and Environment, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK. E-mail: c.chen1@lse.ac.uk

1. Introduction

What are the motivations that drive firms to establish their production facilities in foreign countries? Is it to save trade costs by serving the foreign market locally, or to take advantage of factor-price differentials, or both? The abundant theoretical literature studying the patterns of foreign direct investment (FDI) has identified two main types of FDI: horizontal and vertical FDI. With horizontal FDI, firms serve the foreign market by producing the final products locally to avoid trade costs, whereas with vertical FDI firms take advantage of cross-country factor cost differentials. Hence, the patterns of FDI have often been predicted on the basis of industry and country characteristics in which the affiliates are in operation. However, the main challenge in examining the casual relationship between the locations of FDI and the motivations explained by the theoretical models is to find an identification strategy that allows one to distinguish between horizontal and vertical FDI.

In this paper, I aim at investigating the relative impact of trade costs on horizontal and vertical FDI across industries. Since trade costs are recognized as one of the determinants in both horizontal and vertical FDI theoretical models, the understanding of their impact on different type of FDI is empirically relevant. Although there are abundant empirical studies on the impacts of other determinants, such as market access or factor cost differentials, on the patterns of FDI since 1990s, there are fewer studies on the relative impact of trade costs on the distribution of horizontal and vertical FDI activities. This might be due to limitations on data availability and methods to classify horizontal and vertical FDI. By exploiting unique firm-level data on Taiwanese public listed firms' affiliate in China during the period 2001 to 2011, I aim at providing solid empirical evidence to identify the causal effect of trade costs on the distribution of horizontal and vertical FDI across space.

Alfaro and Charlton (2009) point out that the challenges are mainly related to the need for high quality data. The data should include information on location, ownership, and intra-firm trade flows within multinational firms at the plant level. Due to data limitation, many empirical studies instead employ information on multinational activities at the industry level, such as the share of the affiliates' exports to the parent firm to total affiliates output, or aggregated FDI flows from balance-of–payments statistics as a proxy for foreign affiliate's activity. Empirical findings generally support the market access motive (horizontal FDI) while rejecting the low transport and factor costs motives (vertical FDI). For example, Brainard (1997) assessed the motivations of horizontal FDI by using U.S. trade data and affiliate sales data and found that higher trade costs reduce the affiliate's exports in favour of affiliate sales at the foreign market.

As the theoretical literature predicts (see Markusen, 1984; Helpman, 1984; Markusen & Venables, 2000; etc.), trade costs have different impacts on horizontal and vertical FDI locations. In the horizontal FDI model, given foreign market size, as trade costs between the host and home country increase, firms will prefer to establish foreign production facilities rather than exporting, with the aim of reducing trade costs. Instead, in the vertical FDI model, given the factor cost differentials, firms will chose to locate the production affiliates, which is part of the production processes, in the closer destinations in order to reduce the trade costs resulting from intra-firm trade. However, in the empirical literature, the use of bilateral geographical distance as a proxy for trade costs seems to provide inconclusive predictions on the patterns of FDI. For instance, Fajgelbaum et al. (2013) find that the estimates of trade costs have a significantly negative impact on horizontal FDI activities, which goes against the predictions of the horizontal FDI model[2]. The first contribution of this paper is to shed light on the role of trade costs on horizontal and vertical FDI locations by using panel data on Taiwanese firm-level FDI in Chinese provinces during the period from 2001 to 2011. The findings show that as the distance between Taiwan and the Chinese provinces increases, vertical FDI affiliates tend to locate relatively closer to the home country in comparison to the horizontal ones. These results provide solid support for theoretical predictions on the patterns of horizontal and vertical FDI locations.

Carr et al. (2001) examine the cross-country trade cost effects on the patterns of FDI[3]. Their empirical specification, however, separates the distance effect from the overall trade costs. This is because the sign of the distance variable is ambiguous due to the fact that distance is an element of both exports costs and investment and monitor costs (Carr et al., 2001). Recently, the empirical trade literature also suggests that geographical distance has cross-industry effects and can be at least decomposed into transaction and transport costs. For example, Cristea (2010) indicates that an

[2] Fajgelbaum et al. (2013) argue that these results could be rationalized in an extended version of the model with intermediate inputs. Irarrazabal et al. (2013) show that a negative coefficient on distance is consistent with a model of horizontal FDI when allowing for trade in intermediates goods.

[3] They assess the impact of bilateral trade costs between the host and home country on foreign affiliates sales. The trade costs effects include three estimates: host country trade costs, home country trade costs and the interaction between the host country trade costs and the endowment difference between home and host country.

industry with more relationship-specific investments tends to incur higher transaction costs than industries with few specific-relationship investments. Besides, Horrigan (2010) suggests that industries with higher value-weight ratio in air shipments can afford to trade goods in distant countries. This implies that the distance effect can be further decomposed to exploit the cross-industry variation on the patterns of FDI.

Since Taiwan and China share a common culture and the data on Taiwanese affiliates provides information at provincial level, I can eliminate country-invariant tariff as well as other intangible trade costs such as language or institutions, which are commonly considered as distance correlated costs. Hence, I can better identify the cross-industry distance effects on horizontal and vertical FDI locations. To the best of my knowledge, this has not been fully investigated in the literature. Based on the transaction and transport costs channels identified by Chen (2014), the second contribution of this paper is to provide solid empirical evidence of heterogeneous trade costs effects on the patterns of FDI across industries. The results show that vertical FDI affiliates are more sensitive to both transaction and transport costs channels than horizontal FDI.

The Taiwanese firm-level dataset provided by Taiwan Economics Journal (TEJ) is on the basis of Taiwanese public-listed firms' direct investments in China. It enables me to investigate the effect of trade costs on multinational activities comprehensively at a more disaggregated industry level. The TEJ dataset includes information on location, ownership, primary products and the parent firm's information for each affiliate. By employing this information, I identify more than 3,000 new multinational affiliates in 87 industries and 29 provinces during the period 2001-2011. This unique panel dataset on new FDI affiliates allows me not only to use fixed effects estimators to reduce industrial selection biases or control for unobserved provincial characteristics, but also to clearly assess the effect of trade costs on the new foreign affiliates. Thus, the potential biases resulting from the exit of foreign affiliates in the stock level data can be controlled for. In the data section, I also produce a number of checks to ensure that the data is representative of the full sample.

A limitation of this dataset is that it does not provide the affiliates' sales and intra-firm trade within multinational firms, which is a common way to distinguish horizontal and vertical FDI affiliates in the empirical literature (Brainard, 1997; Yeaple, 2003; Carr et al., 2001; etc.). Following Alfaro and Charlton (2009) and Fajgelbaum et al. (2013), I use a combination of four-digit International Standard

Industrial Classification Rev. 4 (ISIC Rev.4) industry-level information and U.S. Bureau Economic Analysis (BEA) 2002 Benchmark Input-Output Tables to distinguish horizontal and vertical FDI affiliates. In this paper I further break down vertical FDI into inter-and intra-industry vertical FDI based on Alfaro and Charlton's (2009) method. Inter-industry vertical FDI is defined when the parent firm and affiliate have different two-digit ISIC Rev. 4 code, while intra-industry vertical FDI pairs share the same two-digit but different three or four-digit codes.

Although both inter- and intra-industry affiliates are vertical in the sense that they are in industries that provide inputs to their parents firm, Alfaro and Charlton (2009) indicate that their findings derived from intra-industry FDI are not closely consistent with the standard vertical FDI theories, which emphasizes the factor cost differentials motive. They find that intra-industry vertical affiliates, which are mostly located in rich countries and in industries with proximate stage of production process to the parent firm, are less attracted by the host country's comparative advantage. Since trade costs are another important motive in the vertical FDI models, it is worth assessing whether trade costs have a different impact across inter-and intra-industry vertical FDI affiliates. Hence, the third contribution of this paper is to provide the empirical evidence of impact of the trade costs on the intra-industry vertical FDI for theoretical considerations.

The paper is organised as follows: Section 2 provides a discussion of the related theoretical and empirical literature on patterns of FDI. Section 3 describes the data and patterns of horizontal and vertical FDI. Section 4 presents the horizontal and vertical FDI patterns. Section 5 presents the empirical strategy and results. Section 6 offers concluding remarks.

2. Related Literature

A multinational firm is defined as "…an enterprise that controls and manages production establishments-plants-located in at least two countries establishes business enterprises in two or more countries." (Caves, 2007) Although the corporate structure of a multinational firm might be complex, it is generally defined by two types of entities, the parent and the affiliate. According to Antras and Yeaple (2013), parent firms are entities located in one country that control productive facilities, while affiliates are located in other countries. The control between the parent and the affiliate is associated with the ownership resulting from foreign direct investments.

The pattern of multinational activities has long been recognized to be complex, and there was no formal theory about the relationship between multinational firms' activities and host and home country characteristics until the 1980s. The very first general equilibrium model of FDI locations was built by embedding multinational firms' activities in trade theory. This theoretical framework focused on two types of multinationals' investments: horizontal FDI and vertical FDI.

According to the horizontal FDI model, multinationals arise because of the potential to save on transaction and trade costs, as a substitute for exports. When trade costs in the host country are low, a firm can undertake production at home and serve the host country market through exports. However, when trade costs are high, a firm becomes a multinational to undertake the same production both at home and abroad, and serve the foreign market by producing locally instead of exporting to it. This type of FDI is called horizontal because the multinational replicates a subset of its activities or production processes in another country. Hence, the arm's-length exports and horizontal FDI are two alternative ways to serve a foreign market. Firms with headquarters in the home country produce final goods in plants located in the home and host country to serve each market separately (see Markusen, 1984 and Markusen & Venables, 2000)

Firms engage in vertical FDI when they break the value-added chain in order to take advantage of international factor-price differentials. Firms engage in two activities: headquarter services and plants production. Headquarter activities are physical or human capital intensive, while plant activities are manual labour intensive. When there are no factor-price differences across countries, the activities of both the headquarters and plants are carried out in the domestic market. When factor prices differ across countries, firms become multinationals and split the activities of headquarters and plants. Firms locate their headquarters in a country that is relatively abundant in skilled labour and production plants in countries where unskilled labour is relatively abundant. Hence, intra-firm trade of inputs and FDI are complements. Helpman's (1984) model of multinational firms predicts that vertical multinational activities, i.e. maintain their headquarters in the home country and establish production plants in other countries, will increase as the relative factor endowment differences between the home and host countries increase.

