ESSAYS ON THE DETERMINANTS OF FOREIGN DIRECT INVESTMENT AND ITS IMPACT ON HOME COUNTRIES

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ABSTRACT OF THE DISSERTATION

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Both policy makers and policy analysts are interested in the extent to which host country policies influences foreign direct investment (FDI). While much work has focused on the impact of government policies on aggregate FDI, little attention has been paid to the possibility that different types of FDI may respond differently to changes in policies. In this dissertation, I investigate whether local policies affect distinct types of FDI in different ways. In addition, I also study whether the FDI undertaken by multinational enterprises (MNEs) generates spillovers to their home countries.

In the first chapter, I test the effect of environmental policies in host countries on horizontal, vertical and export-platform FDI. In a simple model I show how different types of FDI respond to a stricter environmental policy. Using U.S. outward FDI in 50 host countries and a survey measure of local environmental regulations, I find a significant deterrent effect of environmental regulations on horizontal and export-platform FDI. Furthermore, I find that in host countries with stricter environmental regulations than U.S. regulations, export-platform F-DI exhibits a greater sensitivity to local environmental regulations than horizontal

FDI.

I extend the analysis in the first chapter to the effect of local corporate tax rates in the second chapter. The empirical evidence suggests that the effect of statutory corporate income tax rates is negative and significant on vertical and export-platform FDI but insignificant on horizontal FDI. The tax effect is found to have grown stronger over time. More importantly, I find that different types of FDI respond in distinct ways to variation in tax rates across "third" countries — all other countries beside the actual host country of FDI.

In the third chapter, I investigate the spillovers generated by MNEs when they invest abroad to domestic firms using firm level information from Standard and Poor's Compustat data. Similar to most previous studies on host country spillovers, only spillovers from MNEs to their suppliers are found to be significant. Moreover, the realization of positive spillovers depends on a few firm characteristics, including exporting status, size and absorptive capacity.

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Chapter 1
Introduction

Many studies have found evidence of foreign direct investment (FDI) promoting the economic growth of host countries. Hence the extent to which host country policies influences FDI has drawn great attention among policies makers and policy analysts. In this dissertation I extend previous studies by investigating whether host countries policies have different impacts on distinct types of FDI. FDI can be divided into three broad categories, horizontal, vertical and export-platform, according to the targeting market and production mode of multinational enterprises (MNEs). Distinguishing the different types of FDI helps host country policy makers evaluate the impact of policy changes on FDI activities and make appropriate policy implications. In chapter 2 I test the pollution haven effect which states that pollution intensive industries tend to relocate to jurisdictions with less stringent environmental regulations on different types of FDI. In chapter 3 I extend the analysis in chapter 2 to the effect of local corporate taxes and adopt a more careful approach to distinguish different types of FDI. In chapter 4 I test whether the FDI undertaken by multinational enterprises (MNEs) generates spillovers not only to host countries but also to their home countries.

Chapter 2 studies the Pollution Haven Effect on horizontal, vertical and export-platform FDI and tests whether the three types of FDI have different sensitivities with respect to a stricter environmental regulation. A simple model is developed to describe how different types of multinational corporations respond in distinct ways to a stricter environmental policy in host countries. Using U.S.

outward FDI in 50 host countries and a survey measure of both the stringency and the enforcement of the local environmental policy, I find a significant deterrent effect of environmental regulations on horizontal and export-platform FDI. Furthermore, FDI in a host country is not only affected by local environmental regulations but also by proximate countries' regulations. More importantly, accounting for the relative stringency of environmental regulations between host country and home country is critical to identify a PHE. I find a significantly stronger effect of environmental policies on all types of FDI in host countries with stricter environmental regulations than the U.S. regulations. In these countries, export-platform FDI also exhibits a greater sensitivity to local environmental regulations than horizontal FDI.

Chapter 3 extends the analysis in chapter 2 by investigating whether local corporate income tax rates have asymmetric impact on the different types of FDI using U.S. affiliate sales data from the U.S. Bureau of Economic Analysis from 1998 to 2009. The results demonstrate that vertical and export-platform FDI are more sensitive to local tax rates than horizontal FDI. I also find that the sensitivity of U.S. FDI to tax rates is increasing over time. More importantly, distinguishing between sales to affiliated persons and to unaffiliated persons helps identify the effect of taxes on the different types of FDI. Finally I find that the different types of FDI are affected by tax rates in other countries in an asymmetric way.

Chapter 4 focuses on whether the FDI undertaken by multinational enterprises (MNEs) generates spillovers to their home countries in addition to host countries. Most previous studies on FDI spillovers have focused on spillovers from foreign multinational firms to host country economies and have ignored spillovers may also exist between outward FDI and home countries. There are three major types of these spillovers: horizontal, backward and forward. Horizontal spillovers occur when advanced technologies are transferred from MNCs to other firms in the same industry through imitation, reverse engineering or labor mobility. Backward spillovers occur when MNCs provide assistance to their suppliers to ensure high quality and on-time delivery of intermediate inputs. The upstream firms supplying the MNCs also gain an opportunity to explore economies of scale when their multinational customers experience expansion in foreign markets. The third type, forward spillovers, occur when customers of MNCs receive productivity gains from the higher quality inputs MNCs acquire from advanced foreign technologies through investment abroad. I test for the presence of spillovers from U.S. MNCs to domestic U.S. firms in the same industry, downstream industries and upstream industries using firm level information from Standard and Poor's Compustat data and U.S. outward FDI data from the U.S. Bureau of Economic Analysis. Consistent with most previous studies on host country spillovers, only spillovers from multinational customers to their suppliers are found to be significant. Moreover, the existence of positive spillovers depends on a few firm characteristics, including exporting status, size and absorptive capacity.

Chapter 2

Testing the Pollution Haven Effect: Does the Type of FDI Matter?

2.1 Introduction

This paper studies the effect of local environmental regulations on different types of foreign direct investment (hereafter, FDI) activities. A widely recognized hypothesis called the Pollution Haven Effect (hereafter, PHE) posits that tightening environmental regulations hurts the productivity of firms and in response firms will shift production to locations with relatively lax regulations, which turns those locations into "pollution havens". Studies of PHE initially focused on trade related issues such as how environmental regulations change the comparative advantage between countries and hence the content of trade. The burst of FDI in the late 20th century led researchers to study whether environmental protection may serve as an incentive for FDI such that multinational corporations (hereafter, MNCs) from countries with special emphasis on environmental protection establish plants in and switch production to countries lacking environmental awareness. Limited but significant empirical evidence of PHE has been found by Cole and Elliott (2005), Kellenberg (2009) and Wagner and Timmins (2009). These researchers dealt with several econometric issues such as unobserved heterogeneity, omitted variable bias and the endegeneity of environmental regulations and found that FDI might be stimulated by increasing environmental abatement costs in home countries or lack of environmental regulations in host countries.

Whether the effect of environmental regulations will differ across types of FDI has been largely ignored when analyzing PHE. Theoretical models of the formation of MNCs categorize FDI into several types according to its motivation and production mode. Horizontal and vertical FDI are the most commonly dicussed types of FDI and are modeled in Markusen (1984) and Helpman (1984), respectively. Horizontal FDI takes place between countries of similar size and aims to serve the host country market, while vertical FDI is usually assumed to be motivated by cost reduction. MNCs using vertical FDI outsource certain stages of production to host countries to take advantage of the relatively cheap inputs there. Different types of FDI may have distinct responses to host country environmental policy since the horizontal type is competing mainly with local firms in the host country while the vertical type is competing with firms in the home country. Tightening environmental regulations in a host country affects the competitors of horizontal MNCs but not the competitors of vertical MNCs. Previous researchers have neither modeled nor provided any empirical evidence of how the two types of FDI respond in different ways to environmental regulations. In this paper I build a simple model to explain the difference between the two types of FDI in response to the imposition of a stricter environmental policy in the host country. I also carry out an empirical test on such heterogeneity across the two types of FDI and an additional type of FDI, export-platform FDI. Export-platform FDI represents MNCs using a host country as an export-platform to serve a group of proximate countries. This type of FDI has drawn increasing attention in recent years as the emergence of regional trade treaties removed trade barriers among countries and made certain countries in low trade cost regions ideal locations for an export-platform.

I use U.S. outward FDI data from the Bureau of Economic Analysis (BEA) of the U.S. Commerce Department in 50 countries in both the developing and the developed world. The three types of FDI are approximated by U.S. affiliates sales to different destinations. Unobserved heterogeneity is addressed by including industrial and regional dummies. The endogenous environmental variable is identified through strategic interactions in policy-making among countries proposed by Kellenberg (2009). After accounting for these issues, I find a significant deterrent effect of host country environmental regulations on horizontal and export-platform FDI. By using a different specification that takes into account the relative regulatory stringency between host countries and the U.S., I also find a significant PHE on vertical FDI and quantify the magnitude of such an effect on vertical FDI. More importantly, I find that the effect of environmental regulations on export-platform FDI is significantly greater than that on horizontal FDI, which is consistent with my model's prediction.

This paper is organized as follows. The next section presents a review of recent literature on PHE and FDI. Then, Section 3 presents a model of how horizontal and vertical FDI respond to an increase in the stringency of environmental regulations. Sections 4 and 5 empirically test the prediction of the model and summarize corresponding results. Concluding remarks are offered in Section 6.

2.2 Literature review

This section provides a review of recent studies of PHE and theories of FDI, including the general PHE theory, empirical evidence regarding trade and FDI, and models explaining different types of FDI.

2.2.1 PHE Literature on Trade and FDI

The theory of PHE was first developed in Copeland and Taylor (1994) in which a two country general equilibrium model was developed to show that the production of dirty goods shifts from the country with tight environmental regulations to the country with lax environmental regulations when free trade takes place. Inspired by this work, researchers devoted a great amount of effort to uncover empirical evidence consistent with the theory of PHE. Most empirical work on PHE is based on reduced form regressions since the theory was initially developed from the Heckscher-Ohlin model so that there is no equation to be estimated. Xing and Kolstad (2002) address the issue that the stringency of environmental regulations is not directly observed in most cases. They construct an equation that links regulatory laxity to pollution emissions and uncover regulatory laxity from that equation. To account for endogenous environmental regulation, they instrument with mortality rate and population density which they believe represent the salience of environmental problems and the degree to which the pollutants could spread among populations. The empirical results show that a one percent increase in SO_2 emission resulting from relaxed environmental regulations will on average attract 0.27 million dollars of new investment from U.S. chemical MNCs. However, their sample only has cross-section data which ignores the unobserved heterogeneity across sectors and only covers a small number of observations (22 countries).

Eskeland and Harrison (2003) derive a model of optimizing firms with homogenous goods and perfect competition. The model shows that investments and outputs do not necessarily fall with more stringent environmental regulations since capital and abatement could interact with each other so that abatement makes capital more attractive. Their panel estimates on U.S. FDI in four developing countries at the four-digit sector level does not support a PHE. Furthermore, using emission instead of actual abatement costs only helps to identify a PHE in a few cases with a specific emission measure of air pollution.

While many studies focus on U.S. trade or FDI because of the availability of data, Javorcik and Wei (2005) focus on the transition economies in Eastern Europe and the former Soviet Union. They state that PHE will be more evident in industries that are relatively more pollution intensive, in other words, dirty industries are relatively more attracted to regions with lax regulations. The firm level data used in the study takes advantage of the disaggregated information on firm characteristics. Despite these improvements, the results only demonstrate limited evidence of a PHE and are not robust across different measures of environmental standards.

Dijkstra et al. (2007) provide another reason why PHE is not widely detected. The study uses a three-stage Cournot duopoly game to show that a multinational firm prefers FDI to exporting when the host government introduces a higher environmental tax because the tax increases its opponent's cost more than the MNC's. As a result, if a MNC is aware that engaging in FDI will make the foreign government impose a tax that hurts its rival disproportionately, then FDI will be profitable in countries with more stringent environmental regulations. This result stresses the fact that the direction of influence sometimes goes from FDI to environmental regulations, which makes environmental stringency endogenous.

Summaries of early studies on PHE are provided in the following three studies. The first, by Brunnermeier and Levinson (2004), categorizes the studies of PHE prior to 2003 into three types: effects on location choices (Levinson (1996), List and Co (2000)), effects on output (van Beers and van den Bergh (1997), Ederington and Minier (2003)), and effects on input flows (Greenstone (2002)). The main conclusion is that the ambiguous evidence revealed in previous empirical studies is the result of omitting the unobserved heterogeneity among jurisdictions when using cross-sectional data and failing to control for the endogeneity of environmental regulations. Adopting panel data and instrumenting for regulatory stringency could help detect a PHE. The second study by Jeppesen et al. (2002) reaches a similar result from comparing 11 studies on how environmental regulations affect domestic and foreign plants' location decisions. Their meta-analysis on the 11 studies shows that those using panel methods and considering unobserved sectional heterogeneity are more credible than the purely cross-sectional ones. Moreover, using stringency measures on more disaggregated levels leads to larger effects of environmental policy. The estimated elasticity is also highly sensitive to slight specification changes. The third paper by Taylor (2005) focuses on the internal logic behind PHE. The author decomposes the theory into links between country characteristics, environmental regulations, production costs, and trade flows. For each of the links, the paper discusses related studies which paint a richer picture of the mapping (Ederington et al. (2004)) or provide surprising results that are counter to the conventional wisdom (McAusland (2004)). This work concludes that factors other than environmental regulations of a country, such as relative endowments, government quality and other political economy determinants, also play important roles in altering production and trade patterns. Weighing all relevant factors is critical to detecting supportive evidence of a PHE.

Although most early studies fail to identify consistent evidence of PHE, recent studies introduce various improvements to econometric methods and provide possible explanations for the inconsistent empirical evidence found in previous work. Cole and Elliott (2005) claim that studies failing to identify a PHE falsely believe that PHE is a widespread phenomenon, while in reality PHE should only take place in countries with sufficient levels of capital endowments. Pollution intensive industries are typically also capital intensive and countries with lax environmental regulation are usually labor abundant. Therefore, the lack of capital endowment will generate an opposite force to PHE so that we are unlikely to observe more FDI in countries with low environmental standards. By ranking the capital labor ratio and the environmental stringency of the host countries, the authors point out two countries, Brazil and Mexico, which are more likely to be pollution havens. Then they regress sector level FDI from the U.S. to the two host countries on the pollution abatement operating costs and the sector's capital intensity. Their results support a PHE and confirm the importance of a capital requirement.

Levinson and Taylor (2008) build a partial equilibrium model of pollution abatement costs and net exports to demonstrate how previous empirical studies are biased against PHE. Their model also provides an estimatable function that allows empirical estimation of PHE. The empirical part of the paper shows that after controlling for unobserved heterogeneity, the coefficient of the pollution abatement costs on U.S. net imports from Canada and Mexico becomes significant and larger in magnitude compared to the cross-section regression coefficient.

Wagner and Timmins (2009) address the importance of including the agglomeration effect of existing FDI in the regression equation. Using German outward FDI in about 100 host countries and unique survey data which directly reveals the stringency of environmental regulations in those countries, the authors demonstrate how excluding FDI stocks from the explanatory variables will bias the coefficient on environmental stringency. They find a statistically significant deterrent effect in the chemicals industry. However, the authors do not use any instrument for regulatory stringency. Instead they impose a strong assumption on the error term so that consistent estimators can be obtained by differencing two industries with distinct pollution intensities. Nevertheless, such an assumption could be violated in some cases, which is possibly why a PHE is not found in other pollution intensive industries in their study.

Kellenberg (2009) outlines a framework in which environmental policy as well as other policies are jointly determined among countries, which leads to potential instruments for endogenous environmental policy. With the strategic interaction in policy determination, host country environmental policy is affected by other countries' attributes which do not directly affect host country FDI. The author uses weighted proximate countries' characteristics such as crime index, infrastructure, public school index, capital labor ratio, tractor per worker and arable land per worker as instruments for host country policies including environmental regulations. The proposed instruments help identify supportive evidence of a PHE in U.S. outward FDI when all industries are pooled together. Moreover, the author finds that PHE exists in relatively footloose industries such as food, machinery and electrical equipment.

2.2.2 Types of FDI

MNCs engage in FDI in various ways and there is a large literature on explaining the different modes of FDI. Nonetheless, little attention has been paid to how different forms of FDI respond to environmental regulations and whether PHE is of the same magnitude across all types of FDI. In this section, I first discuss several theoretical papers that lay the foundations for horizontal, vertical and export platform FDI, and then review studies that relate the PHE theory to some specific type of FDI.

The model of vertical FDI is developed in Helpman (1984) which describes a general equilibrium model where intersectoral, intra-industry and intrafirm trade take place. Differences in relative factor endowments and firms' location choices based on cost minimization are the keys to the emergence of vertically integrated MNCs. The model is based on the standard Heckscher-Ohlin model of two countries, two products and two factors of production. Instead of capital, the model has a general purpose input H which is used not only in producing the two goods but also in producing a firm-specific asset that can serve multiple plants without incurring any extra cost once produced. The results show different patterns of trade and equilibria with or without factor price equalization in different regions of the Edgeworth box. Firms engage in intrafirm trade of the H services and intermediate inputs when setting up production facilities abroad.

The horizontal type of FDI in which MNCs replicate their production in multiple countries is discussed in Markusen (1984) and Markusen and Venables (1998). This type of FDI arises from firm-level scale economies when countries are similar in relative endowments and tariff/trade costs are relatively high. Their "new trade theory" predicts the pattern of FDI between developed countries. Using numerical simulations they show the range of parameters where MNCs or national firms are dominant in equilibrium. Following the same framework, Markusen (1998) and Markusen (2004) include both the horizontal type and the vertical type of MNCs in a single framework, which was recognized later as the "Knowledge-Capital Model". The model shows regions with different levels of relative factor endowments, trade costs, and market size where national firms, horizontal MNCs and vertical MNCs are dominant or mixed.

After the work on the theoretical setup of FDI models, empirical tests were carried out to test the theory. Carr et al. (2001) test the implications of the Knowledge-Capital Model with data on sales of U.S. affiliates abroad and foreign affiliates in the U.S.. Their results indicate that increases in host country trade costs lead to higher production of affiliates in host countries, which confirms the trade cost jumping motive of horizontal FDI. Furthermore, when both the U.S. and a host country raise their trade costs, the production of affiliates in the host country will decrease when the host country is a less developed country (vertical FDI) and increase if the host country is a developed one (horizontal FDI). This interesting finding suggests different motivations for the two types of FDI. For this reason we would expect the responses of different types of FDI to be distinct when analyzing the effect of other policies such as environmental regulations.

Recently another type of FDI, export-platform FDI, has emerged quickly and caught the attention of researchers as it is closely related to the rapid trade liberalization among groups of geographically concentrated countries and the formation of various free trade regions. Ekholm et al. (2007) develop a theory explaining the conditions under which MNCs use a country as an export platform to serve other countries. They also find empirical evidence of export-platform FDI for U.S. affiliates in Europe. One major implication of export-platform FDI is that it not only responds to host-country characteristics but also to neighboring countries' characteristics. Using U.S. outbound FDI, Blonigen et al. (2007) and Baltagi et al. (2007) estimate the spatial interdependence of FDI on proximate countries' characteristics. Both studies find significant spatial effects of spatial market potential and spatial lagged FDI. Although such findings depend crucially on the sample chosen, it is important to consider characteristics and policies in neighboring countries when studying FDI activities if one would like to relate empirical findings back to theory.

There are two studies that provide evidence of how environmental regulations affect some specific type of FDI. Dean et al. (2009) focu on determinants of the location of equity joint ventures (EJVs) in Chinese provinces. The EJVs do not belong to any one type of FDI mentioned above. Instead they are a special case of FDI in which MNCs carry the same responsibility and share the same burden with local partners. The results in Dean et al. (2009) illustrate that EJVs founded from ethnically Chinese sources such as Hong Kong, Macao and Taiwan have a smaller probability of locating in provinces with higher environmental standards represented by collected pollution levies and official water pollution-taxes.

Monteiro and Kukenova (2008) formally test third-country PHE using bilateral FDI flows in a large group of countries. They first infer from previous theoretical work that horizonal FDI is neither affected by host country environmental stringency nor spatial stringency, while vertical FDI and export-platform FDI are negatively affected by host country environmental stringency and positively affected by spatial stringency. Using SO_2 emission, CO_2 emission and environmental treaties as measures of environmental regulatory stringency, they find some evidence of a positive effect of spatial stringency. However, they only uses country level FDI data from which they can not identify any specific type of FDI.

Summing up, previous work has addressed several critical problems in empirically detecting a PHE. Researchers also have obtained a rich understanding of the nature of different types of FDI. In the next section I develop a model that combines the two sets of parallel studies together and explains how different types of FDI respond in distinct ways to environmental regulations.

2.3 The Model

This section presents a model describing how different types of FDI respond to a change in environmental policy that raises the cost of production. First consider two types of MNCs, the horizontal type (h-type) and the vertical type (v-type) in two countries, H and Y. H is the home country where the headquarters of the MNCs are located and Y is the host country where the MNCs' affiliates are established. The h-type MNCs can produce in H and export their products to Y, or they can serve the host country market with their affiliates' production in Y. Assume that if the h-type MNCs produce in the home country H, they all have the same marginal costs c_h. If they produce in Y, they will get some benefits from being close to the market, such as avoiding trade costs and being able to adjust more promptly to local changes. The benefits are represented by a decrease in the MNCs' marginal costs. There are n h-type MNCs and each of them has an affiliate in Y. The n h-type affiliates are heterogeneous in how much their marginal costs will be lowered when producing in Y, which is denoted by $c_h - b_i^h$ with $0 = b_1^h < b_2^h < ... < b_i^h < b_{i+1}^h < ... < b_n^h = \theta c_h$ $(0 < \theta < 1)$.

The v-type MNCs can produce and sell their final products in H, or they can fragment production into multiple stages and shift some stages to Y to take advantage of the cheap resources in Y that are specific to those stages. This is consistent with the theory of vertical FDI that fragmentation is usually driven by differences in relative factor endowments and cheaper resources. Similarly, I assume that there are n v-type MNCs with the same marginal cost c_v when producing domestically. If they separate the stages of production so as to access the cheap inputs in Y, they are heterogeneous in the benefits which lower their marginal costs. Their marginal costs when producing in Y will be $c_v - b_i^v$ with $0 = b_1^v < b_2^v < ... < b_i^v < b_{i+1}^v < ... < b_n^v = \theta c_v$ $(0 < \theta < 1)$. So far the two types of MNCs are similar to each other, but they will respond differently if the host country government tightens its environmental policy as discussed later. There are also two representative local firms in Y and H with marginal costs c_{lY} and c_{lH} and they compete with the type of MNCs that are selling in their countries (i.e., the h-type and the v-type), respectively.

2.3.1 Cournot Case

Assume that the products are homogeneous and the MNCs compete with the local firms on the amount of output they will produce, i.e., a Cournot competition. Let the demand in H and Y be linear and the inverse demand functions be

$$P_Y = A - B(\sum_i X_{hi} + X_{lY}) \tag{2.1}$$

$$P_H = A - B(\sum_i X_{vi} + X_{lH}) \tag{2.2}$$

where X_{ji} $(j = h, v)$ are the sales of a j-type affiliate and X_{lY} and X_{lH} are the sales of the local firms in Y and H.

It can be easily shown that the Cournot equilibria in Y and H lead to the following sales of the two types of affiliates

$$X_{hi} = \frac{A + c_{lY} + \sum_{j=1}^{n}(c_h - b_j^h) - (n+2)(c_h - b_i^h)}{(n+2)B} \quad i = 1, ..., n \tag{2.3}$$

$$X_{vi} = \frac{A + c_{lH} + \sum_{j=1}^{n}(c_v - b_j^v) - (n+2)(c_v - b_i^v)}{(n+2)B} \quad i = 1, ..., n \tag{2.4}$$

Assume that country Y's government decides to tighten its environmental policy on all firms in the country. The new and more stringent policy will increase the marginal costs of both types of affiliates in Y by s. Under the new policy, the MNCs' marginal costs will be $c_j - b_i^j + s$ $(j = h, v)$ if they still produce in Y and c_j $(j = h, v)$ if they switch back to home production. Then for those MNCs with small benefits ($b_i^j < s$ $(j = h, v)$), they will find the offshore production no longer profitable and therefore switch back to home production with marginal cost c_j $(j = h, v)$. For those MNCs with large benefits ($b_i^j \geq s$ $(j = h, v)$), the offshore production is still advantageous to the home production although the advantages become smaller. The number of the two types of affiliates that switch to home production will be denoted by k_h and k_v.

The competitors to the two types of affiliates are not affected in the same way by the new policy. The competitor to the h-type is the local firm in Y which is also affected by the new policy. As a result, its marginal cost also increases by s. However, the competitor to the v-type affiliates is the domestic firm located in H. As the burden of the stricter environmental policy does not fall on the local firm in H, the v-type affiliates face a worse scenario where their competitor is not hurt by the stricter policy. The sales of the two types of affiliates in Y reflect how they are affected differently by the increase in environmental standard as following:

$$X'_{hi} = \frac{A + (c_{lY} + s) + \sum_{j=1}^{k_h}(c_h) + \sum_{j=k_h+1}^{n}(c_h - b_j^h + s) - (n+2)(c_h - b_i^h + s)}{(n+2)B}, \quad i = k_h + 1, ..., n \tag{2.5}$$

$$X'_{vi} = \frac{A + c_{lH} + \sum_{j=1}^{k_v}(c_v) + \sum_{j=k_v+1}^{n}(c_v - b_j^v + s) - (n+2)(c_v - b_i^v + s)}{(n+2)B}, \quad i = k_v + 1, ..., n \tag{2.6}$$

Equation (5) and (6) show clearly that the marginal cost of the competing local firm to the h type increases to $c_{lY} + s$, while the marginal cost of the competing local firm to the v type remains at c_{lH}. This is the main reason for potential differences in sensitivities between the two types of FDI. Denote the total sales of the two types of affiliates that stay in Y by TX_h and TX_v, then the total sales after the implementation of the stricter environmental policy are:

$$TX_h = \sum_{i=k_h+1}^{n} X'_{hi} = \sum_{i=k_h+1}^{n} \frac{A + c_{lY} - 2c_h - \sum_{j=k_h+1}^{n} b_j^h + (n+2)b_i^h - (k_h+1)s}{(n+2)B} \tag{2.7}$$

$$TX_v = \sum_{i=k_v+1}^{n} X'_{vi} = \sum_{i=k_v+1}^{n} \frac{A + c_{lH} - 2c_v - \sum_{j=k_v+1}^{n} b_j^v + (n+2)b_i^v - (k_v+2)s}{(n+2)B} \tag{2.8}$$

Consider the case where $c_{lY} = c_{lH} = c_h = c_v = \hat{c}$ and b_i^h and b_i^v follows the same uniform distribution so that $b_i^h = b_i^v = \hat{b}_i \; \forall \; i$. Then the two types of affiliates have the same level of sales before the policy change. The number of affiliates switching out of Y is also the same and can be represented as $k_h = k_v = \hat{k} = \frac{s}{\hat{b}_n} n$ if n is large enough. Then I can compare the differences in sensitivities of the two types of MNCs to s, the environmental cost. Let the sensitivity be denoted by the percentage changes in total sales with respect to s, i.e., semi-elasticity. To compare $\left|\frac{dTX_h/TX_h}{ds}\right|$ and $\left|\frac{dTX_v/TX_v}{ds}\right|$, we first notice that $\frac{TX_h}{TX_v}$ is an increasing function of s. This is true since[1]

$$\frac{d\left(\frac{TX_h}{TX_v}\right)}{ds} = \frac{\hat{b_n}^3 + (A-\hat{c})\hat{b_n}^2 + \frac{1}{2}ns^2\hat{b_n}}{\left[-\frac{1}{2}ns^2 + (\frac{1}{2}n-1)\hat{b_n}s + \hat{b_n}^2 + (A-\hat{c}\hat{b_n})\right]^2} \tag{2.9}$$

In the above equation, $\hat{b_n}^3$, $\frac{1}{2}ns^2\hat{b_n}$ and $\hat{b_n}^2$ are all positive and $A-\hat{c}>0$[2]. Therefore, the derivative of $\frac{TX_h}{TX_v}$ with respect to s is positive.

Then the log of $\frac{TX_h}{TX_v}$, or equivalently $\ln(TX_h)-\ln(TX_v)$, is also increasing in s. Hence

$$\frac{d\left[\ln(TX_h)-\ln(TX_v)\right]}{ds} = \frac{dTX_h/TX_h}{ds} - \frac{dTX_v/TX_v}{ds} > 0 \tag{2.10}$$

Notice that $\frac{dTX_h/TX_h}{ds}$ and $\frac{dTX_v/TX_v}{ds}$ are both negative. Then (10) can be rewritten as

$$\left|\frac{dTX_v/TX_v}{ds}\right| - \left|\frac{dTX_h/TX_h}{ds}\right| > 0 \tag{2.11}$$

Equation (11) implies that the percentage change in the v-type affiliates' sales with respect to an increase in environmental cost s is greater than that of the h-type affiliates.

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[1] The derivation of the following equation is provided in the appendix.

[2] Assume that all MNCs produce in H and there is no environmental cost s, the sales of a single MNC is $\frac{A-\hat{c}}{(n+2)B}$. If we assume every MNC has positive sales, then $A>\hat{c}$.

2.3.2 Bertrand Case

In this section an alternative specification of the model will be discussed, which makes the predictions broader for other circumstances under which MNCs operate. In the case above, the goods produced by MNCs are homogeneous. In reality, MNCs are large corporations enjoying economies of scale and market power which allows them to manipulate prices. Furthermore, MNCs typically have some firm-specific intangible assets which differentiate their products from their competitors'. Therefore the differentiated Bertrand competition model might be a more realistic specification to describe the behaviors of MNCs. Let MNCs produce differentiated products and compete in prices to maximize profits, the direct demand functions for MNCs of the h-type and the v-type are given by

$$q_i^h = A - Bp_i^h + C(\sum_{j \neq i} p_j^h + p_{lY}) \quad i = 1, ..., n \tag{2.12}$$

$$q_i^v = A - Bp_i^v + C(\sum_{j \neq i} p_j^v + p_{lH}) \quad i = 1, ..., n \tag{2.13}$$

where p_i^j $(j = h, v)$ refers to the prices of the h-type products and the v-type products. p_{lY} and p_{lH} are the prices of the local competitors' products in Y and H[3].

Given the demand functions, the two types of MNCs choose their price levels to maximize their profits. The equilibrium can be solved by first solving for the equilibrium prices and then substituting the prices into the demand functions.

[3] These demand functions can be derived from a representative consumer with quadratic utility function $U(q) = \alpha \sum_{i=1}^n q_i - \frac{1}{2}(\beta \sum_{i=1}^n q_i^2 + \gamma \sum_{i=1}^n \sum_{j \neq i}^n q_i q_j)$ where $\gamma \in (0, \beta)$ represents the substitutability of the products, as in Ledvina and Sircar (2011). The closer is γ to β, the more similar are the products to each other. The closer is γ to 0, the more independent are the products. The coefficients A, B and C in (12) and (13) refer to $\frac{\alpha}{\beta+(n-1)\gamma}$, $\frac{\beta+(n-2)\gamma}{(\beta+(n-1)\gamma)(\beta-\gamma)}$ and $\frac{\gamma}{(\beta+(n-1)\gamma)(\beta-\gamma)}$, respectively.

Again, denoting the equilibrium sales of the two types by X_i^j $(j = h, v)$, we have

$$X_{hi} = \frac{-B(B+C)(c_h - b_i^h)}{(2B+C)} + \frac{AB}{(2B-nC)} + \frac{B^2C\left[\sum_{j=1}^n (c_h - b_j^h) + c_{lY}\right]}{(2B+C)(2B-nC)} \quad i = 1, ..., n \tag{2.14}$$

$$X_{vi} = \frac{-B(B+C)(c_v - b_i^v)}{(2B+C)} + \frac{AB}{(2B-nC)} + \frac{B^2C\left[\sum_{j=1}^n (c_v - b_j^v) + c_{lH}\right]}{(2B+C)(2B-nC)} \quad i = 1, ..., n \tag{2.15}$$

In this case, if the host government tightens its environmental policy which increases firms' marginal costs by s, we still have firms with $b_i^j < s$ $(j = h, v)$ switching back to home production and those with $b_i^j \geq s$ $(j = h, v)$ staying in Y. The total sales of the two types of affiliates will be

$$\begin{aligned} TX_h = \sum_{i=k_h+1}^{n} \Bigg\{ & \frac{-B(B+C)(c_i - b_i^h + s)}{(2B+C)} + \frac{AB}{(2B-nC)} \\ & + \frac{B^2C\left[\sum_{j=1}^{k_h} c_h + \sum_{j=k_h+1}^{n} (c_h - b_h^j + s) + (c_{lY} + s)\right]}{(2B+C)(2B-nC)} \Bigg\} \end{aligned} \tag{2.16}$$

$$\begin{aligned} TX_v = \sum_{i=k_v+1}^{n} \Bigg\{ & \frac{-B(B+C)(c_i - b_i^v + s)}{(2B+C)} + \frac{AB}{(2B-nC)} \\ & + \frac{B^2C\left[\sum_{j=1}^{k_v} c_v + \sum_{j=k_v+1}^{n} (c_v - b_v^j + s) + c_{lH}\right]}{(2B+C)(2B-nC)} \Bigg\} \end{aligned} \tag{2.17}$$

This is similar to the Cournot case where only the h-type's competitor is hurt by the stricter regulation. Again, let the sensitivities to the environmental cost s of the two types of MNCs be denoted by $\left|\frac{dTX_h/TX_h}{ds}\right|$ and $\left|\frac{dTX_v/TX_v}{ds}\right|$. Making the same assumptions as in the Cournot case regarding the two types of MNCs' marginal costs and benefits, we can show that[4]

$$\frac{d\left(\frac{TX_h}{TX_v}\right)}{ds} = \frac{\frac{1}{2}\theta BC\hat{c}\left[Q\hat{c}^2 + \theta A(B + \frac{1}{2}C)\hat{c} + \frac{1}{4}nBCs^2\right]}{(Q\hat{c}^2 + Q_2\hat{c} - \frac{1}{4}s^2 nBC)^2} \tag{2.18}$$

[4]The details of getting equation (18) is provided in the appendix.

Let $G(\hat{c}) = Q\hat{c}^2 + \theta A(B + \frac{1}{2}C)\hat{c} + \frac{1}{4}nBCs^2$, then if $G(\hat{c})$ is positive, from equation (18) the derivative of $\frac{TX_h}{TX_v}$ with respect to s is positive. In $G(\hat{c})$ the only term of which the sign is not clear is Q. It is obvious that $G(\hat{c})$ is positive if Q is nonnegative. In the case that Q is less than zero, since $G(0) = \frac{1}{4}nBCs^2 > 0$, then if there exists $\bar{c} > \hat{c}$ such that $G(\bar{c}) > 0$, we can show that $G(\hat{c}) > 0$. Notice from equation (14) that if all MNCs produce in H, the sale of any MNC would be $\frac{B(2B+C)[A-(B-nC)\hat{c}]}{(2B+C)(2B-nC)}$, which implies that $\hat{c} \leq \frac{A}{B-nC}$ if the sale is nonnegative[5]. Pluging $c = \frac{A}{B-nC}$ into $G(c)$, we have

$$G\left(\frac{A}{B-nC}\right) = \frac{(B-nC)BCns^2 + \theta^2 A^2(2B+C)}{4(B-nC)} + \frac{\theta^2 A^2 BC}{4(B-nC)^2} > 0 \quad (2.19)$$

Therefore, $G(\hat{c})$ is positive even if $Q < 0$. For all possible values of $\hat{c}$, $G(\hat{c})$ is greater than zero, which implies from equation (18) that $\frac{TX_h}{TX_v}$ is an increasing function of s. By a similar argument for the Cournot case, it can be inferred that

$$\left|\frac{dTX_v/TX_v}{ds}\right| - \left|\frac{dTX_h/TX_h}{ds}\right| > 0 \quad (2.20)$$

Therefore the prediction that horizontal FDI is less sensitive than vertical FDI to an increase in the strictness of environmental regulations also holds for MNCs with differentiated products. Both the Cournot and Bertrand model show that MNCs competing with firms outside host countries are more severely impacted by host country environmental regulations.

In the next section, I will empirically test the above prediction using U.S. FDI abroad. I include a third type of FDI, export-platform FDI, in the empirical test. This type of FDI is similar to the v-type in the model since the major purpose of export-platform FDI is to serve the neighboring countries of the host

[5]In the case that $Q < 0$, $B - nC$ must be positive. This is because we can rewrite Q as $Q = -\frac{1}{2}\theta\left[(2-\theta)B + (1-\theta)C\right](B - nC) + \frac{1}{4}\theta nC^2$ and it is assumed that $0 < \theta < 1$. If $B - nC \leq 0$, Q must be positive.

country Y^6. Its competitors in the neighboring countries will not be affected by the stricter environmental regulation in Y as in the case of the v-type affiliates. Hence, export-platform (e-type) FDI also has a larger sensitivity to the strictness of environmental regulations than the h-type does.

2.4 Data and the Empirical Model

To empirically test the prediction of the model, I use U.S. foreign affiliate sales data[7] from the Bureau of Economic Analysis (BEA)[8] between the years of 1999 and 2003. A nice feature of the BEA U.S. FDI data is that it contains information regarding the destination of the sales which allows identification of different types of FDI. Horizontal, vertical and export-platform FDI are approximated by U.S. foreign affiliates' local sales, sales back to the U.S. and sales to other foreign countries, respectively. The sample in my analysis includes U.S. affiliate sales in 8 industries and 50 countries[9]. The dependent and explanatory variables used in the analysis are shown in Table 2.1.

To measure the stringency of environmental regulations, I use the Executive Opinion Survey data from the Global Competitiveness Report (GCR) published

[6] An export-platform MNC can serve the host country as well. For instance, A MNC sets up an affiliate in Ireland to service the European market and the local Irish market at the same time. But compared to the European market, the local Irish market is quite small. Therefore the major targeting market of export-platform FDI should be countries neighboring the host country.