The empirical evidence on patterns of FDI activity generally gives strong support to the predictions of the horizontal model. For example, Brainnard (1997) and Carr et al. (2001) show that FDI is high in countries with higher trade costs and low plant economies of scale, while the factor abundance has little impact on FDI locations. Their results support the horizontal investment model along with the market access motive, but reject the vertical FDI, which is motived by low trade costs and comparative advantage across countries.

In recent empirical investigations of vertical FDI, however, the comparative advantages considerations on multinational firms' location decisions are supported by, for example, Yeaple (2003) and Hanson et al. (2005). Alfaro and Charlton's (2009) findings, based on global firm-level data, show that in the more aggregated industrial level, vertical FDI will arise in countries where production factors are relatively cheap.

In the empirical literature on FDI location, it has been well documented that bilateral distance, as a proxy for trade costs, has consistent and negative effect on FDI location (Egger and Pfaffermayr, 2001; Keller & Yeaple, 2009; Mayer et al., 2010; etc.). However, there are only few further investigations on the relative distance effect on vertical and horizontal FDI. This is because the firm-level FDI data with detailed product information, production locations and intra-firm trade flows are difficult to acquire. Hence, the identification strategy to define vertical and horizontal FDI becomes the crucial empirical challenge. Egger (2008) employs US bilateral FDI stocks panel data at industry level to examine the distance-related effects on the distribution of US horizontal and vertical FDI. The results provide strong support for horizontal FDI models. However, in the empirical specification, the use of total FDI stocks as the outcome of interest cannot distinguish the horizontal and vertical FDI. Hence, it is not possible to identify the relative distance effect on horizontal and vertical FDI.

Alfaro and Charlton (2009) exploited the firm-level dataset provided by Dun & Bradstreet on global multinational activities. They establish a method to classify the relationship between the parent and the foreign affiliates into horizontal and vertical FDI by inferring from their products' input-output linkage. They also further define two sub-categories of the vertical FDI: inter- and intra-industry vertical FDI. Inter-industry vertical FDI is defined when the parent and affiliates are in different two-digit Standard Industrial Classification (SIC) codes, while intra-industry vertical FDI is defined when the parent and affiliates are in the same two-digit SIC codes but have different 3 or 4 digit codes. Their findings generally support the trade costs motive on vertical FDI locations, i.e., the negative coefficient on the bilateral distance variable. It is worth noticing that they present the results that intra-industry vertical affiliates tend to locate in richer countries, which contradict to theoretical predictions on factor price differentials. The findings indicate that not only the factor costs comparative advantage become insignificant, but also the magnitude of the coefficient on trade costs decreases. The explanations could be that intra-vertical FDI affiliates, which is in the same proximate production stage as the parent firm, are more likely to establish in the countries with better governance or better quality of contracting institutions[4]. However, they did not provide further results of the relative effect of trade costs on the inter- and intra-industry vertical FDI locations.

Even though trade costs are of theoretical importance, the empirical specification of trade costs is far from being direct and quantifiable. Bilateral distance is commonly used as a proxy for trade costs. The inverse distance is employed as a discount factor to measure region or country market access (Redding & Veneables, 2004; Amiti & Javorcik, 2008). Distance is also the important determinant of transport costs of goods shipments (Hummels, 2007). Moreover, in Mayer et al (2010), transaction costs, which are approximated by bilateral distances, languages and law origins, can be taken as one of the determinants of firms' choice of location. Fujita and Mori (2005) summarized that it is important to distinguish the two different types of impediment to trade in space, i.e. transport costs for goods, and communication costs for doing business over space.

[4] Nunn (2007) shows that countries with a poor contractual environment tend to specialize in industries in which relationship-specific investments are not important. The contracting institutions affect the patterns of trade through comparative advantage channel.

Furthermore, it has been argued that trade costs have heterogeneous effects on the distribution of economic activities across industries. Cristea (2011) indicates that exporting firms in the industry requiring specific-relationship investment, i.e. higher contract intensity, will face higher transaction costs. On the other hand, Harrigan (2010) claims that exporting firms in the industry with higher value-weight air shipments ratio, i.e. higher unit value intensity, will bear relative smaller ad-valorem transport costs than those in the lower value-weight ratio industry. Based on this literature trend, Chen (2014) created the contract intensity and the unit value intensity to measure the relative distance effect on FDI locations across industries. The empirical findings from Chen (2014) suggest that the higher the contract intensity (the higher requirement for relationship-specific investments), the higher the transaction costs. The parent firms tend to establish the foreign affiliate in the higher contract intensity industry in a closer location. On the other hand, the higher the unit value intensity (the higher value-weight ratio of air shipments), the lower the ad-valorem cost premium for the transport cost. Thus, the parent firms can afford to establish the foreign affiliates in the higher unit value intensity industries in the locations further away from the home country than lower ones.

In sum, the horizontal FDI model predicts that market access and trade costs are two major host country characteristics affecting horizontal FDI locations. The larger the market access, the stronger incentive the parent firm has to establish the foreign affiliate in order to serve the local market. Also, if the trade costs become higher, the parent firm will not serve foreign markets through exports but through local affiliates. On the other hand, the location characteristics conducive for vertical FDI differ from those for horizontal FDI and principally concentrate on factor price differentials and low trade costs. As the differences in factor prices increase between the home and host country, the parent firm is motivated to divide production into discrete processes and locate individual process in the country that provides the most favorable environment. Production fragmentation leads to intra-firm trade between headquarters and foreign affiliates. Hence, as trade costs decrease, the intra-firm trade flows increase. Therefore, based on the theoretical literature, this paper aims at providing empirical evidence on the relative importance of trade costs on the pattern of FDI locations by testing the following three hypotheses of related trade costs effects:

1) Trade costs – approximated by bilateral distance - have a negative impact on

the formation of new vertical FDI affiliates in comparison to the horizontal FDI;

2) With the same transaction or transport costs intensities, vertical FDI affiliates will be affected relatively more than horizontal FDI as the trade costs increase;
3) The negative impact of trade costs on intra-industry vertical FDI affiliates is smaller than inter-industry vertical FDI.

3. Data

3.1 Data sources

In this paper, I use three sources of data. In the first place, I use data on Taiwanese public listed firms' FDI in China, collected from the Taiwan Economic Journal (TEJ). TEJ collects the FDI information from firms' annual financial statements as well as FDI registration data from the Ministry of Economic Affairs (MOEA). The unit of foreign affiliates in TEJ dataset is the firm. It provides the business names, addresses, investment types, ownership, primary products, and the capital flow of these affiliates in China. Parent's primary industry code is recoded using Taiwanese industrial classification, which is based on four-digit ISIC Rev. 4 system. The affiliate's code is not reported, but can be filled in by using the information of affiliate's primary products. To be consistent with the empirical literature, I construct the dataset with both parent and affiliate being in the manufacturing sector during the period between 2001 and 2011. Combining the affiliate's name and location in China and MOEA's registration date, it is possible to identify the 3,023 new FDI affiliates spanning cross 87 four-digit ISIC Rev. 4 industries. This paper will use the number of new FDI affiliates as the dependent variable to investigate the impact of the distance at the extensive margin, i.e., more firms participate in multinational activities.

To validate the representative of TEJ data, I compare the number of new TEJ affiliates aggregated by year and province with information on Taiwanese FDI projects by the MOEA (see Figure 1-1 and 1-2). According to Taiwan's FDI regulations, both individuals' and firms' FDI projects in China have to be approved by MOEA, or register in MOEA if the amount of investment is under $200,000. Complete firm-level data is not available, but the MOEA provides monthly and annual reports on all registered/approved FDI projects in China with information covering 25 provinces/regions with two-digit ISIC Rev. 4 codes. However, MOEA's data is based on projects not affiliates. Figure 1 plots total number of FDI projects (by year and province) from the MOEA against total new affiliates (by year and province) in the TEJ data. The correlation between the two datasets is 0.81, suggesting that the cross-province and year distribution of Taiwanese multination activity in the TEJ data matches that in the MOEA registered data. Moreover, Figure 1-2 demonstrates that the two datasets are highly correlated in the cross year-province-two digit ISIC industry level.

In this paper, the major variables of interest are the trade costs between Taiwan and China. Due to data constraints on calculating precise cost measures, I employ the distance between Taiwan and capital city of each Chinese province as a proxy for trade costs[5]. The distance is calculated by using Google Earth.

Also, I include as main control variables, factor prices and agglomeration externalities at the Chinese provincial level. Data on wages and gross industry output are collected from the Chinese Statistical Yearbook. The market access of province j is the summation of: 1) distance discounted final consumption of all other provinces i, i ≠ j, and 2) province j's final consumption discounted by the radius of area. I also construct the market access with zero trade costs within province, i.e. the inversed intra-province distance equals to 1. Two market access measurements are highly correlated (0.71). Hence, considering the huge variation in the size of Chinese provinces (the standard deviation is 118,630.4), the radius intra-province distance is better to account for the ease of the access within each province by controlling the impact of geographic unit.). In the regression analysis, I also use the market access measurement with the zero trade costs (D_{ii}=1) intra-province distance as a sensitivity check. The estimated results are qualitatively consistent with signs and significance as the market access variable with the radius intra-province distance.

Finally, the Taiwanese industrial agglomeration data is collected from the MOEA's annual FDI reports. They provide the number of projects and amounts of FDI in twenty-five Chinese provinces/regions in twenty-three two-digit ISIC Rev.4 industries. I use the cumulated industrial FDI projects as the proxy for Taiwanese agglomeration in each province.

3.2 Horizontal and Vertical FDI

To investigate the patterns and the determinants of FDI locations, the ideal data should be able to distinguish horizontal and vertical FDI. However, it is difficult to have a clear-cut distinction. First of all, not all divisions of production stages can be neatly classified as horizontal or vertical. Secondly, the empirical study requires firm-level information on the sales and purchases of inputs by foreign affiliates.

[5] Distance is commonly used as a proxy for trade costs in the new economy geography or international trade literature. Disdier and Head (2008) provide a thorough evaluation of the distance effect on trades.

Furthermore, foreign affiliates' sales have to be categorised according to their destination: sales to local market, exports to home country, or exports to the third country. And the imported inputs of foreign affiliates need to be classified based on whether they are used for further reprocessing or for resale in the local market. However, detailed firm-level data with which to analyse the activities of multinational firms are not generally available.

Since the Taiwanese dataset does not provide intra-firm trade flows, which is used in the trade literature to identify the vertical FDI, Alfaro and Charlton's (2009) method is a feasible identification strategy to distinguish horizontal and vertical FDI affiliates by using firm ownership data and an input-output matrix. In Alfaro and Charlton's (2009) data, there was no intra-firm trade information to identify vertical and horizontal FDI. They solved this issue by inferring the intra-firm trade from information about the goods produced in the parent firm and foreign affiliates and the aggregate input-output linkage between these goods. As their dataset covered many countries and industries, they argued that this method should not cause concerns about the value of intra-firm trade being affected by transfer pricing. In addition, this method avoids the arbitrariness of classifications of products for the "intermediate" inputs or others. Therefore, this input-output linkage method is employed for the Taiwanese FDI data, which is disaggregated in finer industry level across Chinese provinces and years. Since Taiwanese FDI data is a panel dataset, I can even better control for other unobserved and time invariant provincial, industrial and province-industry characteristics in this empirical study.

According to U.S. input-output tables, horizontal FDI is defined when the activity of foreign affiliates is in the same industry of their parent, and vertical FDI when the activity of foreign affiliates is in the industries upstream from the parent industry. Foreign affiliates are neither vertical nor horizontal if they satisfy neither of these criteria, and if they satisfy both, they will be called complex FDI[6]. In this paper, I characterize the input-output links among industries using the direct requirements table from U.S. Bureau Economic Analysis (BEA) 2002 Benchmark Input-Output Tables. The observation in the table is a commodity-industry pair, and the direct requirements coefficient, d_{ij}, specifies the value of inputs from industry i needed to produce one dollar of output in industry j. The commodities and industries are defined

[6] Please see Alfaro and Charlton (2009) for detailed information.

using the BEA six-digit industry codes, which I can map into the 2007 NAICS classification. And then they are matched to the four-digit ISIC Rev. 4 assigned in the TEJ dataset by using the BEA concordances[7]. There are 130 manufacturing industries in the four-digit ISIC Rev. 4 classification. In this paper, as the literature suggested (Alfaro and Charlton, 2009 and Ramondo et al., 2012), the threshold of d_{ij} >0 is selected to determine the strength of the relationship required to assume that an affiliate is a supplier to this parent[8].

3.3 Transaction and Transport Costs Channels

Based on the methods established in Chen (2014), I reconstruct contract and unit value intensities for three-digit ISIC Rev. 4 codes to investigate the relative impact of transaction and transport costs on horizontal and vertical FDI locations.

As for contract intensity, which is first developed by Nunn (2007) and adopted by Chen (2014), the intensity equation is as following:

$$Contract\ Intensity\ 1 = \sum_j \theta_{ij} R_j^{neither}, \quad \theta_{ij} = \frac{u_{ij}}{u_i},$$

where u_{ij} denotes the value of input j used in industry i, and u_i denotes the total value of all inputs used in industry i. $R_j^{neither}$ is the proportion of input j that is neither sold on an organized exchange nor reference priced; and $R_j^{ref\,price}$ is the proportion of input j that is not sold on an organized exchange but is reference priced[9].

The top five contract intensive industries are: Manufacture of motor vehicles (ISIC 291), Manufacture of parts and accessories for motor vehicles (ISIC 293), Manufacture of bodies (coachwork) for motor vehicles, Manufacture of trailers and semi-trailers (ISIC 292), Manufacture of measuring, testing, navigating and control equipment, watches and clocks (ISIC 265) and Manufacture of irradiation, electromedical and electrotherapeutic equipment (ISIC 266). The least five intensive industries are: Manufacture of refined petroleum products (ISIC 192), Manufacture of basic precious and other non-ferrous metals (ISIC 242), Manufacture of basic

[7] The BEA provides following concordances tables: 2002 I-O industry code to 2002 NAICS, 2002 NAICS to NAICS 2007, and ISIC Rev. 4 to NAICS 2007. Based on the industry descriptions, the direct requirement coefficient is allocated to ISIC Rev. 4 from 2002 I-O industry code.

[8] I also use the BEA 2002 Total Requirement Table and choose various thresholds: 0.01, 0.001 and 0.005. Those results are qualitatively consistent across different thresholds.

[9] The details of data and methodology employed to create the contract intensity can be found in Nunn (2007).

chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms (ISIC 201), Casting of metal (ISIC 243) and Manufacture of other food products (ISIC 107).

As for the unit value intensity, which is first established by Chen (2014), the intensity is calculated in two steps.

First, I establish a product fixed effects estimation to acquire the estimated individual-specific error of each product *i*. And then, the unit value intensity of an industry *j* is measured as an average value of the estimated individual-specific error of product *i*, where product *i* is categorised into aggregated industry *j*. [10]

$$v_{ict} = \alpha_0 + \alpha_1 tariff_{ict} + \alpha_2 gdp_{ct} + v_c + v_t + v_i + \varepsilon_{ipt}$$

$$Unit\ Value\ Intensity_j = \frac{\sum_{i \in j} \hat{g}_i}{N_{i \in j}}$$

$$\hat{g}_i = \bar{v}_i - \bar{v}_c - \bar{v}_t - \hat{\alpha}_1 \overline{tariff_{ict}} + \hat{\alpha}_2 \overline{gdp_{ct}}$$

where v_{ict} is the unit value of product *i* in air shipments (f.o.b value-weight ratio) imported from country *c* in year *t*. Two time varying country or country-product characteristics are included: gdp_{ct} and $tariff_{ict}$. Besides, I also include country and time dummies to control for the unobservable time and country characteristics, which might cause the omitted variable bias on the estimate of unit value.

The top five unit value intense industries are: Manufacture of pharmaceuticals, medicinal chemical and botanical products (ISIC 210), Manufacture of other chemical products (ISIC 202), Manufacture of basic precious and other non-ferrous metals (ISIC 242), Manufacture of medical and dental instruments and supplies (ISIC 325), and Manufacture of man-made fibres (ISIC 203). The five least intensive industries are: Manufacture of furniture (ISIC 310), Manufacture of beverages (ISIC 110), Manufacture of plastics products (ISIC 222), Manufacture of products of wood, cork, straw and plaiting materials (ISIC 162), and Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness; dressing and dyeing of fur (ISIC 151). In short, these two intensity measurements can reflect heterogeneous industrial characteristics on transaction and transports costs.

[10] The product fixed effect estimator is derived from Harrigon (2010) and the data is provided by Hummels (2010). This dataset also includes the GDP and tariff data. The detail please see David Hummel's website: http://www.krannert.purdue.edu/faculty/hummelsd/datasets.asp

4. Patterns of Horizontal and Vertical FDI

By using the direct requirement coefficient matrix with the Taiwanese parent-affiliate industry pairs, I can describe the most frequent manufacturing parent-affiliate combinations. Table 1 shows that, out of all the manufacturing FDI affiliates in the data, 1,361 are vertical and 1,599 are horizontal at four-digit ISIC Rev. 4 level. In Table 2, the most common horizontal pair is Manufacturing Computer Components and Boards (ISIC 2610), and the second is Manufacture of Computers and Peripheral Equipment (ISIC 2620). On the other hand, Table 3 demonstrates that the most common vertical industry pair is Manufacturing of Computers and Peripheral Equipment (ISIC 2620) affiliates supplied by the Manufacturing of Computer Components and Boards (ISIC 2610). The second most common pair is Manufacturing of Computer Components and Boards (ISIC 2610) supplied by Manufacturing of Computers and Peripheral Equipment (ISIC 2620). The third most common pair is Manufacturing of Computer Components and Boards (ISIC 2610) supplied by Plastics Packaging Materials and Unlamented Film and Sheet Manufacturing (ISIC 2220). Those observations suggest that this approach captures mainly supply chain relationships.

The average value of the direct requirements coefficients in the I-O matrix is only 0.001, and 70 percent of the industry pairs do not have an input-output relationship. The direct requirements I-O table also shows that most industries require inputs from similar industries: the entries in the direct requirements matrix tend to be the largest on or near the diagonal. In the Taiwanese parent-affiliate data, the average direct requirements coefficients jump to 0.009 when the affiliate is upstream. This suggests that in the Taiwanese parent-affiliate data, the parent owns affiliates in similar industries and that these industries are important producers of intermediate inputs for each other.

A large share of these production chains linkages is unreported when the data are aggregated at the two-digit ISIC rather than the four-digit ISIC industry. That is, many parent-affiliate pairs operate in industries that share the same two-digit ISIC industry, but have different three and/or four-digit ISIC industries. Table 1 shows that, in two-digit aggregation level, only 780 affiliates are allocated as vertical FDI, while in four-digit level, there are 1,361 vertical FDI affiliates. About 40 percent of the vertical FDI observed is not visible at the two-digit level because only at finer levels of disaggregation it is clear that these foreign affiliates are in industries that produce inputs to their parents' products. Alfaro and Charlton (2009) argue that the distinction between vertical investments visible at the two- and four-digit level is more than of labeling: there are in fact different products, one being an input to the other. Hence, in this paper, the main results are made from using 4-digit ISIC Rev. 4 code to reduce the measurement bias.

Moreover, based on Alfaro and Charlton (2009) definition, I further distinguish the vertical FDI into inter-and intra-industry vertical FDI. Inter-industry vertical FDI is labeled when the parent and affiliate operate across two-digit ISIC codes, and intra-industry vertical when the parent and affiliate operate cross four-digit industry codes. According to the input-output linkages, I argue that the inter-industry vertical FDI has different motivations, product characteristics, and location determinants from intra-industry vertical FDI. This provides the opportunity for further investigations on the relative distance effect on inter-industry and intra-industry vertical FDI. For example, Manufacturing of Computers and Peripheral Equipment (ISIC 2620) affiliates supplied by the Manufacturing of Computer Components and Boards (ISIC 2610) are classified as intra-industry vertical FDI, while Manufacturing of Computer Components and Boards (ISIC 2610) supplied by Plastics Packaging Materials and Unlamented Film and Sheet Manufacturing (ISIC 2220) are as inter-industry vertical FDI. Figure 2 shows the parent-affiliate industry combinations for both inter- and inter-industry vertical FDI in the manufacturing sector (ISIC, 1010-3290). We can observe that intra-industry affiliates are, by construction, close to the diagonal line, whereas inter-industry FDI is more widely spread.