[7] Most scholars agree that affiliate sales is the measure that best describes actual economic activity at an affiliate. Although data of FDI stock are more prevalent, it is affected by use of historical values, etc. FDI flows are financial flows so it differs from capital flows in a number of dimensions. Besides, the correlation between affiliate sales and FDI stock is quite high.

[8] The BEA collects comprehensive data on FDI in the U.S. and U.S. FDI aborad in its annual survey. Data aggregated at the 3-digit and 4-digit NAICS level are available to the public. In my analysis, I use sales of majority-owned nonbank affiliates of nonbank U.S. parents. A majority-owned nonbank affiliate is defined as an affiliate for which the combined ownership of all U.S. parents exceeds 50 percent.

[9] The list of industries and countries is provided in the appendix.

Table 2.1: Descriptive Statistics

	mean	sd	min	max
Local Sales (millions of $)	1480.43	3227.47	0	27463
Sales to the U.S. (millions of $)	440.80	2750.28	0	48577.76
Sales to Other Countries (millions of $)	868.36	2363.77	0	23019.5
Environmental Stringency Index	4.36	1.24	2	6.7
Environmental Enforcement Index	4.21	1.10	2.1	6.4
GDP (millions of $)	413992.2	737463.2	6719.30	4754589
Tariff Rate	8.23	6.15	.001	33.6
Tax Rate	29.20	6.33	12.5	45
Exchange Rate (LCU per US$)	336.04	1491.47	0.41	11786.8
Aggregate FDI Stock (millions of $)	93342.38	116772.2	735.44	615158.5
Industrial FDI Position (millions of $)	751.21	1939.20	-3106.38	22613.09
K/L Ratio (1000 $/worker)	717.72	2560.72	0.57	54145.61
Law and Order	0.70	0.25	0.16	1
Length of Road (km)	365616.1	577430	1934	3316078
Distance (km)	5079.06	2073.88	456	9058
Population (million)	85.63	223.92	2.89	1288.4

Note: Data on affiliate sales, industrial FDI stock and K-L ratio are from the US Bureau of Economic Analysis. Data on environmental indices is from the Global Competitiveness Report. Exchange rates data is from IMF. Data on country level FDI stock is from UNCTAD. Data on GDP, applied tariff rates, length of road and population are from the World Bank. Data on corporate statutory tax is from the Heritage Foundation. Law and order index is from the PRS Group.

by the World Economic Forum (WEF). The report covers a broad range of developed and developing countries. The Executive Opinion Survey started asking questions regarding environmental policies in 1999 and reports not only the stringency of environmental policies but also whether a country's environmental policy is implemented consistently and fairly. There are two indices measuring the stringency of an environmental policy as well as its enforcement. Both indices range from 1 to 7. For the stringency index a value of 1 represents the least stringent and a value of 7 represents the most stringent. For the enforcement index, a value of 1 represents that the policy is not enforced or enforced erratically and a value of 7 means enforced consistently and fairly. The environmental index used in my regression is the product of the two indices so that countries with stricter and more consistently enforced policy have greater scores. The survey data, although less objective than the hard data which are statistical indicators acquired from international or regional organizations, reflects the perceptions of international economic environment by the business executives who are dealing directly with local business situations. Therefore, the survey data is more recent and closer to reality than the hard data which usually shows a "picture of the past", especially in those aspects that are hard to quantify such as the strictness of environmental regulations.

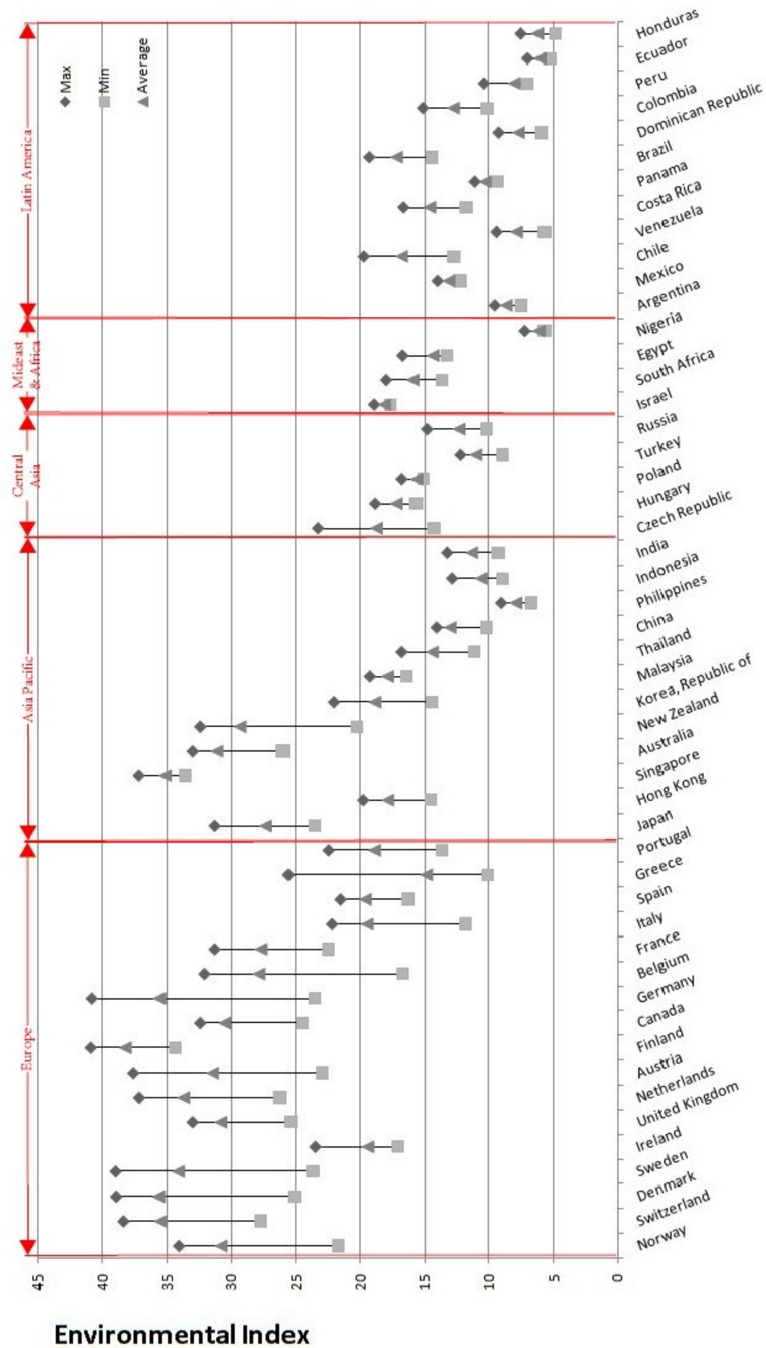
Figure 2.1 shows the environmental indices of the countries in the sample. The countries are grouped by their regions[10] and in each region the countries are ordered by their GDP per capita. The rhombus on the top and the sqaure on the bottom of each line represent the maximum and the minimum value of the environmental index of a country during the sample period. The triangle in between represents the average of the environmental index during the sample period. We

[10]The countries are divided into 5 regions and the countries in each region are listed in the appendix.

can see that in the first two regions (Europe and Asia Pacific) the environmental indices are notably higher than the indices in the other three regions (Central Asia, Africa and Latin America). In Europe, countries with higher GDP per capita on the left generally have higher average index (except for Ireland) than those countries with lower GDP per capita. The same pattern appears in Asia Pacific countries as well. Singapore, Japan, Australia and New Zealand all have a high level of personal income and a large environmental index, while less developed countries such as Philippines and Indonesia have poor environmental regulations. In the other three regions, there is no such a large gap in the environmental index across countries as in Europe and Asia Pacific. Almost all countries are nested in low levels of environmental index that are below the minimum index of New Zealand. Another point worth mentioning is that the environmental indices in most European and Asia Pacific countries experienced large changes during the sample period. The differences between the maximum and minimum of the indices are especially large for Germany, Belgium, Greece and New Zealand. On the other hand, the countries in the other three regions with poor environmental regulations have persistently low environmental indices.

The other RHS explanatory variables include a group of variables that affect FDI activities. First, FDI tends to go to countries with large market potentials. I use real GDP as a measure for market potential. Second, local policies such as tariff rates, corporate tax rates, and exchange rates all have impacts on FDI. Tariffs could serve both as a barrier and an incentive for FDI. Higher tariffs will reduce trade of intermediates inputs but lead to more tariff-jumping FDI, which implies that the sign of this variable could be either positive or negative. Higher corporate tax rates and lower exchange rates reduce affiliates' profit and ability to purchase local assets. Therefore, the signs of these two variables are expected to be negative and positive. Third, Wagner and Timmins (2009) show that ignoring

Figure 2.1: Environmental index of countries in the sample



agglomeration effects would lead to severe omitted variable bias. To account for agglomeration effects, I include both an industry-specific measure[11] and an aggregate measure of FDI stock. The rest of the explanatory variables include distance from the U.S., capital/labor ratios, population, an index measuring law and order, total length of road network, and whether a host country has common official language with the U.S..

The regression equation of the affiliate sales in industry i and country j at time t is shown below. All variables are transformed to their logs so that the estimated coefficients stand for elasticities[12].

$$\ln Sale_{ijt} = \beta_0 + \delta_1 D_i + \delta_2 D_t + \delta_3 R_r + \sum_k \beta_k \ln X_{jt}^k + \sum_l \theta_l \ln Z_{ijt}^l + \epsilon_{ijt},$$

where D_i and D_t are industry and time dummies that control for the industry-specific and time-specific unobserved heterogeneities. R_r is a region dummy[13]. X_{jt} are variables that do not vary across industries, and Z_{ijt} are industry-specific FDI stock and capital/labor ratios. The equation is estimated for each type of sales separately.

As shown by several studies (Xing and Kolstad (2002), Levinson and Taylor (2008), Wagner and Timmins (2009)), failing to address the endogeneity of environmental regulations will greatly bias the estimates. Various ways to instrument the environmental variable have been proposed in the literature. In this paper, I follow Taylor (2005) and Kellenberg (2009) and posit that environmental

[11] The BEA reports in their annual surveys the U.S. direct investment position abroad which measures the cumulative value of parents' investments in their affiliates. The position data are reported for each of the industries included in my sample.

[12] Observations of negative sales are deleted from the sample, and for zero sales I transfer them to $\ln(sales + 1)$ so that they are not dropped from the sample.

[13] I could not include country dummy as the number of countries is relatively large to the number of years in the panel. For Canada and Mexico, they have their own dummies for their special relationship with the U.S..

regulations in a country depend on its own characteristics as well as other countries' characteristics if countries engage in strategic interactions when determining their policies. They assume that there are two major sectors in a country, the manufacturing sector and the agriculture sector. Factors in both sectors affect environmental policy but only factors in the manufacturing sector affect FDI. This provides one way to identify environmental policy. In addition, as countries compete in their environmental policies, every country's policy is a function of other countries' characteristics. As a result, other countries' characteristics which do not directly affect FDI could serve as instruments. Following Kellenberg (2009), I use the number of tractors per agriculture worker as a characteristic for the agriculture sector, and other countries' attributes such as an index for organized crime, the quality of public schools and other countries' tractors per agriculture worker as instruments.[14] Another variable that should be treated as endogenous is a host country's GDP. Studies such as Balasubramanyam et al. (1996), Borensztein et al. (1998) and Li and Liu (2005) have shown that FDI facilitates economic growth by bringing in productive capital and generating knowledge and technical spillovers. A host country's tractors per agriculture worker could be used to identify GDP since this factor contributes to agricultural output but does not impact manufacturing FDI. In summary, there are two endogenous variables and four instruments. The equation is estimated with Generalized Method of Moments (GMM-IV).

[14]All other countries characteristics are of the countries in the same region and weighted by GDP.

2.5 Estimation Results

2.5.1 Baseline Regressions

Table 2.2 shows the estimation results from OLS. The dependent variables in the three columns are local sales, sales back to the U.S. and sales to other foreign countries of the affiliates. We can see that ignoring the endogeneity of the environmental index leads to a result against PHE. The estimated coefficients of the environmental index are positive in all three cases but the estimates may be inconsistent if the environmental policy is determined endogenously.

In table 2.3, I instrument the environmental index and GDP with the set of instruments mentioned above. The coefficients of the environmental index become negative in all equations and are statistically significant in the equations of local sales and sales to other foreign countries. After taking into account the endogeneity of the environmental index, I find countries with more stringent and consistently enforced environmental regulations tend to have less horizontal and export-platform FDI, which provides evidence of a PHE. Regarding the magnitude of the coefficient on the environmental index for each type of FDI, the elasticity of export-platform FDI with respect to the environmental index in column 3 (2.688 in absolute value) is the largest. The elasticity of vertical FDI in column 2 (0.490 in absolute value), however, is smaller than that of horizontal FDI in column 1 (1.570 in absolute value). These results to some extent demonstrate that different types of FDI are not equally sensitive to environmental regulations in host countries. The comparison between export-platform FDI and horizontal FDI is also consistent with the prediction of the model that host country environmental regulations might have a stronger impact on multinationals competing with firms outside the host country. However, as the three equations are estimated separately, we cannot draw any conclusion regarding whether the coefficients on

Table 2.2: OLS estimates of U.S. affiliate sales

VARIABLES	(1) Local Sales	(2) Sales to U.S.	(3) Sales to Other
Environmental Index	0.306**	0.395*	0.184
	(0.135)	(0.211)	(0.258)
GDP	0.882***	-0.0196	-0.0961
	(0.107)	(0.176)	(0.207)
Tariffs	0.0211	0.0266	-0.0363
	(0.0209)	(0.0332)	(0.0397)
Tax rate	-0.148	-1.906***	-1.737***
	(0.144)	(0.231)	(0.273)
Exchange Rate	-0.0399**	-0.0219	0.00649
	(0.0199)	(0.0318)	(0.0380)
Aggregate FDI Stock	0.157***	0.350***	0.544***
	(0.0549)	(0.0871)	(0.103)
Industrial FDI position	0.182***	0.250***	0.352***
	(0.0118)	(0.0199)	(0.0243)
Law and Order Index	0.124	0.797***	0.511**
	(0.117)	(0.180)	(0.223)
Length of Road Network	-0.0618	-0.279***	-0.0634
	(0.0441)	(0.0725)	(0.0859)
K/L Ratio	0.492***	-0.0370	0.307***
	(0.0347)	(0.0535)	(0.0635)
Distance	-0.381**	0.278	-0.195
	(0.153)	(0.247)	(0.302)
Population	-0.135*	0.579***	0.325**
	(0.0815)	(0.137)	(0.162)
Common Language	0.240**	0.830***	0.214
	(0.0943)	(0.153)	(0.184)
Constant	-7.532***	-2.389	-0.726
	(1.516)	(2.442)	(2.886)
Observations	1,156	1,184	1,036
R-squared	0.768	0.668	0.665

All regressions include industry, year and regions dummies.
Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.3: GMM-IV estimates of U.S. affiliate sales

VARIABLES	(1) Local Sales	(2) Sales to U.S.	(3) Sales to Other
Environmental Index	-1.570***	-0.490	-2.688**
	(0.536)	(0.737)	(1.111)
GDP	1.195***	0.525*	0.677**
	(0.185)	(0.290)	(0.331)
Tariffs	-0.0543*	0.0177	-0.125*
	(0.0317)	(0.0445)	(0.0647)
Tax rate	-0.267	-1.896***	-1.751***
	(0.175)	(0.233)	(0.314)
Exchange Rate	0.0401	0.00739	0.124*
	(0.0297)	(0.0480)	(0.0645)
Aggregate FDI Stock	0.342***	0.312**	0.746***
	(0.0859)	(0.140)	(0.190)
Industrial FDI position	0.194***	0.252***	0.367***
	(0.0201)	(0.0271)	(0.0442)
Law and Order Index	0.651***	0.939***	1.280***
	(0.215)	(0.293)	(0.434)
Length of Road Network	0.132*	-0.263**	0.172
	(0.0780)	(0.109)	(0.154)
K/L Ratio	0.473***	-0.0276	0.308***
	(0.0524)	(0.0486)	(0.0808)
Distance	-0.600***	0.307	-0.498
	(0.183)	(0.298)	(0.373)
Population	-0.670***	0.105	-0.658*
	(0.180)	(0.262)	(0.339)
Common Language	0.173	0.824***	0.174
	(0.117)	(0.176)	(0.198)
Constant	-2.662	-2.191	5.092
	(2.206)	(3.598)	(4.756)
Observations	1,156	1,184	1,036
R-squared	0.727	0.662	0.624
Overid p-value	0.592	0.308	0.238

All regressions include industry, year and regions dummies.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

environmental regulations are statistically differ ent across equations. In section 5.4, I will compare the magnitudes of the coefficients in a more formal way to test the prediction on differences in sensitivity.

As the environmental indices are constructed in a scale from 1 to 7, a one percent increase in the environmental index does not have a clear meaning. As a result, whether the coefficients on regulatory stringency representing elasticities are economically meaningful cannot be directly interpreted. I calculate the annual average percent growth rate of each country's environmental index and rank the countries according to their growth rates. Countries with the smallest and the greatest growth rate and at each of the quartiles are listed in table 2.4. According to the estimated elasticity from table 2.3, if Ireland experienced the same increase in environmental regulatory stringency as Denmark did, it would have lost 12.58%[15] of its U.S. horizontal FDI and 21.53% of its U.S. export-platform FDI. As Ireland is one of the major hubs used by U.S. MNCs to serve the integrated Europe, the implied effects of environmental regulations from the estimated coefficients are economically significant.

Table 2.4: Average Annual Change in Environmental Index

Percentiles	Country	Average Change %
min	Venezuela	-11.99
25 percentile	Ireland	1.29
50 percentile	Australia	5.19
75 percentile	Denmark	9.30
max	Greece	26.08

Regarding the validity of the instruments, a Hansen's Overidentification test is carried out to see whether the instruments are exogenous. The large p-values on the bottom of table 2.3 do not reject the null hypothesis that the instruments

[15]The estimated elasticity for horizontal FDI is 1.57 in table 2.3. The average growth rate of regulatory stringency in Ireland and Denmark are 1.29 and 9.30 percent, respectively. The economic effect of environmental regulation in Ireland would be 1.57*(9.30-1.29)% less horizontal FDI. Similarly, the effect on export-platform FDI could be calculated as 2.688*(9.30-1.29)%.

are exogenous in all three equations[16]. Regarding the other explanatory variables, GDP—representing the market potential of the host country—has its expected positive sign, indicating that FDI is generally attracted to wealthier countries. The coefficients on applied tariff rates are negative in two of the three columns and positive but not significantly different from zero in sales to the U.S., while in the OLS regression tariffs are not significant in either of the three columns. This implies that tariffs might serve as a barrier rather than an incentive for FDI. The estimated coefficients on exchange rates are negative in the OLS regression most of the time, but in the GMM estimation they become positive in all columns and statistically significant for export-platform FDI. Another difference between the OLS regression and the GMM-IV regression is the estimated coefficient on population. In table 2.2 population has positive signs for two of the three types of FDI, while in table 2.3 the coefficients are either negative or statistically not different from zero. The negative signs from the GMM-IV estimation are more plausible since given GDP, more population implies less GDP per capita, and FDI tends to be concentrated in rich countries. Corporate statutory tax rates, aggregate FDI stock and industry-level FDI agglomeration all have their expected signs and are statistically significant, showing that higher tax rates deter FDI and existing FDI accumulation attracts new FDI.