Industry characteristics differ among horizontal, inter-industry and intra-industry FDI. Table 4 shows that horizontal FDI affiliates are in industries with higher contract intensity than vertical ones, whereas there is no significant difference in unit value intensity between horizontal and vertical FDI. Host country characteristics of horizontal and vertical FDI also differ. Horizontal FDI, on average, are more likely to be found in distant locations. In Table 5, the average distance is still significantly different between inter-and intra-industry vertical FDI affiliates, while there is no significant difference in the factor costs motive (wages) and market access motive. It suggests that trade costs might still be a dominant determinate of vertical FDI locations. Figure 3-1 and 3-2 demonstrate that the bilateral distance has general negative effect on FDI locations.

5. Empirical Strategies and Results

5.1 Baseline Estimates

Following the empirical literature on FDI location (Egger 2008, Alfaro and Charlton, 2009, Mayer et al., 2010, etc.), I assess the importance of trade costs in the determination of horizontal and vertical patterns by running the following equation (1):

$$
\begin{aligned}
FDI_{spjt} = {} & \beta_0 + \beta_1 Distance_j \\
& + \beta_2 D\_VFDI_{sp} + \beta_3 Distance_j \times D\_VFDI_{sp} \\
& + \beta_4 Wage_{jt-1} + \beta_5 MarketAccess_{jt-1} \\
& + \beta_6 IndAgglomeration_{jt-1} + \beta_7 TaiAgglomeration_{jt-1} \\
& + \boldsymbol{\Theta X_{jt\text{-}1} D\_VFDI_{sp}} + \varepsilon_{spjt}
\end{aligned}
\qquad (1)
$$

where the subscript *s* indexes the industry of foreign affiliate, the subscript *p* indexes the industry of the parent firm, the subscript *j* indexes the Chinese province, and the subscript *t* indexes the time periods, which are from 2002 to 2011. The outcome of interest, FDI_{spjt}, is the measure of the multinational activities either classified as the logarithm of the number of new horizontal affiliates or vertical FDI affiliates in an affiliate-parent industry pair, *s-p*, in province *j* at year *t*. To examine the first hypothesis based on the vertical and horizontal FDI models, trade costs, market access motive and provincial factor prices are included. First, $Distance_j$, used as a proxy for the trade costs, is the logarithm of bilateral distance between Taipei (Taiwan) and the capital city of Chinese province j. $Wage_{jt-1}$ is the logarithm of average salaries of workers and staff in province *j* at year *t-1*. This is used to approximate the factor price differentials between Taiwan and Chinese provinces. $MarketAccess_{jt-1}$ is the logarithm of measure of local market size in province *j* at year *t-1*, defined in the previous section.

In addition, empirical evidence suggests that agglomeration externalities have significant impact on FDI location in Chinese provinces (e.g., Amiti and Javorcik, 2008, Debaere et al., 2010; Chang et al., 2014). Two agglomeration variables are included in order to control for these time varying provincial characteristics. $IndustryAgglomeration_{jt-1}$ is the logarithm of total gross industry outputs in province *j* at year $t-1$. This accounts for the positive externalities that an affiliate can benefit from locating in the province where it has larger supplier access. $TaiAgglomeration_{jt-1}$ is the logarithm of total cumulated FDI projects in province j at year $t-1$. Taiwanese agglomeration is likely to be a favorable factor in Taiwanese firms' location choices. The findings in FDI location literature (e.g., Belderbos, 2002; Debaere et al., 2010; Chang et al., 2014) suggest that for a newly entering firm, the agglomeration of Taiwanese affiliates in the host province demonstrates that the investment environment is favorable because of local information spillovers and lower investment risk.

D_VFDI_{sp} is the vertical FDI indicator, which equals one for the observations that are aggregated from vertical FDI affiliates, and zero for horizontal FDI. The interaction term, $Distance_j \times D\_VFDI_{sp}$, is the interaction of distance and an indicator variable. $\boldsymbol{X}_{jt-1}$ is the vector of provincial control variables in equation (1): $Wage_{jt-1}$, $MarketAccess_{jt-1}$, $IndustryAgglomeration_{jt-1}$, and $TaiAgglomeration_{jt-1}$. $\boldsymbol{X}_{jt-1} \times \boldsymbol{D\_VFDI}_{sp}$, which is the vector of interactions between control variables and the vertical FDI indicator, is included to control for all the additional effects of control variables on the patterns of vertical FDI.

The theoretical predictions suggest that in the vertical FDI sub-sample, a negative coefficient of the distance variable is expected. As provinces are closer to Taiwan, they will attract more vertical FDI projects because of lower trade costs given the similar provincial comparative advantage. On the other hand, in the horizontal FDI sub-sample, a positive coefficient is expected. As provinces are further away from Taiwan, they will attract more horizontal FDI projects because of higher trade costs given the similar size of market access.

Table 6 presents the main results of equation (1) using the ordinary least squares (OLS) estimator. In columns (1) and (2), I present the results using data at the four-digit level of aggregation (58 four-digit manufacturing industries) and information on the number of new horizontal FDI affiliates only. Columns (3) and (4), present the results for aggregated vertical FDI affiliates (63 four-digit manufacturing industries). Two specifications for each outcomes of interest are reported. The first specification regress the distance variable only, reported in columns (1) and (3). Columns (2) and (4) report the estimates from equation (1) including all controls. Overall, the coefficients of the variable of interest, $Distance_j$, show that trade costs have no expected impacts on horizontal and vertical FDI in both specifications. Since the distance variable is likely to be correlated with other unobserved provincial characteristics, such as cultures or institutions, the coefficient of distance variable might be biased. Also, the unobserved time and industrial characteristics are not controlled for. For example, some industries with highly fragmented production processes or higher share of intermediate inputs for producing final goods, such as computer, electronic and optical products or motor vehicles, may incline to agglomerate to benefit from better market or supply access than other industries in which raw materials are major inputs.

Columns (5) and (6) report the results for total FDI affiliates. To estimate the relative effect in trade costs on horizontal and vertical FDI affiliates' location decisions in the full FDI sample, vertical indicator and all its interaction terms with other repressors are included. The estimated coefficient of the distance interaction term, $Distance_j \times D\_VFDI_{sp}$, reveals the average change in the outcomes of interest arising from the types of FDI. With or without control variables, the estimates are positive but not significant, which is not in line with the theoretical predictions. This can be resulted from the same omitted variable bias faced in columns (1) to (4).

5.2 Horizontal vs. Vertical FDI

To reduce omitted variable as well as selection biases, I estimate equation (2) with industry and province-industry fixed effect estimators. The industry here is referred to affiliate's industry. There are two main unobserved affiliate's industry characteristics to control for. First, the cross-industry agglomerations effects have been considered as major determinants of FDI locations in China (see Amiti & Javorcik, 2008; Debaere et al., 2010; Chang et al., 2014). However, due to the data limitation, these agglomeration variables in 4-digit ISIC industry level are not available. In order to uncover their impacts on affiliate's locations, the 4-didgt ISIC industry fixed effects are at play.

Second, the unobserved specific industry-province characteristics, such as comparative advantages, might bias the estimation on vertical FDI location choices. For example, the interactions between the relative difference in skilled-labour intensity or knowledge capital across affiliate's industry and provincial factor endowments might affect the patterns of vertical FDI locations. Yeaple's (2003) and Alfaro and Charlton's (2009) results show that a skilled-labour intensive affiliate industry tends to be located more in the destinations with a relative abundant skilled labour force. Because of the data constraints on factor endowments in provincial level, the industry-province fixed effects estimator is used to reduce the omitted variables bias.

$$FDI_{spjt} = \beta_0 + \beta_1 D\_VFDI_{sp} + \beta_2 Distance_j \times D\_VFDI_{sp} \qquad (2)$$
$$+ \boldsymbol{\Phi X_{jt-1}} + \boldsymbol{\Theta X_{jt-1} D\_VFDI_{sp}}$$
$$+ v_{sj} \times D\_VFDI_{sp} + v_t \times D\_VFDI_{sp} + v_{sj} + v_t + \varepsilon_{spjt}$$

Columns (1) and (2) in Table 7 report the results estimated by using industry fixed effects estimator. Province and time dummies are also included. The estimate of interest in column (1) is not significant and with the positive sign. In column (2), after including additional time-varying provincial control variables, the estimate of interest is significant with the expected negative sign.

Columns (3) and (4) in Table 7 report respectively the results of estimated coefficients from equation (2) by running industry-province fixed effects estimator. The coefficient of distance interaction term in column (3) is negative but not significant. In column (4), the result shows that trade costs have an addition negative impact on vertical FDI locations in comparison to Horizontal FDI. Quantitatively, according to the estimates in column (4), if the distance between Taiwan and Chinese provinces increase by 10 percentage, the number of new vertical FDI decreases by 2.48 percentage comparing to horizontal FDI. This result supports the first hypothesis that vertical FDI affiliates locate in the destinations that are closer to the parent firm to save trade costs.

5.3 Transaction and Transport costs and Patterns of FDI locations

In this section, I further examine the impact of transaction and transport costs on locations of new FDI affiliates. According to the findings in Chen (2014), in the transaction costs channel, as bilateral distances increase, the contract intensive industries will invest less than less intensive ones. On the other hand, in the transport costs channel, industries with higher unit value intensity will tend to invest in locations relatively further away than less intensive ones. In equation (3), the estimated coefficients of the distance interaction terms, *Ln* $Distance_j \times$ *Contract* $intensity_s$ and *Ln* $Distance_j \times$ *Unit value* $intensity_s$, reveal the relative effects of distance on the location choices through transaction and transport cost channels across industries.

$$
\begin{aligned}
FDI_{spjt} = {} & \beta_0 + \beta_1 D\_VFDI_{sp} \\
& + \beta_2 Distance_j \times CI_s \times D\_VFDI_{sp} \\
& + \beta_3 Distance_j \times UVI_s \times D\_VFDI_{sp} \\
& + \boldsymbol{\Phi X_{jt-1}} + \boldsymbol{\Theta X_{jt-1} D\_VFDI}_{sp} \\
& + v_{sj} \times D\_VFDI_{sp} + v_t \times D\_VFDI_{sp} + v_{sj} + v_t + \mu_{sjt}
\end{aligned} \tag{3}
$$

In Table 8, I use the Taiwanese FDI affiliates' data aggregated to three-digit ISIC Rev. 4 level. Columns (1) and (2) report the results for horizontal FDI affiliates and vertical FDI respectively. As for vertical FDI, although the estimated coefficient of transaction costs channel has the expected negative sign and the estimate of the transport costs channel has the positive sign, there is no clear significant impact of transaction and transport costs on vertical FDI locations. In the horizontal sub-sample, the estimated coefficients of transaction costs channel is significant with a negative sign, and the coefficient of transport costs channel is with a positive sign but insignificant. The results are in contrast to the theoretical predictions that horizontal FDI affiliates in relative high contract intensity industry will tend to be located more in the further away destination to save trade costs. Similarly, the locations of horizontal affiliates being in the relative low unit value industry will tend to be further away from the parent frim. In general, we cannot distinguish the relative effects of trade costs on the patterns of FDI.

Next, I examine the relative impact of trade costs through these two channels on horizontal and vertical FDI affiliates. In equation (3), the estimated coefficients of the interaction terms with vertical FDI, $Distance_j \times CI_s \times D\_VFDI_{sp}$ and $Distance_j \times UVI_s \times D\_VFDI_{sp}$, reveal the average additional effects of being vertical FDI affiliates through each specific channel. Column (3) in Table 8 shows that, if vertical affiliates are in the contract intensive industries, the parent firms tend to choose the locations relatively closer in comparison to horizontal FDI affiliates with the same intensity. If horizontal and vertical FDI affiliate are in the same contract intensive industry, a 10 percent increase in the distance reduces the number of vertical FDI affiliates by an additional 4.43 percent than horizontal FDI. The result in column (3) also indicates that, through the transport costs channel, if vertical affiliates are in the unit value intensive industries, parent firms choose locations that are relatively further away in comparison to horizontal FDI locations with the same intensity. If a horizontal and a vertical FDI affiliates are in the same unit value intensive industry, a 10 percent increase in the distance will result in an additional 0.15 percent increase in the number of the vertical FDI affiliate. In column (4), with all control variables, the coefficient of transaction costs is still significant with similar magnitude, while the significance of transport costs drops with the expected positive sign. In short, the empirical findings suggest that vertical FDI locations are much more sensitive to trade costs through both transaction and transport costs channels.

5.4 Patterns of Inter- and Intra-industry FDI

In this section, I further investigate the relative importance of trade costs on inter- and intra-industry vertical FDI by estimating the following equation:

$$\begin{aligned} VFDI_{spjt} = {} & \beta_0 + \beta_1 D\_IntraV_{sp} \\ & + \beta_2 Distance_j \times D\_IntraV_{sp} \\ & + \beta_3 Closeness_{sp} + \beta_4 Closeness_{sp} \times D\_IntraV_{sp} \\ & + \mathbf{\Phi X_{jt-1}} + \mathbf{\Theta X_{jt-1} D\_IntraV_{sp}} \\ & + v_{sj} \times D\_IntraV_{sp} + v_t \times D\_IntraV_{sp} + v_{sj} + v_t + \varepsilon_{spjt} \end{aligned} \tag{4}$$

where the outcome of interest is $VFDI_{spjt}$,, the logarithm of new vertical FDI affiliates in affiliate-parent industry pair, sp, in province j at year t. $Distance_j \times D\_intraV_{sp}$ is the variable of interest, which is the interaction between the distance and the intra-industry vertical FDI indicator. D_intraV_{sp} equals one if the observation is intra-industry vertical FDI, and zero for inter-industry vertical FDI.

Alfaro and Charlton (2009) and Ramondo et al. (2012) show that multinational firms are more likely to own the stages of production closest to the final good they supply. To control for the industrial proximity impact on the patterns of vertical FDI, I introduce a variable, $Closeness_{sp}$, which measures the proximity of two industries in a vertical production chain established by Alfaro and Charlton (2009). $Closeness_{sp}$ is simply the logarithm of absolute difference between the four-digit ISIC Rev. 4 codes of two industries, where subscript s indexes the industry of foreign affiliate and subscript p indexes the industry of parent firm. For example, Manufacturing of Computers and Peripheral Equipment (ISIC 2620) have a closeness of 10 to

Manufacturing of Computer Components and Boards (ISIC 2610) and a closeness of 400 to Plastics Packaging Materials and Unlamented Film and Sheet Manufacturing (ISIC 2220). This closeness variable takes advantage of the fact that the ISIC Rev.4 categorizes similar industries together.

Table 9 presents the results of equation (4). The estimates of distance interaction in columns (1) and (2) are not significant, but in column (2), the estimate of distance interaction term is with positive sign. In columns (3) and (4), I further control for the production proximity effect. The estimated coefficient of distance interaction is with positive sign but not significant in column (4). In short, the results suggest that trade costs might affect less negatively on intra-industry vertical FDI than inter-industry vertical FDI, but this difference is not significant.

The estimated coefficients of the proximity variable are with the expected negative sign as the literature suggests (Alfaro and Charlton, 2009). The results imply that the farther apart two ISIC codes, the less vertical multinational activity is observed between them. Hence, the parent firms tend to invest in the stages of production proximate to their final production, giving rise to a class of similar factor inputs, intra-industry vertical FDI. Columns (3) and (4) also report the results of the estimates of interaction terms of the intra-industry indicator and the proximate variable. The negative and statistically significant coefficients indicate that parent firms tend to own more intra-industry affiliates which are in the similar production stages in comparison to inter-industry vertical FDI. The rationales for why firms choose to own these proximate stages of production might result from information advantages associated with co-ownership of the similar production stage, intellectual property concern or product quality control[11].

5.5 Robustness Check

According to Hummels (2007), air and sea transportation costs have declined since 1970s. Although the distance is still a major part of the costs, it may not catch the change in trade costs over time. Alternatively, it has been suggested that transportation time can be taken as a type of trade costs (Hummels and Schaur, 2013). To provide a more practical measure to catch the time variation for the trade costs in this paper, I construct the estimated passenger air traveling time between Taiwan and

[11] Alfaro and Charlton (2009) provide detail discussion based on the existing trade literature.

each Chinese provincial capital. As discussed in Chen (2014), the passenger air travelling time has two components: actual flight time and estimated transfer time. These are calculated through the flight booking systems of both airlines and flight search engines[12]. This measure takes into account the change in travelling time costs over the period 2001 to 2011. For example, the open of direct flights between Taiwan and Chinese provinces dramatically change the travelling time after 2008.

Following previous specifications, $Distance_j$ is replaced with the passenger's flight time, $Flight\ time_{jt}$, which is a time varying measure of trade costs. Columns (1) and (2) in Table 10 report the results of the relative importance of trade costs on horizontal and vertical FDI. In column (1), without including provincial control variables, the estimate of flight time interaction term is positive. It reflects the similar omitted variables bias discussed in section 5.1. In column (2), once control variables are included, the coefficient of flight time interaction term has expected negative sign but not significant. Columns (3) and (4) report the results of transaction and transport costs channels. The results show that both transaction and transport cost channels are significant with the expected signs. Overall, the travelling time variable gives better results on the two trade costs channels but weaker in the baseline specification. For the transaction and transport costs channels, the robustness check further supports the findings in the previous sections that trade costs have heterogeneous impacts on the patterns of horizontal and vertical FDI across industries and provinces.

[12] For example, I use booking websites such as Skyscanner (www.skyscanner.net) and airline companies' website, such as China Airline and Eva Airways.

6. Conclusions

In this paper, I aim at investigating the relative impact of trade costs on horizontal and vertical FDI across industries. Since trade costs are recognized as one of the determinants in both horizontal and vertical FDI theoretical models, the understanding of their impact on different type of FDI is empirical relevant. Although there are abundant empirical studies on the impacts of other determinants, such as market access or factor cost differentials, on the patterns of FDI since 1990s, there are fewer studies on the relative impact of trade costs on the distribution of horizontal and vertical FDI activities. This might be due to limitations on data availability and methods to classify horizontal and vertical FDI. By exploiting unique firm-level data on Taiwanese public listed firms' affiliates in China during the period 2001 to 2011, I aim at providing solid empirical evidence to identify the causal effect of trade costs on the distribution of horizontal and vertical FDI across space.

Based on horizontal and vertical FDI theoretical models, I test three hypotheses: 1) trade costs – approximated by bilateral distance - have a negative impact on the formation of new vertical FDI affiliates in comparison to the horizontal FDI; 2) with the same transaction or transport costs intensities, vertical FDI affiliates will be affected relatively more than horizontal FDI as the trade costs increase; and 3) the negative impact of trade costs on intra-industry vertical FDI formation is smaller than inter-industry vertical FDI.

The paper exploits a novel source of data, a panel dataset of Taiwanese public-listed firms' affiliates in Chinese provinces with detail information on location, ownership, and four-digit ISIC Rev.4 between 2001 and 2011. As Alfaro and Charlton (2009), I identify each affiliates as a horizontal or vertical FDI on the basis of the input-output linkage of each parent-affiliate industry pair. I estimate the impact of trade costs on the number of new vertical and horizontal FDI affiliates by using the fixed effects estimator. This controls for unobserved industrial and provincial characteristics in order to eliminate omitted variables problems or selection issues that might cause biased estimates.

My findings indicate that the increase in distance between Taiwan and province j of 10 percent reduces the number of new vertical FDI affiliates by 2.48 percent in comparison to horizontal FDI. In addition, if both vertical and horizontal

FDI affiliates are in the same industry, as the distance increases by 10 percent, the number of the vertical FDI affiliates reduces average additional 4.43 percent than horizontal FDI through the transaction costs channel, while the number increases by 0.15 percent through the transport costs channel. Finally, trade costs have no significantly relative impact on inter-and intra-industry vertical FDI.

References

Antràs, P. and S. R. Yeaple (2013) "Multinational Firms and the Structure of International Trade." NBER Working Paper, No. 18775.

Alfaro, L. and A. Charlton (2009) "Intra-Industry Foreign Direct Investment." *American Economic Review*, 99(5), 2096–2119.

Amiti, M. and B. S. Javorcik (2008) "Trade costs and location of foreign firms in China." *Journal of Development Economics,* 85, 129-149.