In summary, once the endogeneity of the environmental regulation is accounted for, the GMM-IV estimation gives an evidence supporting a PHE and more consistent estimates of other variables compared to the OLS regression. It also shows that export-platform FDI has the largest sensitivity to a change in environmental costs.

[16] To further test the relevance of the instruments, the joint significance of the four instruments in the first stage regressions for each type of FDI is tested. The results are provided in the appendix.

2.5.2 Third Country Effect

As suggested by various studies (Blonigen et al. (2007), Baltagi et al. (2007), Monteiro and Kukenova (2008)) FDI is affected by the "third-country effect" which posits that FDI in a host country also depends on characteristics of proximate countries. In terms of PHE, environmental regulation in countries that are proximate to a host country might also have impacts on FDI in that country. To test for this spatial interdependence, I add in two "third-country" variables. One is the spatial market potential represented by the weighted GDP of all other countries. The other is the weighted "third-country" environmental index which represents how strict and consistent environmental regulations are in proximate countries.

A common weight used in economic literature is the inverse of the distance from a country to the host country, although it still gives positive and small but non-zero weights to the countries that are quite far from the host country. I construct my weights as below so that countries in other regions that are far from the host country have almost zero weight[17].

$$weight_{i,j} = \exp\left(\frac{-d_{i,j}}{\min\limits_{k}(d_{i,k})}\right) \text{ if } j \neq i$$

where $d_{i,j}$ is the distance from country j to host country i[18]. The spatial environmental index is expected to positively affect host country FDI. If other countries have stricter environmental regulations and higher environmental costs than a host country, then the host country will be more attractive to MNCs, ceteris paribus. The sign of the spatial market potential, however, should be treated with caution. On one hand, FDI will be diverted to those proximate countries

[17] I also test using the inverse of distance to weight other countries' environmental index and the results are similar to the results in table 2.5. The magnitude of the coefficients on "third-country" environmental index are larger using these weights.

[18] The weights are also normalized to sum to 1.

with large markets so that spatial GDP has a negative effect on market-seeking FDI. On the other hand, export-platform FDI aiming directly to serve the neighboring countries will be attracted to countries with large surrounding market potentials. The story may be even more complicated. Blonigen et al. (2007) suggests that for export-platform FDI, the "third-country" market potential may have a negative effect because of the border costs. In their view, if the border costs between countries in a region are significant enough, MNCs could locate in the country with the largest own market potential which on the other hand has the smallest "third-country" market potential so as to avoid the border costs. Therefore, I turn to empirical evidence to identify the net effect of the spatial market potential.

Table 2.5 reports the estimates with the "third-country" variables included. First, the coefficients on the environmental index in host countries remain negative. After including the spatial variables, the coefficient on the environmental index for vertical FDI also becomes significant and the coefficient for export-platform FDI again has the largest magnitude. Second, although the spatial elasticities are not as large as the elasticities with respect to a host country's own regulation, they are positive and significant for all types of FDI. This supports PHE from another perspective: if the neighboring countries of a host country raise their environmental standards, it will make the host country a more favorable place for FDI. The magnitudes of the effect of spatial environmental regulations are quite similar across different types of FDI. Finally, the coefficients of the "third-country" market potential are negative and significant in all cases, which indicates that greater market potential in proximate countries will make a host country less desirable for FDI. The negative signs are also consistent with the results of Blonigen et al. (2007) which states that for export-platform FDI the border costs are so important that export-platform FDI tends to locate in

Table 2.5: GMM-IV estimates of U.S. affiliate sales with 3rd country effect

VARIABLES	(1) Local Sales	(2) Sales to U.S.	(3) Sales to Other
Environmental Index	-4.068***	-2.282**	-6.226***
	(1.161)	(1.145)	(1.930)
GDP	1.945***	1.142***	1.770***
	(0.316)	(0.398)	(0.536)
3rd Country Index	1.756***	1.719**	2.037*
	(0.574)	(0.719)	(1.067)
3rd Country GDP	-1.360***	-1.156***	-2.269***
	(0.277)	(0.307)	(0.478)
Tariffs	-0.183***	-0.1000	-0.294***
	(0.0604)	(0.0634)	(0.103)
Tax Rate	-0.391*	-1.893***	-1.754***
	(0.233)	(0.253)	(0.368)
Exchange Rate	0.247***	0.154**	0.377***
	(0.0750)	(0.0739)	(0.118)
Aggregate FDI Stock	0.638***	0.485***	1.219***
	(0.159)	(0.175)	(0.286)
Industrial FDI position	0.208***	0.266***	0.368***
	(0.0216)	(0.0281)	(0.0447)
Law and Order Index	1.381***	1.414***	2.217***
	(0.385)	(0.368)	(0.628)
Length of Road Network	0.354***	-0.0781	0.548**
	(0.131)	(0.146)	(0.229)
K/L Ratio	0.432***	-0.0553	0.319***
	(0.0635)	(0.0511)	(0.0867)
Distance	-0.438**	0.392	-0.248
	(0.222)	(0.298)	(0.415)
Population	-1.492***	-0.533	-1.909***
	(0.356)	(0.400)	(0.599)
Common Language	0.109	0.885***	0.114
	(0.133)	(0.173)	(0.213)
Constant	9.233**	6.885	25.97***
	(4.642)	(5.604)	(8.413)
Observations	1,156	1,184	1,036
R-squared	0.622	0.650	0.536
Overid p-value	0.995	0.214	0.648

All regressions include industry, year and regions dummies.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

countries with large own market potential and small border costs.

2.5.3 PHE in Countries with Stricter Regulations than the U.S.

Failing to empirically detect a PHE might be due to falsely assuming that the deterrent effect of environmental regulations is proportional to the stringency. Wagner and Timmins (2009) tried to include a second order term of environmental stringency in their regression but find no evidence supporting the specification. In my analysis, I propose that the deterrent effect to FDI will be stronger if the environmental index of a host country is higher than that of the home country (the United States). The justification for the hypothesis is that if MNCs have already upgraded their production technology in their U.S. headquarters to comply with the U.S. environmental standards, then they do not have to upgrade again in a host country with environmental standards below the U.S. level. MNCs are going to use their technology developed in the U.S. in host countries anyway. Therefore, MNCs will not be hurt when a host country raises its environmental standard as long as the new standard does not exceed the U.S. level. From this hypothesis, PHE will be more evident in countries with an environmental policy that is stricter than the U.S. policy. Taking the hypothesis into my regression, I expect a smaller (but larger in absolute value) slope of the environmental index in observations where the host country's environmental index is higher than the U.S. index.

To implement such a specification in the regression, I create a dummy variable indicating whether a host country's environmental index is greater than the U.S. index. The dummy variable D_{jt} is equal to one if the environmental index of country j at year t is greater than the US index at year t. Both the dummy and its interaction with the country's environmental index will be included in the regression. The interaction term is expected to have a negative coefficient suggesting that environmental regulations have a larger deterrent effect on FDI if a host country's regulation is stricter than the U.S. regulation. As the environmental index itself is endogenous, the dummy variable is probably also endogenous and so is the interaction term. To get consistent estimates of the two variables, notice that the dummy variable is constructed by comparing a host country index with the U.S. index. As a result the instruments for the host country's index can be used as instruments for the dummy variable as well. For the interaction term, I use the product of the instruments[19] as an instrument. The equation is still estimated with GMM-IV and results are shown in table 2.6.

The coefficients on the environmental index change signs in the last two columns and remain negative for horizontal FDI, yet none are significantly different from zero. This indicates that if a host country's environmental policy is not as strict as the U.S. policy, then it is less likely that FDI will be deterred by its environmental regulations. The interaction term is negative and significant for each type of FDI, which confirms our hypothesis that environmental regulations have a greater impact on FDI in countries with environmental standards higher than the U.S. standards. If we focus on countries with stricter environmental policies than the U.S., the elasticity of the environmental index are negative and significant for all types of FDI. The elasticity for horizontal FDI (2.698) is arithmetically smaller than that for vertical (4.723) and export-platform FDI (5.895), although we are still not sure whether they are statistically different.

The findings in table 2.6 stress the significance of relative regulatory stringency in detecting a PHE. Most earlier studies only consider environmental stringency

[19] Specifically the product of tractor per agriculture worker and the index for public school quality.

Table 2.6: GMM-IV estimates of U.S. affiliate sales with non-linear effect

VARIABLES	(1) Local Sales	(2) Sales to U.S.	(3) Sales to Other
Environmental Index	-0.466	2.100	2.405
	(1.030)	(1.754)	(2.210)
D_{jt}*Environmental Index	-2.232*	-6.822***	-8.301***
	(1.251)	(2.322)	(2.549)
D_{jt}	7.413*	23.50***	26.44***
	(4.091)	(7.752)	(8.331)
GDP	0.741**	-0.659	-1.297**
	(0.332)	(0.525)	(0.659)
Tariffs	-0.0654*	0.00119	-0.207**
	(0.0366)	(0.0527)	(0.0835)
Tax rate	-0.251	-2.033***	-1.870***
	(0.170)	(0.251)	(0.316)
Exchange Rate	-0.00345	-0.0916	-0.0725
	(0.0483)	(0.0842)	(0.0994)
Aggregate FDI Stock	0.304***	0.207	0.497**
	(0.0938)	(0.181)	(0.236)
Industrial FDI position	0.191***	0.241***	0.358***
	(0.0202)	(0.0279)	(0.0456)
Law and Order Index	0.625***	0.729**	1.330**
	(0.232)	(0.341)	(0.552)
Length of Road Network	0.0777	-0.433***	-0.0543
	(0.0857)	(0.150)	(0.197)
K/L Ratio	0.483***	0.00882	0.350***
	(0.0508)	(0.0580)	(0.0800)
Distance	-0.655**	0.463	-1.012
	(0.306)	(0.466)	(0.638)
Population	-0.219	1.334**	1.310*
	(0.333)	(0.581)	(0.712)
Common Language	0.148	0.767***	0.284
	(0.130)	(0.223)	(0.261)
Constant	-3.061	-5.063	6.953
	(2.722)	(4.335)	(6.494)
Observations	1,156	1,184	1,036
R-squared	0.742	0.637	0.597
Overid p-value	0.395	0.301	0.834

All regressions include industry, year and regions dummies.
Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

either in host countries or in parent countries, which ignores the possibility of a condition of relative stringency under which PHE will become more significant. The results also show that tightening environmental regulations in host countries which are less regulated than the home country only has marginal effects on FDI since MNCs could simply transfer or are already using less pollution intensive technologies developed in their home country. This is consistent with a Pollution Halo Effect that MNCs sometimes bring advanced and clean technologies to host countries with poor environmental regulations to help improve environmental status there. Our hypothesis does not treat Pollution Halo Effect and Pollution Haven Effect as exclusive, and our empirical findings suggest that their existence depends on the relative strictness of environmental regulations between home countries and host countries.

2.5.4 Difference in Sensitivities

For all of the regressions in previous sections the effect of environmental regulations are estimated separately for each type of FDI, which makes it difficult to test whether coefficients are statistically different across equations. In this section, I regress the three equations simultaneously so that cross equation constraints can be tested. A system of three equations of horizontal, vertical and export-platform FDI is estimated using 3-stage least squares. One caveat is that in order to estimate the three equations simultaneously a host country needs to have non-missing values for all three types of FDI. As a result, the sample size is greatly reduced for each equation.

First I estimate the three equations in table 2.3 as a system of equations and allow the standard errors to be correlated across equations. Table 2.7 compares the estimated coefficients on environmental stringency from a system of equations and the coefficients in table 2.3. The estimates are of larger magnitudes from the simultaneous regression than they are estimated separately. This probably is a result of the reduction of about 25% in sample size as shown in table 2.7. The relative magnitudes across equations remain the same with the coefficient for export-platform FDI being the greatest. After allowing for possible correlations between equations, we can directly test the prediction of the model on difference in sensitivities. Specifically we want to test whether the magnitudes of the coefficients for vertical and export-platform FDI are statistically greater than that for horizontal FDI. The results reported in the bottom part of table 2.7 suggest that although the coefficient for export-platform FDI is arithmetically smaller than that for horizontal FDI, the two estimates are not statistically different.

Table 2.7: Simultaneous Regression of the Baseline Specification

	Separate Regression		
VARIABLES	Local Sales	Sales to U.S.	Sales to Other
Environmental Index	-1.570***	-0.490	-2.688**
	(0.536)	(0.737)	(1.111)
Observations	1,156	1,184	1,036
	Simultaneous Regression		
VARIABLES	Local Sales	Sales to U.S.	Sales to Other
Environmental Index	-2.492***	-1.129	-3.897**
	(0.921)	(1.181)	(1.551)
Observations	847	847	847
	Difference from the Coefficient for Local Sales		
$\beta^{Index} - \beta^{Index}_{Local}$	-	1.363	-1.405
	(-)	(1.193)	(1.144)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As discussed in section 5.3, the environmental regulations might be more relevant to FDI decisions in countries with stricter regulations than the United States.

Therefore, the difference in sensitivities implied by the model might be more evident when the environmental index exceeds the U.S. index. In table 2.8, I regress the equations of the specification with the dummy variable in table 2.6 simultaneously as a system of equations. If we consider countries with environmental regulations stricter than the U.S. regulations, the elasticities of the environmental index become greater in magnitude when we estimate the three equations simultaneously but the coefficient for horizontal FDI remains the smallest in magnitude. In the bottom part of table 2.8, I test the difference between the coefficients across different types of FDI and find that the coefficient for export-platform FDI is statistically greater than that for horizontal FDI in magnitude. The difference between the coefficients for vertical FDI and horizontal FDI, however, is still not significantly different from 0. After accounting for the relative stringency between host country and home country environmental regulations, I find that the sensitivity of export-platform FDI is statistically greater than that of horizontal FDI to local environmental policies, which directly supports the model's prediction.

2.6 Concluding Remarks

This paper constructs a model that shows how horizontal FDI and vertical FDI are distinct in responding to a stricter environmental policy. The model describes a Cournot and a Bertrand competition equilibrium in which MNCs compete with a local firm either in their home country or in their host country. Because the competitors of the two types of MNCs are affected in different ways by host country environmental regulations, horizontal MNCs are less sensitive to a tightening of environmental policy than vertical MNCs. The prediction of the model also applies to the difference between horizontal and export-platform FDI. Previous failures to empirically detect a PHE may arise because PHE is less significant on

Table 2.8: Simultaneous Regression of the Non-Linear Specification

	Separate Regression		
VARIABLES	Local Sales	Sales to U.S.	Sales to Other
Environmental Index(β_1)	-0.466	2.100	2.405
	(1.030)	(1.754)	(2.210)
$D_{j,t}$*Index(β_2)	-2.232*	-6.822***	-8.301***
	(1.251)	(2.322)	(2.549)
Observations	1,156	1,184	1,036
$\beta_1 + \beta_2$	-2.698***	-4.723***	-5.895***
	(0.970)	(1.644)	(1.818)

	Simultaneous Regression		
VARIABLES	Local Sales	Sales to U.S.	Sales to Other
Environmental Index(β_1)	-1.210	2.970	1.645
	(1.468)	(2.176)	(2.597)
$D_{j,t}$*Index(β_2)	-2.246	-8.649***	-10.12***
	(1.970)	(2.922)	(3.486)
Observations	847	847	847
$\beta_1 + \beta_2$	-3.456***	-5.679***	-8.476***
	(1.211)	(1.796)	(2.143)

	Difference from the $\beta_1 + \beta_2$ for Local Sales		
$(\beta_1 + \beta_2) - (\beta_1^{Local} + \beta_2^{Local})$	-	-2.223	-5.020***
	(-)	(1.939)	(1.749)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

certain types of FDI.

In addition, I empirically test the prediction of the model using sales of U.S. affiliates abroad which are categorized to represent the three types of FDI and a survey measure of both the stringency and enforcement of host country environmental regulations. First, I find that it is critical to treat environmental policy as endogenously determined, as shown by many previous studies. Simple OLS estimation would greatly bias the estimates. After accounting for the endogeneity of environmental regulations, I find that host country environmental policies have significant deterrent effect on horizontal and export-platform FDI. The negative impact of environmental policies on FDI is also economically significant. If a country with small changes in its environmental regulations experienced a greater increase in environmental regulatory stringency as some other countries, it would have lost about 12% of its horizontal U.S. FDI and 21% of its export-platform U.S. FDI. In addition to host country regulations, stricter regulations in countries that are proximate to a host country also make the host country more desirable for investment and lead to more FDI of all types in the host country. Furthermore, it is critical to take into account of the relative regulatory stringency between host countries and home countries in order to detect a PHE. I find evidence that in countries with stricter regulation than the U.S. the deterrent effect of environmental regulations is much more stronger. Lastly, estimating PHE on the three types of FDI in a system of equations allows me to directly test the model's prediction regarding differences in sensitivities. The results indicate that when the relative stringency if controlled for, export-platform FDI is more sensitive to environmental regulations than horizontal FDI, which supports the prediction of the model.

Future studies may extend the current work in various ways. The model only includes two types of FDI and an exogenously determined environmental policy.

Therefore it is only a partial equilibrium model. A possible extension could add the other side of the story by introducing how the environmental cost s is optimally determined by host country government to derive a general equilibrium. Modeling explicitly how export-platform FDI responds to environmental policy changes rather than simply assuming it is similar to vertical FDI in the current work could be another goal to achieve. Moreover, using affiliate sales to different destinations to represent different types of FDI is only an approximate measure. More detailed data on the content and intended use of the products would help to better distinguish FDI of different natures. In summary, this paper lays out a new path for the study of how cross country differences in environmental regulations affect FDI and underlines that such effects may be more or less evident depending on the nature of FDI.

2.7 Appendix

Derivation of equation (9)

Given $c_{lY} = c_{lH} = c_h = c_v = \hat{c}$, $b_i^h = b_i^v = \hat{b_i}$ and $k_h = k_v = \hat{k} = \frac{s}{\hat{b_n}}n$, (7) can be rewritten as

$$\begin{aligned} TX_h &= \sum_{i=\hat{k}+1}^{n} \frac{A - \hat{c} - \sum_{j=\hat{k}+1}^{n} \hat{b_j} + (n+2)\hat{b_i} - (\hat{k}+1)s}{(n+2)B} \\ &= (n-\hat{k})\frac{A - \hat{c} - (\hat{k}+1)s}{(n+2)B} - (n-\hat{k})\frac{\sum_{j=\hat{k}+1}^{n} \hat{b_j}}{(n+2)B} + (n+2)\frac{\sum_{i=\hat{k}+1}^{n} \hat{b_i}}{(n+2)B} \\ &= (n-\hat{k})\frac{A - \hat{c} - (\hat{k}+1)s}{(n+2)B} + (\hat{k}+2)\frac{\sum_{i=\hat{k}+1}^{n} \hat{b_i}}{(n+2)B} \\ &= (n-\hat{k})\frac{A - \hat{c} - (\hat{k}+1)s}{(n+2)B} + \frac{\hat{k}+2}{(n+2)B}\frac{(s+\hat{b_n})(n-\hat{k})}{2} \\ &= (n-\frac{s}{\hat{b_n}}n)\frac{A - \hat{c} - (\frac{s}{\hat{b_n}}n+1)s}{(n+2)B} + \frac{\frac{s}{\hat{b_n}}n+2}{(n+2)B}\frac{(s+\hat{b_n})(n-\frac{s}{\hat{b_n}}n)}{2} \end{aligned} \quad (2.21)$$

The fourth equation in (21) is because $\hat{b}_{\hat{k}+1} = s$ and as $\hat{b_i}$ $(i = 1, ..., n)$ are uniformly distributed over $[0, \hat{b_n}]$, $\sum_{i=\hat{k}+1}^{n} \hat{b_i} = \frac{(s+\hat{b_n})(n-\hat{k})}{2}$.