Brainard, S. L. (1997) "An Empirical Assessment of the Proximity-Concentration Trade-Off between Multinational Sales and Trade." *American Economic Review*, 87(4), 520–544.

Caves, R. E. 2007. *Multinational Enterprise and Economic Analysis*. Third edition. Cambridge, UK: Cambridge University Press.

Carr, D. L., J. R. Markusen, and K. E. Maskus (2001) "Estimating the Knowledge-Capital Model of the Multinational Enterprise." *American Economic Review,* 91(3), 693–708.

Chang, K.-I., Hayakawa, K., & Matsuura, T. (2014) "Location choice of multinational enterprises in China: Comparison between Japan and Taiwan." *Papers in Regional Science*, 93(3), 521-537

Chen, C. (2014) "Does the Distance Matter? The effect of Change in Trade costs on FDI Locations." FREIT Working Paper, No. 707.

Cristea, A. D. (2011) "Buyer-Seller Relationships in International Trade: Evidence from U.S. States' Exports and Business-Class Travel." *Journal of International Economics*, 84(2), 207-220.

Debaere, P., J. Lee, and M. Paik (2010) "Agglomeration, backward and forward linkages: Evidence from South Korean investment in China." *Canadian Journal of Economics*, 43(2), 520-546.

Disdier, A. and K. Head (2008) "The Puzzling Persistence of the Distance Effect on Bilateral Trade." *The Review of Economics and Statistics*, 90(1), 37-48.

Fajgelbaum, P., G. Grossman, and E. Helpman (2013) "A Linder Hypothesis for Foreign Direct Investment." Mimeo Harvard University

Egger, P. and M. Pfaffermayr (2001) "Distance, trade and FDI: A Hausman-Taypor SUR approach." *Journal of Applied Econometrics,* 19, 227-246.

Egger, P. (2008) "On the Role of Distance for Outward FDI." *The Annals of Regional Science*, 42(2), 375-389.

Fujita, M. and T. Mori (2005) "Frontiers of the New Economic Geography." *Papers in Regional Science*, 84(3), 377-405

Hanson, G. H., R. J. Mataloni, Jr., and M. J. Slaughter (2005) "Vertical Production Networks in Multinational Firms." *Review of Economics and Statistics*, 84(4), 664-678.

Harrigan, J. (2010), "Airplanes and Comparative Advantage." *Journal of International Economics*, 82, pp. 181-194.

Hummels, D. (2007) "Transportation Costs and International Trade in the Second Era of Globalization." *Journal of Economic Perspectives*, 21(3), 131-154.

Hummels, D. and Schaur, G. (2013), "Time as a Trade Barrier." *American Economic Review,* 103(7), 2935–2959.

Keller, W. and R. Yeaple (2009) "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States." *The Review of Economics and Statistics*, 91(4), 821-831.

Markusen, J. R. (1984) "Multinationals, Multi-plant Economies, and the Gains from Trade." *Journal of International Economics*, 16(3-4), 205–226.

Markusen, J. R., and A. Venables (2000) "The Theory of Endowment, Intra-Industry and Multi-national Trade." *Journal of International Economics*, 52(2), 209–234.

Mayer, T., I. Mejean, and B. Nefussi (2010) "The Location of Domestic and Foreign Production Affiliates by French Multinational Firms." *Journal of Urban Economics*, 68(2), 115–128.

Nunn, N. (2007) "Relationship-Specificity, Incomplete Contracts and the Pattern of Trade." *Quarterly Journal of Economics***,** 122(2), 569-600.

Ramondo, N., V. Rappoport, and K. Ruhl (2012) “Horizontal vs. Vertical FDI: Revisiting Evidence from U.S. Multinationals.” Mimeo Arizona State University

Redding S. and A.J. Venables (2004) “Economic Geography and International Inequality.” *Journal of International Economics*, 62(1), 53-82.

Yeaple, S. R. (2003) “The Role of Skill Endowments in the Structure of U.S. Outward Foreign Direct Investment.” *Review of Economics and Statistics*, 85(3), 726–734

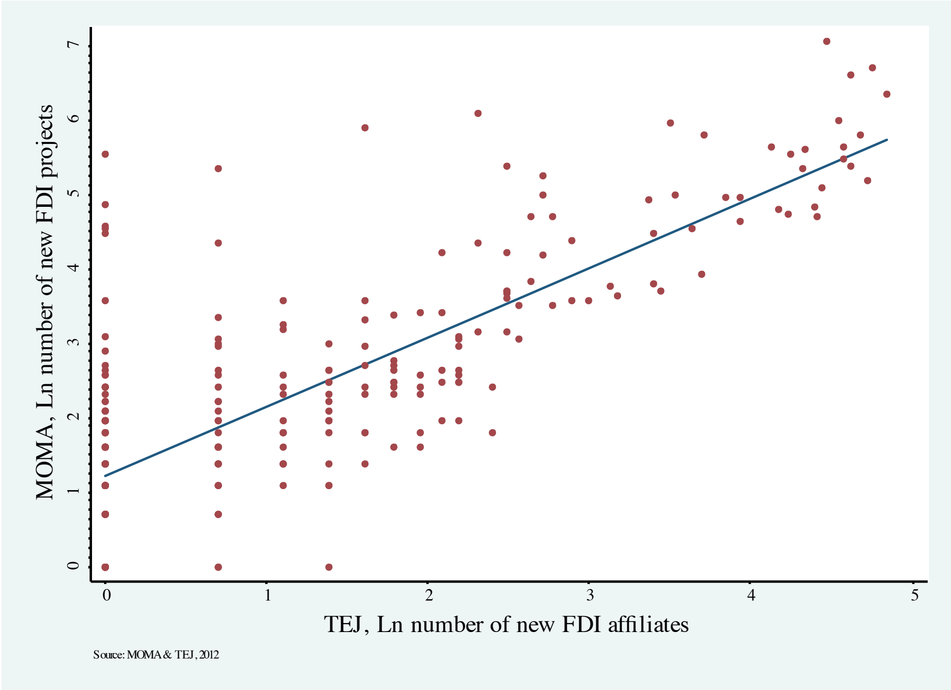

Figure 1-1

Comparison of Cross-year and province Taiwanese FDI in China:

TEJ vs. MOEA, 2001-2011

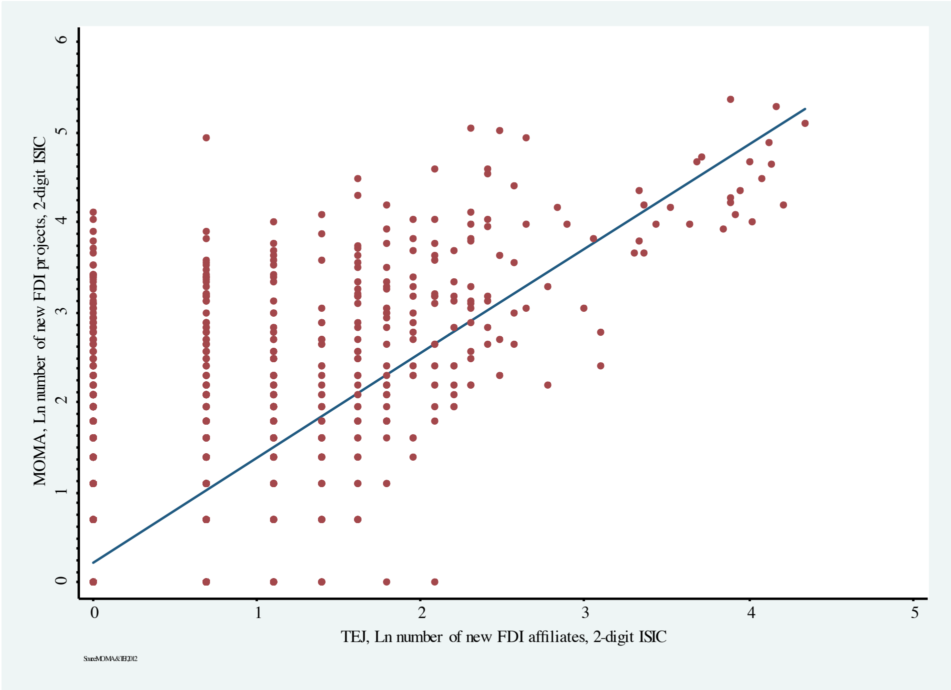

Figure 1-2

Comparison of Cross-year, province and industry Taiwanese FDI in China: TEJ vs. MOEA, 2001-2011

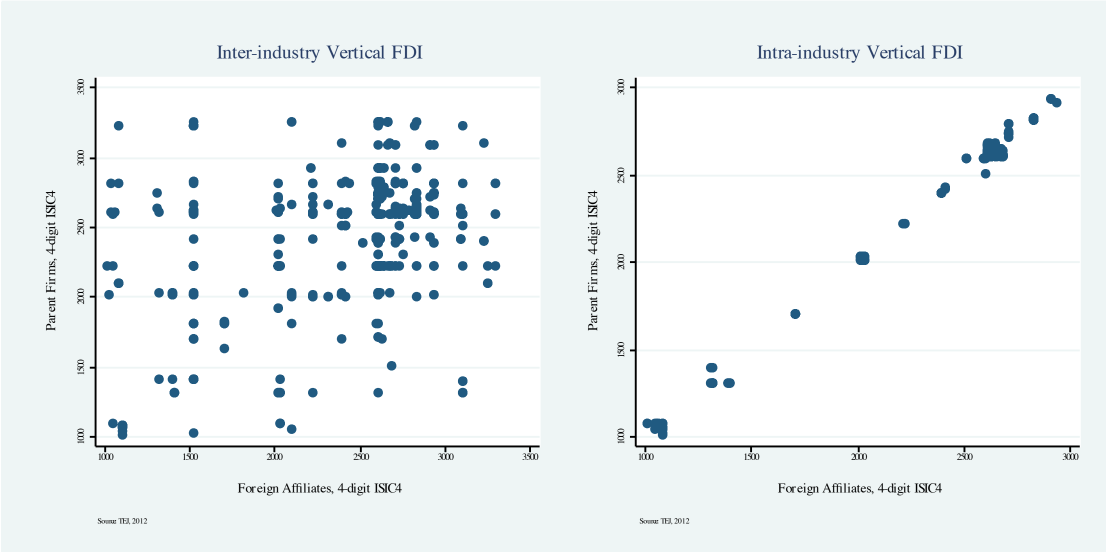

Figure 2

Taiwanese Inter- and Intra-industry Vertical FDI, 2001-2011

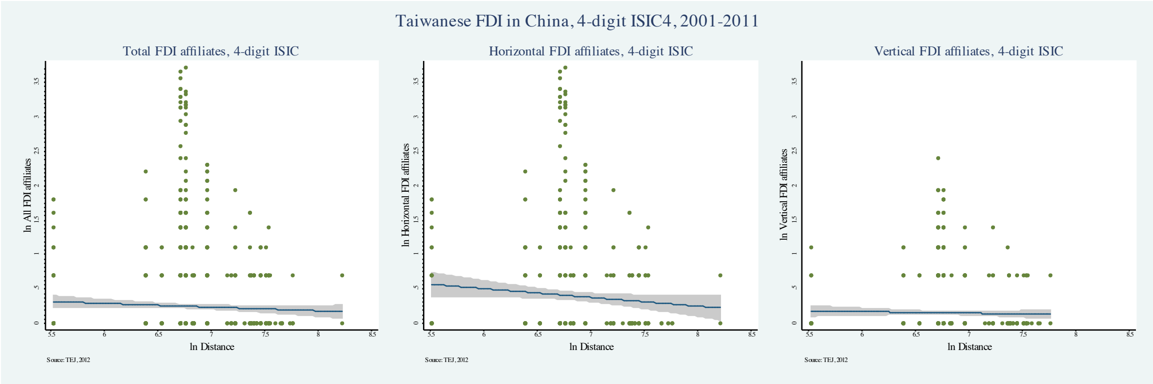

Figure 3-1

Taiwanese Total, Horizontal and Vertical FDI in China, four-digit ISIC4, 2001-2011

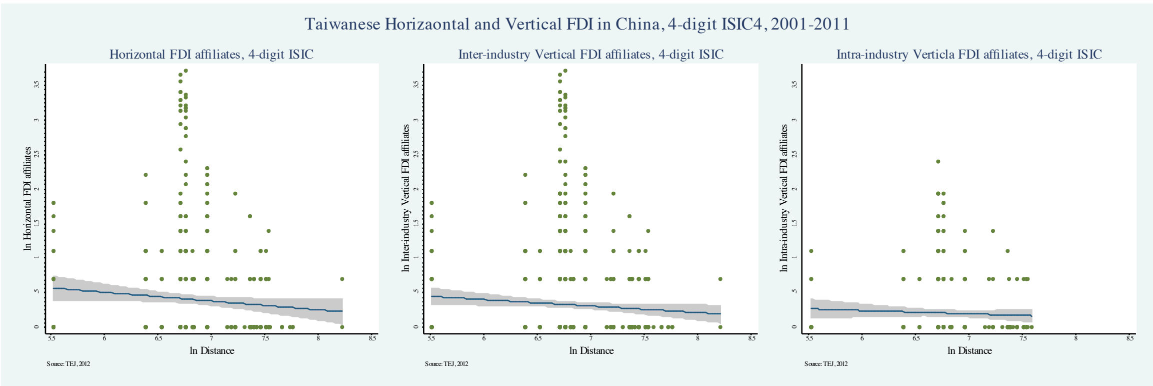

Figure 3-2

Taiwanese Horizontal, Inter-and Intra-Industry Vertical FDI in China, four-digit ISIC4, 2001-2011

Table 1

Patterns of Taiwanese FDI Affiliates in China

	Four-digit	Three-digit	Two-digit
Total	2960	2960	2960
Horizontal	1599	1723	2180
Vertical	1361	1237	780
Vertical inter	780	780	780
Vertical intra	581	457	
Percentage			
Horizontal	54%	58%	74%
Vertical	46%	42%	26%
Vertical inter	26%	26%	26%
Vertical intra	20%	15%	

Source: Authors' calculation using TEJ data.

Table 2

Most Frequent Parent-Affiliate Horizontal Industry Pairs

Parent Industry	Parent ISIC code	No. of Affiliates
Electronic components and boards	2610	820
Computers and peripheral equipment	2620	181
Electric motors, generators, transformers, and electricity distribution and control apparatus	2710	75
Communications equipment	2630	60
Footwear	1520	37
Plastics products	2220	31
Optical instruments and photographic equipment	2670	27
Parts and accessories for motor vehicles	2930	25
Wearing apparel, except fur apparel	1410	22
Plastics and synthetic rubber in primary forms	2013	22
Pharmaceuticals, medicinal chemical and botanical products	2100	22
Other special-purpose machinery	2829	21
Prepared animal feeds	1080	16
Pulp, paper and paperboard	1701	14
Glass and glass products	2310	14
Other fabricated metal products	2599	14
Batteries and accumulators	2720	13
Soft drinks; production of mineral waters and other bottled waters	1104	12
Rubber tyres and tubes; retreading and rebuilding of rubber tyres	2211	12
Medical and dental instruments and supplies	3250	12
Consumer electronics	2640	11
Basic iron and steel	2410	10
Bicycles and invalid carriages	3092	10
Magnetic and optical media	2680	8
Other chemical products	2029	7
Irradiation, electromedical and electrotherapeutic equipment	2660	7
Sports goods	3230	7
Made-up textile articles, except apparel	1392	6
Corrugated paper and paperboard and of containers of paper and paperboard	1702	6
Articles of concrete, cement and plaster	2395	6

Source: TEJ, 2012

Table 3

Most Frequent Parent-Affiliate Upstream Vertical Industry Pairs

Parent Industry	Affiliate Industry	Parent ISIC code	Affiliate ISIC code	No. of firms
Computers and peripheral equipment	Electronic components and boards	2620	2610	127
Electronic components and boards	Computers and peripheral equipment	2610	2620	58
Electronic components and boards	Plastics products	2610	2220	54
Cement, lime and plaster	Articles of concrete, cement and plaster	2394	2395	45
Electronic components and boards	Optical instruments and photographic equipment	2610	2670	30
Computers and peripheral equipment	Communications equipment	2620	2630	28
Computers and peripheral equipment	Plastics products	2620	2220	27
Electronic components and boards	Other fabricated metal products	2610	2599	26
Electronic components and boards	Cutlery, hand tools and general hardware	2610	2593	25
Electronic components and boards	Other electronic and electric wires and cables	2610	2732	23
Communications equipment	Electronic components and boards	2630	2610	22
Communications equipment	Computers and peripheral equipment	2630	2620	21
Pulp, paper and paperboard	Corrugated paper and paperboard and of containers of paper and paperboard	1701	1702	18
Other special-purpose machinery	Electronic components and boards	2829	2610	18
Electronic components and boards	Forging, pressing, stamping and roll-forming or metal; powder metallurgy	2610	2591	17
Electronic components and boards	Electric lighting equipment	2610	2740	17
Computers and peripheral equipment	Electric motors, generators, transformers, and electricity distribution and control apparatus	2620	2710	17
Basic iron and steel	Treatment and coating of metals; machining	2410	2592	16
Electric motors, generators, transformers, and electricity distribution and control apparatus	Electronic components and boards	2710	2610	16
Plastics and synthetic rubber in primary forms	Plastics products	2013	2220	15
Electronic components and boards	Communications equipment	2610	2630	15
Electronic components and boards	Treatment and coating of metals; machining	2610	2592	14
Electronic components and boards	Electric motors, generators, transformers, and electricity distribution and control apparatus	2610	2710	14
Electronic components and boards	Wiring devices	2610	2733	12
Electronic components and boards	Wiring devices	2620	2733	12
Other electronic and electric wires and cables	Electronic components and boards	2732	2610	12
Parts and accessories for motor vehicles	Electric lighting equipment	2930	2740	12
Electronic components and boards	Other special-purpose machinery	2610	2829	11
Computers and peripheral equipment	Basic precious and other non-ferrous metals	2620	2420	11
Other special-purpose machinery	Treatment and coating of metals; machining	2829	2592	11

Source: TEJ, 2012

Table 4

Characteristics of Horizontal and Vertical FDI

	Horizontal FDI	Vertical FDI	Difference
Average log distance between Taiwan and Chinese provinces	6.84 (6.80-6.88)	6.78 (6.76-6.80)	0.06***
Average industry-contract intensity of subsidiary	0.64 (0.63-0.65)	0.56 (0.55-0.57)	0.08***
Average industry-unit value intensity of subsidiary	0.98 (0.91-1.05)	0.96 (0.89-1.02)	0.02
Average log wage of subsidiary province	9.95 (9.92-9.99)	10.02 (9.99-10.04)	-0.07***
Average log market access of subsidiary province	4.70 (4.66-4.74)	4.75 (4.72-4.78)	-0.05**
Average log gross industry output of subsidiary province	9.51 (9.43-9.59)	9.88 (9.83-9.94)	-0.37***
Average log Taiwanese FDI stock of subsidiary province	11.90 (11.69-12.12)	12.97 (12.85-13.09)	-1.07***

Note: 95% confidence interval in brackets.
*** Significant at the 1 percent level, ** Significant at the 5 percent level, and * Significant at the 10 percent level

Table 5

Characteristics of Inter- and Intra-industry Vertical FDI

	Inter-industry FDI	Intra-industry FDI	Difference
Average log distance between Taiwan and Chinese provinces	6.76 (6.74-6.79)	6.81 (6.76-6.85)	-0.05*
Average log wage of subsidiary province	10.03 (9.99-10.06)	10.02 (9.97-10.06)	0.01
Average log market access of subsidiary province	4.76 (4.72-4.80)	4.73 (4.68-4.78)	0.03
Average log gross industry output of subsidiary province	9.97 (9.91-10.04)	9.74 (9.65-9.83)	0.23***
Average log Taiwanese FDI stock of subsidiary province	12.87 (12.72-13.02)	13.13 (12.93-13.33)	-0.26**

Note: 95% confidence interval in brackets.
*** Significant at the 1 percent level, ** Significant at the 5 percent level, and * Significant at the 10 percent level