Similarly, (8) can be rewritten as

$$TX_v = \sum_{i=\hat{k}+1}^{n} \frac{A - \hat{c} - \sum_{j=\hat{k}+1}^{n} \hat{b_j} + (n+2)\hat{b_i} - (\hat{k}+2)s}{(n+2)B}$$

$$= (n - \frac{s}{\hat{b_n}} n) \frac{A - \hat{c} - (\frac{s}{\hat{b_n}} n + 2)s}{(n+2)B} + \frac{\frac{s}{\hat{b_n}} n + 2}{(n+2)B} \frac{(s + \hat{b_n})(n - \frac{s}{\hat{b_n}} n)}{2} \tag{2.22}$$

Divide (21) by (22), we have

$$\frac{TX_h}{TX_v} = \frac{A - \hat{c} - (\frac{s}{\hat{b_n}} n + 1)s + \frac{1}{2}(\frac{s}{\hat{b_n}} n + 2)(s + \hat{b_n})}{A - \hat{c} - (\frac{s}{\hat{b_n}} n + 2)s + \frac{1}{2}(\frac{s}{\hat{b_n}} n + 2)(s + \hat{b_n})}$$

$$= \frac{-\frac{1}{2} ns^2 + \frac{1}{2} n\hat{b_n} s + \hat{b_n}^2 + (A - \hat{c})\hat{b_n}}{-\frac{1}{2} ns^2 + (\frac{1}{2} n - 1)\hat{b_n} s + \hat{b_n}^2 + (A - \hat{c})\hat{b_n}} \tag{2.23}$$

Differentiate (23) with respect to s leads to equation (9).

Derivation of equation (18)

Given $c_{lY} = c_{lH} = c_h = c_v = \hat{c}$, $b_i^h = b_i^v = \hat{b_i}$, $k_h = k_v = \hat{k} = \frac{s}{\hat{b_n}} n$ and $\hat{b_n} = \theta \hat{c}$, (16) can be rewritten as

$$TX_h = \frac{2nB(\theta\hat{c} - s)}{\theta^2 \hat{c}^2 (2B + C)(2B - nC)} (Q\hat{c}^2 + Q_1 \hat{c} - \frac{1}{4} ns^2 BC) \tag{2.24}$$

where

$$Q = \frac{1}{2}\theta \left[(B^2 - (n-1)BC - \frac{1}{2} nC^2)\theta - 2(B - nC)(B + \frac{1}{2} C) \right]$$

and

$$Q_1 = -\frac{1}{2} sB^2 + (\frac{3}{4} nsC + A)B + \frac{1}{2} C(\frac{1}{2} nsC + A).$$

Similarly,

$$TX_v = \frac{2nB(\theta\hat{c} - s)}{\theta^2 \hat{c}^2 (2B + C)(2B - nC)} (Q\hat{c}^2 + Q_2 \hat{c} - \frac{1}{4} ns^2 BC) \tag{2.25}$$

where

$$Q_2 = -\frac{1}{2}sB^2 + (\frac{3}{4}(n - \frac{2}{3})sC + A)B + \frac{1}{2}C(\frac{1}{2}nsC + A).$$

Then the ratio of the two types of MNCs' total sales can be obtained as

$$\frac{TX_h}{TX_v} = \frac{Q\hat{c}^2 + Q_1\hat{c} - \frac{1}{4}ns^2BC}{Q\hat{c}^2 + Q_2\hat{c} - \frac{1}{4}ns^2BC} \tag{2.26}$$

Differentiate the ratio with respect to s will give equation (18).

First Stage Regression Results

The first row reports the joint significance of all instruments in regressing the endogenous variable (environmental index) on all exogenous variables. Each column reports the F statistics of all instruments using corresponding sample from each regression in table 2.3. The second row reports the joint significance of all instruments in explaining the other endogenous variable (GDP). As shown in table 2.8, the exogenous instruments are jointly significant in every case.

Table 2.9: First Stage F-test Statistics of the Instruments

	(1)	(2)	(3)
Endogenous Variables	Local Sales	Sales to U.S.	Sales to Other
Environmental Index	15.51	17.43	12.84
	(0.000)	(0.000)	(0.000)
GDP	159.17	110.58	119.41
	(0.000)	(0.000)	(0.000)
Observations	1,156	1,184	1,036

p-value in parentheses

List of industries and countries included in the sample

Industries: mining; food; chemicals; primary and fabricated metals; machinery; computers and electronic products; electrical equipment, appliances, and components; transportation equipment.

Countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Costa Rica, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Finland, France, Germany, Greece, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Nigeria, Norway, Panama, Peru, Philippines, Poland, Portugal, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, Venezuela.

List of countries in each region

Europe: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Netherlands, Norway, Ireland, Italy, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Central Asia: Czech Republic, Hungary, Poland, Russia, Turkey.

Asia Pacific: Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand.

Mideast and Africa: Egypt, Israel, Nigeria, South Africa.

Latin America: Argentina, Brazil, Chili, Colombia, Costa Rica, Dominican Republic, Ecuador, Honduras, Panama, Peru, Venezuela.

Chapter 3

The Asymmetric Effect of Corporate Tax Rates on Various FDI types: Evidence from a Panel of U.S. Outward FDI

3.1 Introduction

In the last few decades, foreign direct investment (FDI) has played an important role in promoting the economic growth of both developing and developed countries. United Nations data show that even though the 2007 crisis slowed FDI flows to developed countries, FDI flows to developing and transition economies have grown steadily and exceed FDI flows to developed countries in 2010. The significant benefits of inward FDI to host countries have been confirmed in the economics literature[1]. Foreign multinational enterprises (MNEs) not only bring productive capital and employment opportunities to host countries but also generate secondary spillovers to host countries' productivity through technology diffusion[2].

Policy instruments adopted by host country governments to attract FDI have contributed to the growth of FDI flows. Local corporate income tax rates are widely considered a critical determinant of FDI flows by many economists. During the past decade, many countries have reformed their corporate tax system in order

[1] Görg and Greenaway (2004) provide a thorough survey of studies on benefits of FDI to host countries.

[2] see Xu (2000) and Wang and Blomström (1992).

to become more competitive in the world market, which has the potential to affect MNEs' investment decisions. Theoretically, if capital is fully mobile, it will flow to jurisdictions with higher after-tax returns.

The tax-elasticity of FDI flows and the impact of taxes on MNEs' locational decisions have been studied by a long list of economists. According to a detailed survey of 25 empirical studies on tax-elasticities by De Mooij and Ederveen (2003), the median tax-elasticity of FDI is -3.3. However, the estimated tax-elasticity can vary substantially by the type of FDI data used, the measures of tax rates and the countries included in the sample. Another review of the literature by Devereux et al. (2007) also points out that different tax rates, such as effective average tax rate (EATR), effective marginal tax rate (EMTR) and statutory tax rate, are not equally important in MNEs' investment decisions. To make more refined policy predictions, researchers should study the conditions under which tax rates are more likely to affect FDI flows, which tax rate is most relevant to different types of FDI, and what type of FDI is more likely to respond to differences in tax rates.

In this study, I complement the extant literature by investigating how MNEs with different motivations for FDI are affected by host country tax. Mutti and Grubert (2004) provide some evidence of the asymmetric effect of average effective corporate income tax rates on export-oriented FDI and local market-oriented FDI. They found that the degree to which U.S. MNEs depend on the local market of host countries has a significant impact on the effect of tax rates. However, they did not separate local market-oriented FDI from export-oriented FDI. If the type of FDI that is insensitive to local tax rates is mixed with the type that is sensitive, as in most studies that use aggregated measures of FDI, the estimated coefficient on tax rates may be biased.

The aim of this study is to distinguish different types of FDI and directly test whether they are equally affected by host country tax rates. I use the destination of affiliate sales to divide FDI activities into three categories — the horizontal, vertical and export-platform types of FDI — and examine whether these distinct types of FDI have different sensitivities to local tax rates. Horizontal FDI refers to MNEs that are local-market oriented and use affiliates to serve the local market of host countries. Vertical FDI refers to MNEs that shift some stages of production to host countries and then sell the output back to their home countries. Export-platform FDI refers to MNEs that use host countries as a platform to serve other proximate countries.

Some researchers claim that horizontal FDI is less sensitive to differences in local tax rates since physically being in the local market is more important than cost saving to horizontal MNEs. A formal model that explains the difference in sensitivity of various types of FDI to local environmental tax rates is provided in Tang (2012). The study developed a partial-equilibrium model that shows how an increase in local environmental tax rates affects the different types of FDI. The model predicts that MNEs that compete with firms outside host countries, i.e., vertical and export-platform MNEs, are more sensitive to local environmental costs than horizontal MNEs, which mainly compete with local firms in host countries. A possible reason for such a difference is that when a host country raises the stringency of its environmental regulations, both the horizontal type MNEs and their local competitor are affected by the associated higher cost. However, for the affected vertical type and export-platform types of MNEs, their competitors which are located outside the host country are not impacted by the higher environmental costs. Such a prediction can also be applied to the impact of local corporate tax rates on different types of MNEs.

I find that local corporate income tax rates have a negative and significant impact on vertical and export-platform FDI but not on horizontal FDI, which is consistent with the hypothesis regarding the asymmetric tax effect. Using

U.S. foreign affiliate sales to host countries, to the United States and to other foreign countries as proxies for horizontal, vertical and export-platform FDI and a dynamic investment equation, I find that sales back to the United States and sales to other foreign countries are negatively affected by the contemporaneous and lagged statutory corporate income tax rates. The coefficients on tax rates for local sales are not statistically different from zero. Such results suggest that even though many studies suggest that local taxes in host countries have a deterrent effect on inward FDI, the deterrent effect can vary greatly across FDI of different types. The asymmetric tax effect found in the baseline regression is also confirmed in several robustness tests.

In addition, the baseline regression results suggest distinctively different effects of taxes on vertical and export-platform FDI, which can hardly be explained by theory. A possible reason for such a distinctive difference is that sales to other foreign countries used to represent export-platform FDI include both sales to affiliated persons and sales to unaffiliated persons and the former is likely to be vertical FDI. Sales to affiliated persons in other foreign countries are typically products sold to other affiliates with the same U.S. parent for further processing before exporting back to the United States and therefore may be closer to vertical FDI rather than export-platform FDI. After distinguishing between sales to affiliated and to unaffiliated persons, I get more plausible results of the tax effect on export-platform FDI.

Finally, I test whether different types of FDI respond to tax rates in countries other than the host and home countries of a MNE. The spatial dependence of FDI on other countries' characteristics has been discussed in several papers but none have examined whether the spatial effect varies across different types of FDI. I find that similar to host country tax rates, third country tax rates have a greater impact on vertical and export-platform FDI than on horizontal FDI. Moreover, the effects of corporate income tax rates in countries proximate to a host country are opposite for vertical and export-platform FDI.

The rest of the study is structured as follows. In the next section, I review related literature on the impact of taxes on FDI. Section 3 describes the data used and the econometric models. Section 4 presents the baseline regression results and section 5 discusses some robustness tests. Sections 6 and 7 discuss the issue of sales to affiliated versus to unaffiliated persons and the effect of third country rates. Section 8 draws final conclusions.

3.2 Literature Review

Early studies on the tax affect of FDI trace back to Hartman (1984) and Hartman (1985). In his papers, Hartman investigated how tax changes through investment incentives and saving incentives can have different impacts on FDI in the United States and demonstrated some corresponding welfare implications. He also differentiated FDI initiated from retained earnings and that from new transfers of capital. For "mature" MNEs which mostly finance their investment by investing earnings, they are subject to both host and home country tax rates when they repatriate their foreign profits or pay dividends to their parent firms. As home country taxes are probably unavoidable to the "mature" MNEs, Hartman hypothesized that home country tax rates would be less relevant to "mature" MNEs. On the contrary, "immature" MNEs which rely heavily on funds from their parent firms to finance overseas investment will respond to home country tax rates. In the empirical test of his hypothesis, Hartman did not use tax rates in the home countries of the MNEs investing in the United States but simply assumed that such an omission will not generate significant differences in the estimation results.

There are many studies of the effect of taxes on FDI in the United States and on U.S. FDI abroad in the 1980s and 1990s since the United States was the largest source country of outward FDI and also was the largest host country of inward FDI during that period. Grubert and Mutti (1991) and Hines and Rice (1994) use aggregate data on U.S. outward FDI from the U.S. Bureau of Economic Analysis (BEA) to examine the effect of tax rates on the stock of property, plant and equipment of U.S. MNEs. Both papers find a significant tax coefficient but the magnitudes are quite different. The estimated tax elasticity is 0.11 in Grubert and Mutti (1991) and 3.3 in Hines and Rice (1994). This is probably because the latter study focused on U.S. MNEs in tax havens.

Devereux and Griffith (1998) analyze the discrete location choices made by MNEs instead of the extent to which existing FDI will be affected by local tax rates. The authors used firm level panel data from Standard and Poor's Compustat dataset to test how U.S. firms' investment in European countries is affected by cross-country tax differentials. The research demonstrates that differences in EATRs have a significant impact on U.S. firms' decision of choosing which European countries to invest in but not on the decision of whether to invest in or out of Europe. EMTRs, nevertheless, show no predictive power in explaining U.S. MNEs' investment behavior. One caveat that should be mentioned is that these results depend on some strict assumptions made regarding firms' choices. For example, firms are only allowed to make investment in one foreign country.

Another reason to study the U.S. inward and outward FDI is that the United States experienced a major tax reform in 1986, the Tax Reform Act 1986 (TRA 1986), which provided a great opportunity for researchers to investigate its impact on FDI. Altshuler et al. (2000) use a panel data of U.S. FDI from the U.S. Department of Treasury to study changes in the sensitivity of U.S. MNEs to differences in tax rates across foreign jurisdictions. They find that over the period of 1984 to 1992, there was a significant increase in the tax elasticity of

U.S. MNEs' foreign capital from 1.5 to 2.8 for U.S. manufacturing MNEs. The authors believe that one of the reasons for such an increase in tax elasticity is that the TRA 1986 lowered the excess foreign tax credit expectations.

Recent studies of the effect of taxes on FDI have began to focus on countries other than the United States, but are restricted to developed countries or European countries due to the availability of data. Bénassy-Quéré et al. (2005) use a gravity model to study the impact of tax differentials on a panel of bilateral FDI among 11 OECD countries. They also adopt alternative measures of tax rates from the related literature for comparison, including statutory corporate tax rates, the AETR and the METR. Besides confirming that in general higher tax rates deter FDI inflows, their results also suggest an asymmetric effect of higher taxes and lower taxes. While higher taxes discourage MNEs from investing, lower taxes do not attract foreign MNEs. They also find that such an asymmetry in the effect of taxes on FDI only applies to countries with the worldwide system but not those with the territorial system. This is because the former react linearly to tax differentials while the latter can use partial crediting arrangement to cancel out small tax differentials but not large differentials. Bellak and Leibrecht (2009) use similar strategies to study the tax effect on FDI flows from the European Union and the United States to Central and East European countries. Using EATRs in both host and home countries, they find a tax semi-elasticity of FDI of 4.3 which is greater than the estimates in many previous studies.

There are also several studies that use firm level data in European countries. Buettner and Ruf (2007) look at German MNEs' investment location choices using a firm level panel data from German MNEs. Their logit regression results suggest that the effects of tax rates on MNE's location decisions are most significant when statutory rates are used. No evidence of tax sensitivity is found when effective marginal rates are used. This is consistent with Devereux and

Griffith (1998)'s results regarding the impact of different tax rates on U.S. firms' investment decisions.

Becker et al. (2012) use a more detailed firm level data from AMADEUS to study the effect of tax rates on both the quantity and the quality of FDI. The hypothesis is that two FDI projects of the same amount of investment can be qualitatively different to host countries in terms of welfare. This hypothesis implies that policy makers should consider not only how corporate tax rates affect the amount of inward FDI but also the welfare implications associated with changes in the structure of FDI. The results of the paper show that the negative quantity effect of higher tax rates on FDI is partly mitigated by the quality effect of higher tax rates on labor income.

Although some previous studies have addressed the issue that tax rates can have asymmetric impact on FDI of different nature[3], none have explicitly investigated how different types of FDI may respond to variation in local tax rates. Some MNEs' FDI is motivated by high trade barriers in host countries and similar relative factor endowments between host and home countries. Such MNEs establish affiliates in foreign host countries mainly to circumvent possible trade costs and serve the local markets of host countries. Markusen (1984) and Markusen and Venables (1998) provide the theoretical foundation of this type of FDI which is called horizontal FDI.

A different type of FDI refers cases where MNEs shift some stages of production to their affiliates in host countries mainly because input prices are cheaper in the host country. FDI arising from differences in relative factor endowments is

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[3]For example, the distinction between "mature" and "immature" MNEs in Hartman (1985), manufacturing MNEs versus financial MNEs in Harris (1993) and Altshuler and Hubbard (2003), and MNEs from worldwide system countries versus those from from territorial system countries in Bénassy-Quéré et al. (2005).

called vertical FDI and is modeled in **?**. The paper describes a general equilibrium model in which a firm engages in international intrafirm trade when the firm possesses a firm-specific asset that can serve multiple plants without incurring any extra cost once produced.

The third type of FDI, export-platform FDI, emerged with the rapid development of trade liberalization and the formation of free trade agreements (FTA) in many parts of the world, such as the North American Free Trade Agreement (NAFTA). MNEs typically choose one country in a group of countries under the same FTA as a low cost location and use that country as a platform to serve markets in the other countries.

Mutti and Grubert (2004) provide some evidence that the degree to which U.S. MNEs depend on the local market of host countries affects the impact of tax rates. Their results suggest that the more a MNE depends on local sales to host countries, the less it will be affected by local tax rates as it needs to physically stay in the country to access the local market. However, there is no theoretical background provided by the authors regarding such a hypothesis. Tang (2012) develops a partial-equilibrium model that shows local market oriented FDI is less sensitive than export-oriented FDI to changes in local environmental costs. This study extends the analysis in Tang (2012) to the impact of local tax rates on different types of FDI.

3.3 Data and Regression Strategy

I categorize different types of FDI according to the destinations of U.S. foreign affiliate sales. The affiliate sales data is from the financial and operating statistics of U.S. MNEs produced by the BEA. The affiliates included in the sample are majority-owned nonbank foreign affiliates[4] of nonbank U.S. parents. The BEA reports data on U.S. foreign affiliate sales to the country where the affiliates are located, to the United States and to foreign countries other than the country where the affiliates are located. The three types of sales are used to represent the horizontal, vertical and export-platform type of FDI activities, respectively. The sample includes 47 developed and developing countries over the 12 year period 1998 to 2009.

There are at least two reasons why the affiliate sales data is more suited to this study than FDI flow data. First, the data on U.S. FDI flows measures financial flows which are different from flows of capital in a number of dimensions. Second, the model in Tang (2012) suggests that the asymmetric effect on FDI fall on MNEs' output which is better represented by affiliate sales.

Table 3.1 shows the composition of U.S. foreign affiliate sales by sample year and by region. As shown in the upper panel, U.S. FDI is largely horizontal investment. Local sales of U.S. foreign affiliates constitute about 60% to 65% of total affiliate sales. Sales back to the United States constitute about 10% and sales to other foreign countries constitute about 25% to 30%.

The fractions of the three types of FDI have changed over time. Horizontal type sales decreased from approximately 65% in the late 1990s to about 60% after 2004. This decrease was accompanied by an increase in export-platform FDI from below 25% to about 30%. Vertical FDI is relatively more stable than the other two types remaining at about 10% for most of the sample years.

The lower panel of table 3.1 shows the average values and percentages of the three types of U.S. FDI over the sample period in different regions. Canada attracted a large portion of horizontal and vertical FDI, which suggests that U.S.

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[4]According to the definition of the BEA, a majority-owned foreign affiliate is defined as a "foreign affiliate in which the combined ownership of all U.S. parents exceeds 50 percent".

FDI activities in Canada rarely involve a third country. Vertical FDI also makes up a large fraction of total FDI in Latin America, Africa and the Middle East. European countries and Asia and Pacific countries, because of their large market potentials and long distance from the U.S. continent, are the major targets of U.S. horizontal and export-platform type MNEs. More than 90% of the U.S. affiliate sales in Europe and Asia and Pacific are either local sales or sales to other foreign countries.

Table 3.1: Composition of U.S. Foreign Affiliate Sales, in Millions of Dollars

	Local Sales		Sales to US		Sales to Other	
Year	Dollars	% of Total	Dollars	% of Total	Dollars	% of Total
1998	1275436	64.68	211533	10.73	484940	24.59
1999	1494903	67.37	230975	10.41	493067	22.22
2000	1649526	65.79	287885	11.48	570022	22.73
2001	1626631	64.43	272066	10.78	625762	24.79
2002	1622688	64.50	274374	10.91	618580	24.59
2003	1832682	63.96	292746	10.22	739798	25.82
2004	2051165	61.92	354535	10.70	906831	27.38
2005	2289801	60.47	404112	10.67	1092953	28.86
2006	2495885	59.87	443856	10.65	1229261	29.49
2007	2778975	58.60	495560	10.45	1468064	30.95
2008	3048457	58.60	519161	9.98	1634573	31.42
2009	2953315	60.81	432005	8.89	1471690	30.30
	Local Sales (Average)		Sales to US (Average)		Sales to Other (Average)	
Region	Dollars	% of Total	Dollars	% of Total	Dollars	% of Total
Canada	302363	73.74	95539	23.30	12138	2.96
Europe	1022756	57.23	108075	6.05	656180	36.72
Latin America	240077	61.46	69410	17.77	81115	20.77
Africa	31092	57.04	10616	19.48	12797	23.48
Middle East	13648	53.03	5035	19.57	7051	27.40
Asia and Pacific	483144	66.99	62735	8.70	175347	24.31

Source: The U.S. Bureau of Economic Analysis

Various measures of tax rates have been used in the empirical studies of the effect of taxes on FDI. Devereux et al. (2007) argue that the effective average rate is more relevant to the discrete decision of investment location while the effective marginal rate is more relevant to the scale of investment. Given that the measure of FDI activities used in this study is the scale of affiliate sales, marginal effective rates are the most appropriate rates for the purpose of this study. However, the sample includes a large number of developed and developing countries and there is no information on EMTRs available for all the countries in the sample over the time period[5]. In addition, since MNEs can defer the repatriation of profits back to their home country, effective tax rates on MNEs may be different from those on domestic firms in host countries. Given the complexity of taxes on MNEs and the availability of data, I use the statutory corporate income tax rates from the Heritage Foundation in my analysis. The rates reported by the Heritage Foundation are the basic central government statutory corporate income tax rates and the data covers more than 190 countries all over the world.

Table 3.2 presents information on tax rates for each of the countries included in the sample. The countries are ranked by their average percent changes in s-tatutory corporate tax rates between 1998 and 2009. As shown in the table, most countries experienced a decrease in their statutory corporate tax rates during the sample period. Of all the 47 countries, only eight have a positive average percent change in tax rates and only Hungary, Chile and Brazil had an average increase over 1%. For those countries that reduced their corporate income tax rates, Germany and Ireland have the largest two reductions on average, followed by Poland and the Czech Republic. The last two rows of table 3.2 show the weighted statistics for developing and developed countries respectively[6]. Developed countries on average have a greater reduction in corporate tax rates than developing countries.

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[5]Devereux et al. (2002) calculated EATRs and EMTRs for a group of 19 countries using the statutory rate, depreciation rates, financial returns and discount rates and the data is available from the Institute for Fiscal Studies. However, the calculations of EATRs and EMTRs only apply to developing countries.

[6]For the last two rows, the mean, standard deviation and average percent changes are weighted by each country's average GDP.

Table 3.2: Statutory Corporate Income Tax Rate by Country

Country	**Mean**	**S.D.**	**Min**	**Max**	**Average Change (%)**
Germany	29.14	9.90	15.83	47.48	-8.02
Ireland	17.29	7.04	12.50	32.00	-7.76
Poland	24.75	6.50	19.00	36.00	-5.20
Czech Republic	28.17	4.93	21.00	35.00	-4.40
Turkey	27.73	6.23	20.00	33.00	-4.15
Greece	33.21	5.94	25.00	40.00	-4.06
Barbados	35.08	5.94	25.00	40.00	-3.96
Canada	24.43	3.72	19.50	29.12	-3.49
Singapore	22.75	2.92	18.00	26.00	-3.16
Honduras	28.80	5.80	25.00	40.30	-3.15
Russia	28.58	5.66	24.00	35.00	-2.86
Netherlands	31.76	4.12	25.50	35.00	-2.73
Denmark	29.08	2.97	25.00	34.00	-2.68
Portugal	28.50	3.85	25.00	34.00	-2.62
Israel	37.55	3.44	31.40	41.25	-2.57
Italy	33.67	3.33	27.50	37.00	-2.53
Austria	30.25	4.63	25.00	34.00	-2.41
Korea, Republic of	26.62	1.87	25.00	30.80	-2.01
South Africa	30.92	2.54	28.00	35.00	-1.92
Mexico	32.00	3.10	28.00	35.00	-1.70
France	36.23	2.39	34.43	41.66	-1.70
Australia	31.33	2.46	30.00	36.00	-1.57
Belgium	36.58	3.20	33.99	40.20	-1.40

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Table 3.2 – *Continued from previous page*

Country	**Mean**	**S.D.**	**Min**	**Max**	**Average Change (%)**
Spain	33.96	1.98	30.00	35.00	-1.35
India	35.13	2.01	33.00	40.00	-1.33
Malaysia	27.92	0.90	26.00	30.00	-1.27
China	30.58	2.27	25.00	33.00	-1.21
Japan	30.38	1.30	30.00	34.50	-1.19
United Kingdom	29.75	0.87	28.00	31.00	-0.90
New Zealand	32.50	1.17	30.00	33.00	-0.83
Finland	27.58	1.44	26.00	29.00	-0.62
Colombia	35.63	1.84	33.00	38.50	-0.44
Costa Rica	30.00	0.00	30.00	30.00	0.00
Indonesia	30.00	0.00	30.00	30.00	0.00
Panama	30.00	0.00	30.00	30.00	0.00
Sweden	28.00	0.00	28.00	28.00	0.00
Switzerland	8.50	0.00	8.50	8.50	0.00
Thailand	30.00	0.00	30.00	30.00	0.00
Venezuela	34.00	0.00	34.00	34.00	0.00
Hong Kong	16.75	0.69	16.00	17.50	0.06
Philippines	33.58	1.44	32.00	35.00	0.06
Peru	29.93	1.02	27.00	31.10	0.14
Norway	27.65	1.23	23.75	28.00	0.25
Argentina	34.50	0.90	33.00	35.00	0.55
Hungary	18.11	1.36	16.00	20.00	1.15
Chile	16.14	0.95	15.00	17.00	1.28
Brazil	21.42	8.47	15.00	34.00	9.33

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Table 3.2 – *Continued from previous page*

Country	**Mean**	**S.D.**	**Min**	**Max**	**Average Change (%)**
Developed	27.94	8.50	47.50	3.00	-2.26
Developing	28.86	15.00	40.30	3.22	-1.39
Source: The Heritage Foundation					

Since local tax rates are not the sole determinant of FDI inflows, other variables that affect inward FDI need to be included to control for the effect of taxes. There is a large literature using the gravity model of trade to predict the FDI flows between countries and the gravity specification seems to fit well with cross country FDI data. The gravity model mainly assumes that trade or FDI flows between two countries are determined by the market potential of each country and also the distance between the two countries. Since in this study there is only one home country, the United States, I include GDP per capita of the host countries in the control variables to represent market potential. In addition, I include the host country population as a control for market size. The real GDP per capita data accounting for purchasing power parity and the population data are provided by the Penn World Tables. The distances between the host countries and the United States[7] and a variable indicating whether the host country speaks the same language as the United States are also included in the explanatory variables.

Many studies also show that exchange rates have a significant impact on FDI flows, including Fosfuri et al. (2001), Klein and Rosengren (1994) and Blonigen (1997). Intuitively, an appreciation of the currency in MNEs' home country

[7]The distance between the host countries and the United States are the Great Circle distance between the capital cities of the host countries and the United States.

makes the MNEs more wealthy, which leads to greater funds for the MNEs to invest abroad. This is especially true when FDI takes the form of acquisition of indigenous firms in host countries. The empirical results found in most papers are consistent with the hypothesis that a depreciation of host country currencies or an appreciation of home country currencies leads to an increase in the FDI flows to host countries[8]. To control for the effect of exchange rates on FDI, I use the exchange rates from the Penn World Tables as a regressor. The exchange rates are represented as the value in terms of local currencies of one U.S. dollar and the sign of this variable is expected to be positive.

Trade protection is also one of the factors that are widely believed to affect FDI. The protection can take different forms including tariffs, quotas and anti-dumping duties. Empirical studies on trade protection and FDI generally indicate that MNEs tend to substitute affiliate production for exports when host countries tighten their trade protection[9]. Such tariff-jumping or antidumping-jumping FDI is mostly undertaken by the horizontal type of MNEs which aim to serve the protected host country consumers. Because of the availability of data, I only include tariff rates as a measure of trade protection. The tariff data comes from the World Trade Organization's (WTO) Integrated Data Base and the rates used are the average effective rates on U.S. exports. In addition to the direct measure of trade protection, I also include a variable indicating the openness of the host countries from the Penn World Tables. The openness variable is constructed as the ratio of exports plus imports and real GDP per capita. For vertical and export-platform MNEs that involve imports and exports in host countries, a higher degree of openness indicates lower costs associated with importing intermediate inputs from their home countries or exporting their products to other

[8]See Cushman (1985), Froot and Stein (1991) and Blonigen (1997) for related discussions.

[9]See Belderbos (1997), Blonigen et al. (2004) and Neary (2009) for related discussions.

countries. For horizontal MNEs, a higher degree of openness may also have a positive effect if FDI and trade are complements. There are many empirical studies that have investigated whether openness determines FDI[10], although the results largely depend on the sample countries chosen and the specification of the model.

Wagner and Timmins (2009) point out that ignoring the agglomeration effect of FDI may cause serious bias to the estimated coefficient of policy variables. The agglomeration effect refers to the possibility that FDI activities may be impacted by the clustering of incumbent MNEs and such impacts may be either positive or negative. Agglomeration externalities would be positive if MNEs develop forward and backward linkages across industries and facilitate further specialization in production. Agglomeration externalities may be negative if congestion and cut-throat competition arises when MNEs locate their activities near each other. Omitting the agglomeration effect may bias the coefficient on tax rates if the clustering of the MNEs is a factor that is taken into account when host country governments set tax policy. Following previous studies, I use the existing stock of U.S. FDI in host countries as a measure of the agglomeration effect. The sign of the coefficient on the agglomeration variable depends on whether the benefits outweigh the disadvantages or not. Descriptive statistics of the dependent and independent variables are provided in table 3.3.

The traditional approach to measuring the determinants of FDI typically regresses FDI activities on a set of explanatory variables using cross sectional or panel data techniques. This study applies a dynamic panel approach that has several merits compared to the traditional approach. First, investment by MNEs is typically lumpy and takes time to adjust to the optimal stock. The partial adjustment model implies that a dynamic specification is more appropriate for

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[10]See Lucas (1993), Harms and Ursprung (2002), Goodspeed et al. (2006) and Busse and Hefeker (2007).

Table 3.3: Descriptive Statistics

	Mean	S.D.	Min	Max	N
Total Affiliate Sales [Millions of $]	68741.79	103098.30	1386.43	597845.20	564
Local Affiliate Sales [Millions of $]	44945.60	73070.69	394.93	409116.60	537
Affiliate Sales to US [Millions of $]	6877.88	15956.29	1.06	121578.20	540
Affiliate Sales to Other [Millions of $]	23054.97	41503.28	3.51	352714.60	552
Statutory Tax Rate	28.87	6.86	8.50	47.48	560
GDP [Billions of $]	773.14	1087.34	7.28	8629.17	564
FDI Stock [Billions of $]	370.57	666.66	1.30	4305.41	558
Exchange Rate [LCU per $]	303.74	1380.75	0.26	10389.90	564
Tariff Rate	4.34	4.82	0.00	42.79	460
Openness Index	89.70	69.16	20.53	433.05	564
Population [Thousands]	88728.81	235770.80	271.29	1323592.00	564
Distance to US [Kilometers]	8094.96	3889.89	733.89	16370.82	564
Common Language	0.23	0.42	0.00	1.00	564

FDI activities than a static model. Second, the dynamic panel specification takes into account any country specific effect that may be correlated with tax rates but unobserved by the econometricians. Last but not least, the dynamic panel approach allows potentially endogenous explanatory variables without using external instrumental variables as explained in detail below. The dynamic investment equation is specified as follows:

$$FDI_{i,t} = \alpha FDI_{i,t-1} + \beta X_{i,t} + \theta Z_i + \gamma R_t + \eta_i + \epsilon_{i,t} \tag{3.1}$$

$X_{i,t}$ includes time-variant explanatory variables including the corporate income tax rates. Z_i is a vector of time-invariant explanatory variables. R_t represents time dummies. η_i is a country fixed effect and $\epsilon_{i,t}$ is an i.i.d. shock.

The econometric approach I use was developed by Arellano and Bond (1991). The method specifically deals with "small T and large N" dynamic panel equations in which regressors can be endogenous or predetermined. Equation (1) is first transformed to purge the individual fixed effect. There are two approaches to the transformation. The first is the first-difference transform where a variable x_t is transformed to $\Delta x_t \equiv x_t - x_{t-1}$. Then equation (1) becomes

$$\Delta FDI_{i,t} = \alpha \Delta FDI_{i,t-1} + \beta \Delta X_{i,t} + \gamma \Delta R_t + \Delta \epsilon_{i,t} \tag{3.2}$$

However, in unbalanced panels, if $x_{i,t}$ is missing, then $\Delta x_{i,t}$ and $\Delta x_{i,t+1}$ are also missing. The first-difference transform leads to a large loss of observations in this case. Such a weakness can be avoided using the second method of transformation, the "orthogonal deviations", where all available observations of a variable are averaged and then subtracted from the contemporaneous observation so that the transformation will not be affected by gaps. Specifically, a variable x is transformed to $x^{\perp}_{t+1} \equiv \sqrt{T_t/(T_t+1)}(x_t - \frac{1}{T_t}\sum_{s>t} x_s)$ where T_t is the number of the available future observations. Then equation (1) becomes

$$FDI^{\perp}_{i,t} = \alpha FDI^{\perp}_{i,t-1} + \beta X^{\perp}_{i,t} + \gamma R^{\perp}_t + \epsilon^{\perp}_{i,t} \tag{3.3}$$

Both of the two methods of transformation eliminate the country specific effect η_i. However, they also lead to potential endogeneity problems of the lagged dependent variable on the right hand side. In equation (2), $\Delta FDI_{i,t-1}$ is correlated with $\Delta\epsilon_{i,t}$ because $FDI_{i,t-1}$ is correlated with $\epsilon_{i,t-1}$. In equation (3), $FDI^{\perp}_{i,t-1}$ is correlated with $\epsilon^{\perp}_{i,t}$ for the same reason. To deal with the endogeneity issue, Arellano and Bond (1991) propose using $FDI_{i,t-2}$ and longer lags as instruments for $\Delta FDI_{i,t-1}$ or $FDI^{\perp}_{i,t-1}$. These instruments are valid as long as the term $\epsilon_{i,t}$ is not serially correlated.

Some of the independent variables are predetermined, which means they are not correlated with the contemporaneous $\epsilon_{i,t}$ but are correlated with past FDI activity. These variables are exogenous in the untransformed equation but become endogenous after the transformation just like the lagged dependent variable. Similarly, for a predetermined $x_{i,t}$, $x_{i,t-1}$ can serve as instruments for $\Delta x_{i,t}$ or $x^{\perp}_{i,t}$ because $x_{i,t-1}$ is only correlated with $\epsilon_{i,t-2}$ and older shocks. There are also some independent variables that are endogenous even in the untransformed equation and they need to be instrumented with further lags such as $x_{i,t-2}$. These instruments can be used to generate moment conditions and Arellano and Bond (1991) develop a General Method of Moment (GMM) estimator using the moment conditions.

A problem of the Arellano-Bond estimator is that if the dependent variable is close to a random walk, Blundell and Bond (1998) show that past levels do not convey much information about future changes so using the lagged levels as instruments suffers fron the weak instrument problem. To deal with this problem, Blundell and Bond followed an approach in Arellano and Bover (1995) to develop a strategy that uses lagged differences of a variable $\Delta x_{i,t-1}$ as an instrument for the variable $x_{i,t}$ in levels. This instrument is valid if $\Delta x_{i,t}$ is uncorrelated with the fixed effect η_i and Blundell and Bond (1998) specify some initial conditions under which the validity of the instruments is most likely to hold. The authors also develop a system estimator using both the set of instruments for the differenced equation and the set of instruments for the equation in levels to improve efficiency. Another benefit of using the system estimator is that the coefficients on time-constant variables which cannot be estimated in the differenced equation can be obtained in the system equations.