Table 6

Baseline Estimates: Horizontal and Vertical FDI

	Dependent Variable: Ln New Taiwanese Vertical FDI Affiliates$_{spit}$, 4-digit ISIC4					
	Horizontal FDI		Vertical FDI		Total FDI	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln Distance$_i$	-0.127*	0.0234	-0.0222	0.0520**	-0.127*	0.0234
	(0.0765)	(0.0826)	(0.0232)	(0.0221)	(0.0764)	(0.0825)
Ln Distance$_i$ × D_VFDI$_{sp}$					0.104	0.0286
					(0.0805)	(0.0864)
D_VFDI$_{sp}$					-0.960*	2.228*
					(0.577)	(1.246)
Control variables						
Ln Wage$_{it-1}$		0.169		-0.108**		0.169
		(0.238)		(0.0520)		(0.238)
Ln Market Access $_{it-1}$		-0.133		0.00781		-0.133
		(0.260)		(0.0519)		(0.259)
Ln Industrial		0.0176		0.0262		0.0176
Agglomeration $_{it-1}$		(0.0759)		(0.0179)		(0.0757)
Ln TAI FDI		0.0933***		0.0356***		0.0933***
Agglomeration $_{it-1}$		(0.0291)		(0.00958)		(0.0291)
Ln Wage$_{it-1}$ ×D_VFDI$_{sp}$						-0.278
						(0.213)
Ln Market Access$_{it-1}$						0.141
×D_VFDI$_{sp}$						(0.233)
Ln Industrial						0.00861
Agglomeration$_{it-1}$×D_VFDI$_{sp}$						(0.0772)
Ln TAI Agglomeration$_{it-1}$						-0.0577**
×D_VFDI$_{sp}$						(0.0248)
Observations	651	651	1,059	1,059	1710	1710
Within R-squared	0.007	0.142	0.001	0.042	0.05	0.153

Note: Observations are at industry-province-year level. The periods are from 2002 to 2011. The dependent variable is natural log of Taiwanese new FDI affiliates. Ln Distance is the natural log of the distance between Taiwan and Chinese provincial capital that is defined as a proxy for transaction costs and transport costs. The vertical FDI dummy variable, D_VFDI, equals one for the industrial pairs with direct input requirements greater than zero in the IO table, and zero otherwise. Control variables are one year lagged. OLS estimator is used for 4 specifications and standard errors are in parentheses. Industry-province cluster Standard errors are reported.

* Significant at the 10 percent level; ** Significant at the 5 percent level; ***Significant at the 1 percent level

Table 7

The Relative Impact of Trade Costs on Horizontal and Vertical FDI

Dependent variable: Ln New Taiwanese FDI Affiliates$_{spjt}$, 4-digit ISIC4				
	(1)	(2)	(3)	(4)
Ln Distance$_j$ × *D_VFDI*$_{sp}$	0.0697	-0.125*	-0.028	-0.248***
	(0.0615)	(0.0645)	(0.0887)	(0.0917)
D_VFDI$_{sp}$	-2.376	-19.33	6.099	41.84
	(16.91)	(41.83)	(20.16)	(54.52)
Control variables				
Ln Wage$_{jt-1}$		-0.0719		0.0134
		(0.246)		(0.314)
Ln Market Access$_{jt-1}$		-1.098		-1.265
		(0.772)		(0.939)
Ln Industrial Agglomeration$_{jt-1}$		-0.0373		0.0434
		(0.145)		(0.194)
Ln TAI Agglomeration$_{jt-1}$		0.151***		0.137**
		(0.0204)		(0.0542)
Ln Wage$_{jt-1}$×*D_VFDI*$_{sp}$		-0.125		0.211
		(0.119)		(0.176)
Ln Market Access$_{jt-1}$×*D_VFDI*$_{sp}$		0.0385		-0.0166
		(0.122)		(0.144)
Ln Industrial Agglomeration$_{jt-1}$ ×*D_VFDI*$_{sp}$		0.111**		0.247***
		(0.0480)		(0.0726)
Ln TAI Agglomeration$_{jt-1}$ ×*D_VFDI*$_{sp}$		-0.173***		-0.338***
		(0.0208)		(0.0324)
Time Dummy	Y	Y	Y	Y
Province Dummy	Y	Y	N	N
Fixed Effects	Industry	Industry	Industry-Province	Industry-Province
Observations	1,710	1,710	1,710	1,710
Within R-squared	0.158	0.235	0.159	0.254

Note: Observations are at industry-province-year level. The periods are from 2002 to 2011. The dependent variable is natural log of Taiwanese new FDI affiliates. Ln Distance is the natural log of the distance between Taiwan and Chinese provincial capital that is defined as a proxy for transaction costs and transport costs. The vertical FDI dummy variable, D_VFDI, equals one for the industrial pairs with direct input requirements greater than zero in the IO table, and zero otherwise. Control variables are one year lagged. Coefficients are reported from the fixed effect estimators and standard errors are in parentheses.
* Significant at the 10 percent level; ** Significant at the 5 percent level; ***Significant at the 1 percent level

Table 8

Transaction and Transport Costs Channels

Dependent variable: Ln New Taiwanese FDI Affiliates$_{spjt}$, 3-digit ISIC4				
	Horizontal FDI	Vertical FDI	Total FDI	
	(1)	(2)	(3)	(4)
Ln Distance$_j$×Contract Intensity	-0.609**	-0.0258		
	(0.250)	(0.190)		
Ln Distance$_j$×Unit Value Intensity	0.00728	0.00489		
	(0.0435)	(0.0408)		
Ln Distance$_j$×CI$_s$×D_VFDI$_{sp}$			-0.399***	-0.443***
			(0.0457)	(0.0448)
Ln Distance$_j$×UVI$_s$×D_VFDI$_{sp}$			0.0144**	0.0148**
			(0.00585)	(0.00603)
Control variables	Y	Y	N	Y
Time Dummy	Y	Y	Y	Y
Province Dummy	Y	Y	N	N
Fixed Effects	Industry	Industry	Industry-Province	Industry-Province
Observations	723	952	1,691	1,691
Within R-squared	0.33	0.068	0.173	0.239

Note: Observations are at industry-province-year level. The periods are from 2002 to 2011. The dependent variable is natural log of Taiwanese new FDI affiliates. Ln Distance is the natural log of the distance between Taiwan and Chinese provincial capital that is defined as a proxy for transaction costs and transport costs. The vertical FDI dummy variable, D_VFDI, equals one for the industrial pairs with direct input requirements greater than zero in the IO table, and zero otherwise. Control variables are one year lagged. Coefficients are reported from the fixed effect estimators and standard errors are in parentheses.
Control variables include: Ln Wage, Ln Market access, Ln Industrial agglomeration, and Ln Taiwanese agglomeration in the 2-digit ISIC4 level. Controls*D_VFDI are included as well.
* Significant at the 10 percent level; ** Significant at the 5 percent level; ***Significant at the 1 percent level

Table 9

Trade Costs on Inter-and Intra-industry Vertical FDI

Dependent variable: Ln New Taiwanese Vertical FDI Affiliates$_{spjt}$, 4-digit ISIC4				
	(1)	(2)	(3)	(4)
Ln Distance$_j$×D_IntraV$_{sp}$	-0.0148	0.197	-0.0121	0.208
	(0.138)	(0.158)	(0.137)	(0.157)
Ln Closeness$_{sp}$			-0.0258	-0.0215
			(0.0187)	(0.0186)
Ln Closeness$_{sp}$×D_IntraV$_{sp}$			-0.0756*	-0.101**
			(0.0388)	(0.0390)
Control variables	N	Y	N	Y
Time Dummy	Y	Y	Y	Y
Fixed Effects	Industry-Province	Industry-Province	Industry-Province	Industry-Province
Observations	1,059	1,059	1,059	1,059
Within R-squared	0.031	0.059	0.046	0.077

Note: Observations are at industry-province-year level. The periods are from 2002 to 2011. The dependent variable is natural log of Taiwanese new FDI affiliates. Ln Distance is the natural log of the distance between Taiwan and Chinese provincial capital that is defined as a proxy for transaction costs and transport costs. The intra-industry vertical FDI dummy variable, D_IntraV, equals one for the industrial pairs in the same 2-digit ISIC4 code and zero otherwise. Control variables are one year lagged. Coefficients are reported from the fixed effect estimators and standard errors are in parentheses.
Control variables include: Ln Wage, Ln Market access, Ln Industrial agglomeration, and Ln Taiwanese agglomeration in the 2-digit ISIC4 level. Controls*D_IntraV are included as well.
* Significant at the 10 percent level; ** Significant at the 5 percent level; ***Significant at the 1 percent level

Table 10

Alternative Measure of Trade Costs: Air Travelling Time

	DV: Ln New Taiwanese FDI Affiliates$_{spjt}$, 4-digit ISIC4		DV: Ln New Taiwanese FDI Affiliates$_{spjt}$, 3_digit ISIC4	
	(1)	(2)	(3)	(4)
Ln Flight time$_{jt}$	-0.0842	0.0637	0.265**	0.275***
	(0.118)	(0.125)	(0.109)	(0.101)
Ln Flight time$_{jt}$×D_VFDI$_{sp}$	0.233***	-0.0262		
	(0.0877)	(0.100)		
Ln Flight time$_{jt}$ ×CI$_s$×D_VFDI$_{sp}$			-0.447***	-0.456***
			(0.0562)	(0.0541)
Ln Flight time$_{jt}$ ×UVI$_s$×D_VFDI$_{sp}$			0.0157**	0.0167**
			(0.00723)	(0.00749)
Control variables	N	Y	N	Y
Time Dummy	Y	Y	Y	Y
Fixed Effects	Industry-Province	Industry-Province	Industry-Province	Industry-Province
Observations	1,710	1,710	1,675	1,675
Within R-squared	0.15	0.25	0.169	0.235

Note: Observations are at industry-province-year level. The periods are from 2002 to 2011. The dependent variable is Taiwanese new FDI affiliates. Ln Distance is the natural log of the distance between Taiwan and Chinese provincial capital that is defined as a proxy for transaction costs and transport costs. The vertical FDI dummy variable, D_VFDI, equals one for the industrial pairs with direct input requirements greater than zero in the IO table, and zero otherwise. Control variables are one year lagged. Coefficients are reported from the fixed effect estimators and standard errors are in parentheses.

Control variables include: Ln Wage, Ln Market access, Ln Industrial agglomeration, and Ln Taiwanese agglomeration in the 2-digit ISIC4 level. Controls*D_VFDI are included as well.

* Significant at the 10 percent level; ** Significant at the 5 percent level; ***Significant at the 1 percent level