3.4 Baseline Regression Results

In the baseline specification, I apply a system GMM estimation to equation (1) following the instructions from Roodman (2009). The main variable of interest, the statutory corporate income tax rate, is considered exogenous. Concerns over the endogeneity of local tax rates have been expressed by several researchers, but mostly upon backward-looking tax rates. The backward-looking measures of tax rates differ from the forward-looking rates in the sense that the former are based on data on profits and taxes directly related to investment. Therefore, the backward-looking measures of tax rates are more likely to be endogenous to investment. On the contrary, the statutory corporate income tax rates should suffer less from the endogeneity problem. Among the other explanatory variables, the exchange rates variable is treated as endogenous as it may respond to contemporaneous fluctuations of FDI. Real GDP per capita, the tariff rates and the existing stock of FDI are considered as not strictly exogenous and predetermined by past FDI.

Regarding the choice of the instruments for the endogenous and predetermined variables, using all the available lags as instrument leads to several problems. First, the variance matrix of the moments is quadratic in the number of instruments and using too many instruments usually leads to a nonsingular matrix. Second, using too many instruments tends to overfit the first stage regression and leads to biased estimates. Nevertheless, there is no rule of thumb in determining how many instruments should be included in the regression. Stata generates a warning when the number of instruments is greater than the number of panel id. In the baseline regression, I use one to four periods of lags as instruments for predetermined variables and two to five periods of lags as instruments for endogenous variables which are the longest lags can be included without incurring a warning[11]. The transformation of equation (1) in the baseline specification follows the orthogonal approach as in equation (3). Regarding the errors, I use a two-step estimator which is robust to any pattern of heteroskedasticity and autocorrelation within panels. The results from the baseline specification are shown in the left panel of table 3.4.

The first two columns of table 3.4 show the effect of tax rates on local-market

[11] A specification using only two to three periods of lags as instruments are provided in the appendix table 3.12.

oriented (horizontal) FDI represented by local sales and export oriented FDI represented by affiliate sales back to the United States and other foreign countries. The coefficients on the lagged dependent variables are significant and less than 1 in absolute value, which suggests that FDI is lumpy and takes time to adjust to its optimal path. The coefficient on local corporate income tax rates is not significant for horizontal FDI but is negative and significant for export-oriented FDI, which is consistent with the hypothesis that host country taxes have an asymmetric impact on FDI of various types. The coefficient of -838.1 implies that the elasticity of U.S. export-oriented FDI with respect to local corporate tax rates is -0.81 at the mean, which close to the result of Grubert and Mutti (1991).

The last two columns of table 3.4 further divide export-oriented FDI into vertical FDI represented by sales back to the United States and export-platform FDI represented by sales from one host country to other host countries. The coefficients on tax rates remain negative and significant for vertical and export-platform FDI, which indicates that they are more sensitive to local tax differentials than horizontal FDI. Another thing to note is that the estimated coefficient on tax rates is -30.95 for vertical FDI, which is much smaller than the estimate for export-platform FDI which is -601.4. Given these point estimates, the tax elasticity of U.S. vertical FDI is -0.13 and that of U.S. export-platform FDI is -0.75.

A possible explanation for such significant differences in the estimated elasticities is that U.S. affiliate sales to other foreign countries may include both vertical and export-platform FDI. If a vertical U.S. MNE has affiliates in multiple host countries, the intermediate inputs produced by one affiliate may be sold to another affiliate in a different host country for further processing before eventually sold back to the United States. Therefore, affiliate sales to other foreign countries may also be a part of the vertical fragmentation of vertical MNEs, depending on whether the goods are sold to consumers in other foreign countries or other affiliates under the same headquarter in other foreign countries. Details about the composition of sales to other foreign countries will be discussed in later sections.

Table 3.4: The Effect of Local Tax Rates on Different Types of FDI

	Local Sales	Sales to US and Other Countries	Sales to US	Sales to Other
VARIABLES				
Lag Local Sales	0.981***			
	(0.00610)			
Lag Sales to US & Other		0.0208***		
		(0.00419)		
Lag Sales to US			0.870***	
			(0.0133)	
Lag Sales to Other				-0.0112***
				(0.00404)
Tax Rate	49.30	-838.1***	-30.95***	-601.4***
	(39.16)	(124.5)	(10.55)	(95.18)
GDP Per Capita	0.0188	1.436***	0.0137	1.171***
	(0.0743)	(0.229)	(0.0153)	(0.242)
FDI Stock	4.200***	31.70***	1.111***	24.79***
	(0.506)	(2.992)	(0.152)	(2.039)
Exchange Rate	0.00436	4.976***	0.276***	2.924***
	(0.218)	(1.190)	(0.0641)	(1.111)
Tariff Rate	-452.4***	57.02	-27.74	21.84
	(145.6)	(301.7)	(31.42)	(301.6)
Openness	0.926	52.65	3.365*	12.39
	(5.347)	(39.70)	(1.837)	(28.27)
Population	0.00802***	0.0250***	0.00156**	0.0182**
	(0.00154)	(0.00790)	(0.000660)	(0.00713)
Distance	-0.0504	-1.513*	-0.211***	-0.239
	(0.152)	(0.857)	(0.0628)	(0.547)
Common Language	-60.78	22,156***	1,935***	8,464
	(1,433)	(5,899)	(544.1)	(5,343)
Constant	-2,126	6,783	904.5	-756.7
	(2,435)	(6,247)	(607.7)	(7,140)
Observations	384	383	389	406
Number of countries	47	47	47	47
Number of Instruments	41	41	41	41
Hansen Statistic p-value	0.567	0.0593	0.357	0.285

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Regarding the other explanatory variables, GDP per capita has its expected sign for all types of FDI and is significant for aggregate FDI and export-platform FDI, which confirms the importance of market potentials in the gravity model.

The agglomeration externality represented by existing FDI stocks has a positive effect on all types of FDI, suggesting that the benefits of clustering outweigh the congestion effect for U.S. FDI abroad. The exchange rate also has its expected positive impact on FDI and its estimated coefficients are significant at the 1% level except for horizontal FDI. The negative coefficient on tariff rates for aggregate FDI indicates that tariffs in general serve as a barrier rather than an incentive for FDI. The tariff coefficients are not significant when FDI is categorized and become positive for export-platform FDI. The coefficients on openness, distance and common language dummy all have their expected signs. On the last row of table 3.4, the p value of the Hansen's overidentification test are reported. The large p values in all four cases suggest that the instruments which are the lags of the dependent and independent variables are valid[12].

3.5 Robustness Tests

3.5.1 Lagged Tax Rates

Since MNEs may need time to adjust to changes in local tax rates, the impact of tax may not fall on contemporaneous FDI activities. In table 3.5, I repeat the regression in table 3.4 with one period lagged tax rates. The effects of tax found in the table are slightly larger than those found using contemporaneous ones. The empirical pattern of asymmetric effect of taxes on different types of FDI remains in the specification with lagged tax rates. The coefficient on tax rates is negative and significant for export oriented FDI while not significant for local-market oriented FDI. Vertical sales and export-platform sales also exhibit a greater sensitivity to local tax rates than horizontal sales when they are investigated separately.

[12] A problem with this test is that its power can be greatly weakened when there is a large number of instruments.

Table 3.5: The Effect of Lagged Tax Rates on Different Types of FDI

	Local Sales	Sales to US and Other Countries	Sales to US	Sales to Other
VARIABLES				
Lag Local Sales	0.981***			
	(0.00594)			
Lag Sales to US & Other		0.0185***		
		(0.00406)		
Lag Sales to US			0.866***	
			(0.0132)	
Lag Sales to Other				-0.0124***
				(0.00418)
Lag Tax Rate	30.99	-889.8***	-46.27***	-658.1***
	(35.61)	(121.5)	(10.50)	(98.50)
GDP Per Capita	0.0200	1.440***	0.0143	1.205***
	(0.0672)	(0.234)	(0.0154)	(0.226)
FDI Stock	4.317***	32.56***	1.127***	25.40***
	(0.495)	(3.138)	(0.151)	(2.331)
Exchange Rate	0.0256	5.099***	0.285***	2.349*
	(0.201)	(1.244)	(0.0702)	(1.313)
Tariff Rate	-390.2***	-59.17	-28.30	133.0
	(133.3)	(293.0)	(30.87)	(262.9)
Openness	1.212	47.67	2.869	19.70
	(5.040)	(41.02)	(1.850)	(29.99)
Population	0.00753***	0.0287***	0.00157**	0.0201***
	(0.00150)	(0.00767)	(0.000634)	(0.00646)
Distance	-0.0436	-1.673*	-0.215***	-0.346
	(0.147)	(0.875)	(0.0651)	(0.567)
Common Language	-102.3	23,123***	2,047***	8,107*
	(1,390)	(5,732)	(527.1)	(4,902)
Constant	-2,003	9,089	1,402**	-296.8
	(2,083)	(6,540)	(655.8)	(7,230)
Observations	381	380	386	403
Number of countries	47	47	47	47
Number of Instruments	41	41	41	41
Hansen Statistic p-value	0.554	0.126	0.404	0.335

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

3.5.2 Certain Countries Excluded

As shown in table 3.1, the composition of U.S. affiliate sales varies across different regions. For instance, U.S. FDI in Canada is mainly horizontal and vertical while in Europe U.S. FDI has a large fraction of export-platform FDI. Therefore, it would be interesting to test whether the asymmetric pattern of the tax effect on FDI are driven by certain areas or certain countries such as Canada or Ireland. Nevertheless, the Arellano-Bond estimator requires a panel sample of "large N and small T", which makes the regression less reliable if samples are restricted to certain regions or countries. As a compromise, I exclude certain countries from the sample as a robustness test on whether the empirical pattern of local market-oriented versus export-oriented FDI is driven by these countries. Four countries that may impact the effect of tax rates on U.S. outward FDI, Canada, the United Kingdom, Ireland and China, are excluded from the sample one at a time. Corresponding results are shown in table 3.6 with the explanatory variables other than the lagged dependent variable and the tax rate variable compressed.

In the first panel from the top of table 3.6 I exclude Canada from the sample because of its special relationship with the United States. U.S. FDI in Canada is concentrated in the horizontal and vertical types. The adjacency of the two countries and the similarity in language and culture between the two countries makes it relatively easy for U.S. MNEs to conduct businesses in Canada and serve the Canadian consumers. The 1994 North America Free Trade Agreement (NAFTA) which greatly reduced trade barriers between Canada and the United States also makes Canada an ideal place for vertical fragmentation of U.S. MNEs. In the second panel, the United Kingdom is excluded from the sample. Being the largest recipient of U.S. FDI over the sample period, the United Kingdom has a long history of hosting U.S. MNEs and excluding it from the sample may have some impact on the estimated tax effects. Ireland is another European country

Table 3.6: The Taxation Effect of FDI with Certain Countries Excluded

VARIABLES	Local Sales	Sales to US	Sales to Other
		Canada Excluded	
Lag Dependent Variable	0.984***	0.939***	0.0255***
	(0.00453)	(0.0180)	(0.00476)
Tax Rate	27.97	-20.59**	-729.2***
	(22.14)	(8.410)	(91.52)
		UK Excluded	
Lag Dependent Variable	0.982***	0.902***	0.0622***
	(0.00516)	(0.0153)	(0.00404)
Tax Rate	18.19	-29.54***	-533.3***
	(27.32)	(9.961)	(89.33)
		Ireland Excluded	
Lag Dependent Variable	0.974***	0.856***	-0.0269***
	(0.00728)	(0.0106)	(0.00424)
Tax Rate	19.53	-28.78**	-506.0***
	(43.99)	(11.61)	(84.64)
		China Excluded	
Lag Dependent Variable	0.980***	0.870***	-0.0115***
	(0.00580)	(0.0136)	(0.00406)
Tax Rate	35.34	-29.49***	-607.2***
	(38.12)	(9.973)	(95.38)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

that has attracted a large number of U.S. MNEs and also MNEs from other countries because of its low tax rates and skilled labor. The MNEs in Ireland are concentrated in manufacturing industries and are highly export-oriented. Many studies use Irish FDI as an example of export-platform FDI in Europe so in the third panel I exclude U.S. FDI in Ireland to see whether the main results are sensitive to the Irish case. In the last panel I exclude China from the sample as it is the most rapidly growing developing country in the last few decades. The rapidly expanding market and cheap labor force in China lead to a significant growth of U.S. FDI in the country during the sample period, which may affect the tax effect estimation.

The results in table 3.6 suggest that the asymmetric effect of taxes on different types of U.S. FDI are not driven by any of the four countries. The statutory tax rates have a negative and significant effect on vertical and export-platform FDI and an insignificant effect on horizontal FDI. The magnitudes of the estimated coefficients on tax rates are also similar to those in the baseline specification. The result that vertical and export-platform FDI are more sensitive than horizontal FDI to local tax rates is robust to excluding any of the four countries from the sample. In addition, the taxation coefficients for sales to other foreign countries remain much larger than those for sales back to the United States.

3.5.3 Manufacturing Sales

The FDI sales data from the BEA includes sales of U.S. foreign affiliates in all industries. Some sectors such as the service sector, the finance sector and the information sector do not produce physical goods. MNEs in these sectors are mainly local market-oriented and typically do not export either back to the U-nited States or to other foreign countries. Moreover, in the model that shows the asymmetric effect of local regulations on FDI described in Tang (2012), the difference in sensitivity is a result of the increase in the marginal costs of production. Such a model may better fit the manufacturing industries than the service, finance and information industries of which the costs of production typically do not depend on the quantity of output. In table 3.7, I restrict the sample to manufacturing affiliates to test whether excluding non-manufacturing sectors affects the baseline regression results.

As shown in table 3.7, there are two major differences between the results of manufacturing sales and the baseline results. First, using manufacturing sales instead of sales of all industries greatly changes the estimated coefficients on the lagged dependent variable and tax rates for export-platform FDI. Unlike in the previous regressions where the magnitudes of the coefficients on lagged export-platform FDI are small, the coefficients are now above unity in table 3.7, which is also much closer to those on lagged horizontal and vertical FDI. The magnitude of the coefficient on local tax rates becomes smaller for export-platform FDI as well. In the baseline regression, the estimated tax elasticity of export-platform FDI is as six times large as that of vertical FDI, which can hardly be explained by theory. When the dependent variable is restricted to manufacturing affiliate sales, there is no longer a distinctive difference between the tax effect on vertical FDI and export-platform FDI. A 1 percentage point decrease in tax rates is associated with an increase of 46.43 million dollars in manufacturing export-platform FDI and an increase of 14.32 million dollars in manufacturing vertical FDI. Converting to elasticities, the points estimates imply a tax elasticity of -0.118 for U.S. export-platform FDI and a tax elasticity of -0.086 for U.S. vertical FDI.

Second, the taxation coefficients for horizontal FDI are now positive and significant as shown in column (1), which suggests that horizontal MNEs may even be positively affected by higher local tax rates. Such a counterintuitive result can take place if higher tax burdens hurt the rivals of horizontal MNEs more than the

Table 3.7: The Taxation Effect on Different Types of Manufacturing FDI

VARIABLES	Local Sales	Sales to US	Sales to Other
Lag Local Sales	0.939***		
	(0.0157)		
Lag Sales to US		0.913***	
		(0.0190)	
Lag Sales to Other			1.063***
			(0.0147)
Tax Rate	77.68***	-14.32**	-46.43***
	(24.13)	(6.150)	(10.23)
GDP Per Capita	0.00922	0.0269***	0.0718***
	(0.0421)	(0.00954)	(0.0268)
FDI Stock	1.430***	0.0597	-0.180
	(0.304)	(0.0833)	(0.214)
Exchange Rate	0.597**	0.208***	0.0545
	(0.244)	(0.0558)	(0.0349)
Tariff Rate	-173.9***	65.92***	76.32***
	(64.85)	(21.74)	(28.91)
Openness	3.849	1.567	-2.306
	(4.367)	(1.087)	(1.708)
Population	0.00496***	0.000548	0.00115**
	(0.00134)	(0.000392)	(0.000538)
Distance	-0.0973	-0.141**	0.0540**
	(0.0974)	(0.0553)	(0.0234)
Common Language	422.5	1,120***	-355.0
	(839.6)	(423.2)	(231.1)
Constant	-2,266	22.57	-1,434**
	(1,396)	(473.2)	(671.0)
Observations	375	343	341
Number of countries	47	47	46
Number of Instruments	41	41	41
Hansen Statistic p-value	0.555	0.308	0.278

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

MNEs themselves[13].

3.5.4 Changes in Sensitivity Over Time

As shown in Altshuler et al. (2000), the sensitivity to local tax rates may change over time. If technological advances and globalization gradually made it easier for MNEs to move capital or production activities to foreign countries, then sensitivities to differences in tax rates across host countries would become greater in later years of the sample. To test whether there is an increase in the sensitivity to local tax rates, I regress the three types of sales on tax rates for the first 6 years and the last 6 years of the sample period, respectively. The corresponding results are shown in table 3.8.

For horizontal FDI the coefficient on tax rates is positive and significant in the first half of the sample period and becomes insignificant in the second half, which suggests that the positive and significant taxation coefficient in table 3.7 is probably driven by the first 6 sample years[14]. In either period, local tax rates do not have a deterrent effect on horizontal sales. For vertical sales the taxation coefficient is negative but insignificant in the first period and becomes greater in magnitude and significant at the 1% level in the second period. For sales to other countries, the coefficients on tax rates are significant in both periods but the magnitude is as about two times larger in the second period. These results show that vertical and export-platform FDI became more sensitive to local tax rates over time, which is consistent with the findings in Altshuler et al. (2000)

[13] Dijkstra et al. (2011) show that a more stringent environmental policy can act as an incentive for MNEs if the increase in the environmental abatement cost of the domestic competitors is sufficiently larger than that of the MNEs.

[14] I also regress horizontal manufacturing FDI on local tax rates for each of the two subperiods. The results are consistent with the results in table 3.8. The effect of local tax rates is positive and significant on horizontal manufacturing FDI in the first subperiod but insignificant in the second.

Table 3.8: The Taxation Effect in Different Periods

	1998-2003			2004-2009		
VARIABLES	Local Sales	Sales to US	Sales to Other	Local Sales	Sales to US	Sales to Other
Lag Local Sales	0.912***			0.989***		
	(0.00766)			(0.0105)		
Lag Sales to US		0.779***			0.919***	
		(0.0156)			(0.0201)	
Lag Sales to Other			-0.142***			0.170***
			(0.00502)			(0.00679)
Tax Rate	145.4***	-23.55	-198.0**	16.53	-39.75**	-627.6***
	(38.87)	(15.58)	(95.32)	(65.60)	(17.54)	(176.5)
GDP Per Capita	-0.114**	0.0382***	0.910***	0.00549	-0.00434	1.667***
	(0.0496)	(0.0136)	(0.235)	(0.102)	(0.0273)	(0.317)
FDI Stock	10.96***	2.156***	46.05***	4.481***	1.505***	18.67***
	(0.603)	(0.302)	(2.664)	(0.914)	(0.250)	(2.303)
Exchange Rate	-0.204	0.331	2.302	-0.137	0.150	2.871***
	(1.371)	(0.272)	(2.124)	(0.166)	(0.0956)	(1.090)
Tariff Rate	-330.2***	-90.80***	716.9***	-286.2***	2.751	-99.91
	(92.67)	(19.11)	(264.1)	(75.26)	(40.07)	(363.6)
Openness	-30.67***	-6.438**	12.12	1.842	3.326	38.84
	(5.283)	(2.829)	(17.15)	(5.896)	(2.450)	(38.26)
Population	0.00429**	0.00270***	0.0110	0.00617***	0.00114	0.0314***
	(0.00170)	(0.000560)	(0.00680)	(0.00192)	(0.000903)	(0.00819)
Distance	-0.234*	-0.435***	0.101	0.189	-0.0647	-0.237
	(0.133)	(0.0508)	(0.369)	(0.132)	(0.0900)	(0.854)
Common Language	2,722	4,012***	5,689	-636.1	828.3	-3,892
	(1,680)	(426.4)	(3,594)	(1,209)	(775.0)	(5,808)
Constant	964.2	345.2	-9,768	-4,145	44.58	-10,526
	(3,789)	(1,335)	(10,649)	(2,786)	(915.7)	(10,278)
Observations	165	168	171	219	221	235
Number of countries	44	43	45	46	46	46
Number of Instruments	41	41	41	37	37	37
Hansen Statistic p-value	0.496	0.329	0.476	0.477	0.537	0.426

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

regarding the changes in U.S. MNEs' sensitivity to tax rates in an earlier period from 1984 to 1992. Moreover, comparing the the effects of tax rates on the three types of FDI in the two subperiods respectively, we can see that local tax rates still have a greater deterrent effect on export-oriented FDI than on horizontal FDI in the two subperiods.

3.6 Sales to Affiliated or to Unaffiliated Persons

As mentioned earlier, a possible reason for the distinctively large tax effect on export-platform FDI is that sales to other foreign countries include both sales to affiliated and to unaffiliated persons. If MNEs shift some stages of production to multiple host countries so output produced by an affiliate in one host country will be sold to an affiliates in another host country for further processing before shipped back to the United States, then sales to other foreign countries are a closer representation of vertical FDI rather than export-platform FDI. Export-platform FDI is better represented by sales to unaffiliated persons in other foreign countries. As shown in table 3.9, the fractions of sales to unaffiliated persons in other foreign countries which represent export-platform FDI activities are less than half. More than half of the total sales to other foreign countries are sold to other affiliates with the same parent. To get consistent estimates for the export-platform FDI equation, these two types of sales should be separately regressed on tax rates and other variables.

The affiliate local sales and sales back to the United States may also suffer from this problem but to a lesser extent. As shown in table 3.9, more than 90% of local sales are sold to unaffiliated persons which are probably local customers. For sales back to the United States, about 80% are sold to the affiliates' parents. These products probably will be further processed or distributed to customers by the U.S. parents, which is consistent with the motivation of vertical FDI. There are also some U.S. affiliates that sell their output directly to customers in the United States, which constitutes less than 20% of sales back to the United States in most of the years.

Table 3.9: Fractions of Affiliates Sales to Affiliated and Unaffiliated Persons

	Fractions of Local Sales (%)		Fractions of Sales to US (%)		Fractions of Sales to Other (%)	
Year	To Affiliated	To Unaffiliated	To Affiliated	To Unaffiliated	To Affiliated	To Unaffiliated
1998	5.06	94.94	86.37	13.63	58.18	41.82
1999	6.91	93.09	85.30	14.70	56.16	43.84
2000	7.24	92.76	85.24	14.76	55.67	44.33
2001	7.01	92.99	84.35	15.65	52.29	47.71
2002	7.26	92.74	84.76	15.24	54.12	45.88
2003	7.95	92.05	83.73	16.27	55.74	44.26
2004	8.65	91.35	81.28	18.72	54.61	45.39
2005	8.59	91.41	80.96	19.04	56.46	43.54
2006	8.83	91.17	78.86	21.14	55.66	44.34
2007	9.16	90.84	78.66	21.34	55.16	44.84
2008	9.48	90.52	79.34	20.66	52.54	47.46
2009	9.85	90.15	76.65	23.35	54.20	45.80

Source: The U.S. Bureau of Economic Analysis

In table 3.10, I divide local sales, sales back to the United States and sales to other foreign countries into sales to affiliated and unaffiliated persons and regress them on tax rates respectively. The first three columns report the results of using sales to affiliated persons as the dependent variable and the last three columns report the results using sales to unaffiliated persons. For local sales to either affiliate or unaffiliated persons, the coefficient on tax rates remains insignificant, which is consistent with the hypothesis that horizontal FDI is less likely to be sensitive to local tax rates. For vertical sales, the taxation coefficient is negative and significant for sales to affiliates' U.S. parents which constitute about 80% of the total affiliate sales back to the United States. For the other 20% sales sold to unaffiliated persons in the United States, the taxation coefficient is negative but insignificant, which suggests that the negative and significant coefficient for vertical FDI found in the baseline regression is mainly determined by the effect of tax rates on affiliate sales to their U.S. parents.

Table 3.10: The Taxation Effect on Sales to Affiliated and to Unaffiliated Persons

	To Affiliated Persons			To Unaffiliated Persons		
VARIABLES	Local Sales	Sales to US	Sales to Other	Local Sales	Sales to US	Sales to Other
Lag Local Sales	0.779***			0.954***		
	(0.0163)			(0.00924)		
Lag Sales to US		0.848***			0.735***	
		(0.0158)			(0.0110)	
Lag Sales to Other			1.060***			0.808***
			(0.0117)			(0.0179)
Tax Rate	-4.744	-24.20**	-67.93***	41.26	-3.852	-46.56**
	(7.298)	(10.13)	(18.25)	(31.23)	(4.891)	(20.74)
GDP Per Capita	-0.00259	0.0235*	0.0170	0.0810	0.000667	0.143***
	(0.0217)	(0.0124)	(0.0205)	(0.0734)	(0.00694)	(0.0360)
FDI Stock	1.406***	0.848***	0.223	4.250***	0.616***	3.029***
	(0.153)	(0.121)	(0.222)	(0.500)	(0.0522)	(0.270)
Exchange Rate	0.0239	0.222***	0.236***	0.0350	0.109***	-0.792***
	(0.0582)	(0.0539)	(0.0868)	(0.255)	(0.0226)	(0.115)
Tariff Rate	-109.8***	-22.64	128.4***	-283.9***	4.589	-76.33
	(19.87)	(26.65)	(29.59)	(106.9)	(7.948)	(52.09)
Openness	4.235**	1.979	0.502	-0.639	1.158*	5.396
	(2.118)	(1.970)	(2.160)	(7.097)	(0.695)	(3.466)
Population	0.00109**	0.00176***	-0.000189	0.00784***	0.000272*	0.00182
	(0.000458)	(0.000633)	(0.000489)	(0.00172)	(0.000151)	(0.00128)
Distance	-0.00433	-0.194***	0.00909	-0.0595	-0.101***	0.182***
	(0.0345)	(0.0661)	(0.0183)	(0.178)	(0.0151)	(0.0540)
Common Language	-18.16	1,938***	228.2	1,189	732.4***	-1,688***
	(358.1)	(527.8)	(253.9)	(1,667)	(169.3)	(453.0)
Constant	816.1*	693.2	28.37	-2,807	495.9**	-2,889***
	(438.0)	(736.1)	(572.0)	(2,280)	(212.9)	(1,112)
Observations	388	388	402	384	385	402
Number of countries	47	47	47	47	47	47
Number of Instruments	41	41	41	41	41	41
Hansen Statistic p-value	0.729	0.406	0.390	0.433	0.297	0.514

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results in table 3.10 also show that distinguishing between sales to affiliated and unaffiliated persons in other foreign countries helps better identify the effect of tax rates on sales to other foreign countries. The coefficients on tax rates for sales to other foreign countries become smaller in the third and the last column of table 3.10. The coefficients on lagged dependent variable for sales to other foreign countries also greatly changed after dividing into sales to affiliated and unaffiliated persons and become closer to those for the other two types of sales. For sales to affiliate persons in other foreign countries which are probably part of the vertical integration of MNEs, the coefficient on tax rates is negative and significant, which again confirms that vertical FDI is more sensitive to local tax rates than horizontal FDI. The negative and significant coefficient on tax rates for sales to unaffiliated persons in other foreign countries shows that export-platform FDI is also more sensitive than horizontal FDI to local tax rates.

3.7 Third Country Tax Rates

Many studies have extended the two-country FDI framework to include a country other than the home and host country, the "third country"[15]. The tax rates in other countries may also have different effects on distinct types of FDI. For horizontal FDI which is motivated by market access and circumventing trade barriers, third country tax rates would not matter to the MNEs. Theoretically, such a prediction would more likely to occur if the trade barriers in the destination country are so high that exporting is always not preferred or MNEs need to be physically located in the host country to serve their customers.

For vertical and export-platform MNEs which are efficiency-seeking, they are

[15]See Keller and Shiue (2007), Ekholm et al. (2007) and Blonigen et al. (2007)

more flexible than horizontal FDI in choosing a host country to locate their affiliates. Third country tax rates are more likely to have significant impacts on these two types of MNEs. For the purest form of export-platform FDI in which MNEs choose the lowest-cost country in a region to serve the whole region, third country tax rates are expected to be positively correlated with FDI in host countries. The third country tax effect on vertical FDI is more complicated. If vertical FDI is in its simplest form in which MNEs choose only one host country with the lowest cost in all candidate countries to locate their production in that country, production in other countries is a substitute to production in the destination country. In this case higher tax rates in other countries tend to discourage investment in these countries and lead to a higher level of FDI in the destination country. Vertical FDI may takes a more complex form in which MNEs shift multiple stages of production to multiple host countries. In this case affiliates in a host country become complements to affiliates in other countries under the vertical fragmentation of the same production chain. As shown in the previous section, more than 50% of sales to other foreign countries are sold to affiliated persons, which provides some evidence of such a complex form of vertical FDI. If other host countries are complements to the destination country, higher third country tax rates may lead to lower vertical FDI in the other host countries which in turn lowers vertical FDI in the destination country.

To test whether third country tax rates have any effect on host country FDI and whether the third country tax effect on FDI varies across distinct types of FDI, I construct a measure of third country tax rates for each of the host countries as a weighted average of the tax rates in all countries other than the host country. A widely used weight for third country variables is the inverse of the distance from a third country to a host country. However, such weight still gives positive weight to countries that are quite remote to a host country and unlikely to be either complement or substitute to the host country for FDI. To deal with such a problem, I use a weight that decays exponentially with respect to the distance so countries with large distances get much smaller weight[16]. Specifically, the weight associated with tax rates in a third country j of a host country i is as follows:

$$weight_{ij} = \exp\left(\frac{-d_{ij}}{\min_k(d_{ik})}\right) \text{ if } k \neq j$$

where d_{ij} is the distance from the host country i to country j.

The effects of third country tax rates on different types of FDI are shown in table 3.11. As illustrated in the previous section that sales to affiliated persons should be distinguished from sales to unaffiliated persons especially for sales to other foreign countries, in table 3.11 I separate these two types of sales in sales to other foreign countries and regress them on third country tax rates respectively.

For local sales in the first column, the coefficient on third country tax rates is insignificant and so is the coefficient on local tax rates. This is consistent with the hypothesis that horizontal FDI motivated by market access and circumventing trade barriers are not sensitive to tax rates in either the targeted host country or other countries. For sales back to the United States, the negative and significant coefficient on third country tax rates suggests that vertical FDI is most in a complex form that involves productions in multiple host countries. Production activities in countries proximate to a host country are complements to production in the host country. Higher tax rates in proximate countries reduce vertical FDI activities in those countries, which in turn leads to fewer vertical FDI activities in the host country. For sales to other foreign countries, third country tax rates have opposite effects on sales to affiliated and to unaffiliated persons. This shows again that sales to other foreign countries may include both vertical and export-platform FDI and failing to distinguish between the two may generate misleading

[16]Regressions with third country tax rates weighted by the inverse of the distance from a third country to a host country are also shown in the appendix table 3.13.

Table 3.11: Third Country Taxation Effect

VARIABLES	Local Sales	Sales to US	Sales to Other	
			Affiliated	Unaffiliated
Lag Local Sales	0.986***			
	(0.00654)			
Lag Sales to US		0.863***		
		(0.0154)		
Lag Sales to Other			1.059***	0.813***
			(0.0123)	(0.0172)
Tax Rate	48.84	-36.15***	-67.49***	-30.35
	(39.80)	(12.23)	(17.87)	(22.55)
3rd Country Tax Rate	170.7	-86.43***	-49.29**	226.0***
	(128.1)	(29.80)	(20.76)	(60.77)
GDP Per Capita	0.0239	0.00338	0.0155	0.114***
	(0.0746)	(0.0186)	(0.0215)	(0.0340)
FDI Stock	4.010***	1.267***	0.244	3.292***
	(0.517)	(0.167)	(0.218)	(0.277)
Exchange Rate	-0.0495	0.286***	0.216**	-1.084***
	(0.227)	(0.0711)	(0.0979)	(0.131)
Tariff Rate	-394.6**	-50.91	122.8***	-46.88
	(160.6)	(33.12)	(31.04)	(48.26)
Openness	1.160	3.800**	0.824	5.039
	(5.375)	(1.765)	(2.161)	(3.459)
Population	0.00777***	0.00148**	-0.000140	0.00168
	(0.00153)	(0.000648)	(0.000490)	(0.00126)
Distance	0.0146	-0.243***	-0.00979	0.263***
	(0.156)	(0.0758)	(0.0193)	(0.0596)
Common Language	-508.2	2,057***	300.0	-1,758***
	(1,440)	(628.1)	(251.5)	(438.7)
Constant	-7,356	3,865***	1,477	-9,814***
	(4,683)	(1,359)	(925.0)	(2,285)
Observations	384	389	402	402
Number of countries	47	47	47	47
Number of Instruments	42	42	42	42
Hansen Statistic p-value	0.652	0.417	0.380	0.701

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

implications. The third country tax effect on sales to affiliated persons in other foreign countries is similar to that on sales back to the United States. Higher tax rates in proximate countries are associated with lower sales in host countries, which suggests that sales to affiliated persons in other countries are part of the vertical fragmentation of MNEs. The coefficient on third country tax rates for sales to unaffiliated persons is positive and significant. This is consistent with the model of export-platform FDI in which MNEs choose the lowest-cost country in a region as a base to serve other countries in the same region. The results in table 3.11 suggest that the effect of third country tax rates on different types of FDI may also be asymmetric, depending on whether FDI in third countries is substitute, complement, or irrelevant to host country FDI.

3.8 Conclusion

This study extends the analysis in Tang (2012) to the effect of taxes on FDI. Specifically, I examine whether local corporate income tax rates have different impacts on distinct types of FDI. Most previous studies suggest that higher tax rates have a deterrent effect on aggregate FDI but the deterrent effect may be greater on certain types of FDI. Using U.S. foreign affiliate sales to host countries, to the United States and to other foreign countries as proxies for horizontal, vertical and export-platform FDI, I test for the asymmetry of the effect of local statutory corporate income tax rates on the three types of FDI in a dynamic setting. Using data from a panel of 47 countries over the period of 1998 to 2009 I employ a GMM method derived in Arellano and Bond (1991) and Blundell and Bond (1998) which controls for unobserved country fixed effects and potential endogenous variables.

The regression results in the baseline specification first show that U.S. FDI activities abroad are lumpy. Past affiliate sales are a significant determinant of current sales. The results also show that the deterrent effect of local taxes on FDI is not significant on the horizontal type MNEs. Neither current nor lagged tax rates have a significant effect on local sales of the U.S. affiliates in host countries. More importantly, I find that local tax rates have a greater impact on vertical and export-platform FDI than on horizontal FDI. The coefficients on tax rates are negative and significant for sales back to the United States and sales to other foreign countries. The differences in the sensitivities to local tax rates of different types of FDI are also robust to specifications with lagged tax rates, manufacturing sales and when specific countries such as Canada, the United Kingdom, Ireland and China excluded. In addition, the sensitivity of U.S. FDI to corporate income tax rates in host countries seems to have become greater over time.

The study also distinguishes between sales to affiliated and to unaffiliated persons. Sales to other foreign countries are an appropriate representation of export-platform FDI if the output are sold to unaffiliated customers in other foreign countries. Nevertheless, more than half of the total sales to other foreign countries are sold to affiliated persons. These sales are more likely to be sales of intermediate inputs to affiliates in other foreign countries for further processing before exporting back to the U.S. parent. Therefore they are a better representation of vertical FDI which involves shifting multiple stages of production to multiple host countries rather than export-platform FDI. The estimated coefficients on tax rates for sales to other foreign countries are distinctively larger than those for sales back to the United States in the baseline regression. After extracting sales to unaffiliated persons from the total sales to other foreign countries, the coefficients on tax rates become smaller in magnitude and empirically more plausible. For the other proportion of the sales to other foreign countries that are sold to affiliated persons, tax rates have a negative and significant effect. The magnitude of the tax effect on sales to affiliated persons is similar to the that on vertical FDI. The effect on horizontal FDI is still not significant either for sales to unaffiliated or to affiliated persons.

I also test whether asymmetric effect of taxes found for host country tax rates applies to third country tax rates. Adding a weighted average of tax rates in other host countries shows that horizontal FDI remain insensitive to tax rates in other host countries. The effect of local corporate income tax rates on U.S. horizontal FDI does not seem to cross boarders. Third country tax rates seem to have a counterintuitive effect on vertical FDI that higher tax rates in proximate countries of a host country are associated with lower vertical FDI in the host country. This suggests that U.S. vertical FDI usually involves more than one host country and MNEs shift multiple stages of production to multiple host countries. When higher tax rates in proximate countries to a host country negatively affect vertical affiliates' production in those countries which are complements to vertical FDI in the host country, the higher third country tax rate would have a negative impact on vertical FDI in the host country. The effect of third country tax rates on export-platform FDI is consistent with the simplest form of such type of FDI in which MNEs choose the lowest-cost countries to locate their affiliate to serve other proximate countries. Higher third country tax rates are found to encourage export-platform FDI in a host country.

In summary, this study shows that local policies such as corporate income tax rates can have distinctively different effects on FDI of different types. The results suggest that policy makers should take into account that the degree to which inward FDI will respond to policy changes varies across the different natures of FDI. Some extensions can be made on the current study in the future. For instance, the division of horizontal, vertical and export-platform FDI may still be too rough. Baldwin and Okubo (2012) show that FDI can be further divided into more distinct types using the sourcing pattern of intermediate inputs in addition to the destination of sales. It would be interesting to study how the further categorized types of FDI respond in different ways to local policy changes.

3.9 Appendix

Table 3.12 shows the results of using fewer number of lags as instruments for the predetermined and endogenous variables. Table 3.13 shows the results of using the inverse of the distance from a third country to a host countries as weight for the tax rates of the third country.

Table 3.12: Baseline Regression with Fewer Lags as Instruments

	Local Sales	Sales to US and Other Countries	Sales to US	Sales to Other
VARIABLES				
Lag Local Sales	0.979***			
	(0.0144)			
Lag Sales to US & Other		0.122***		
		(0.0140)		
Lag Sales to US			0.891***	
			(0.0235)	
Lag Sales to Other				0.0810***
				(0.0128)
Tax Rate	142.2*	-521.0***	-22.70	-378.5**
	(79.91)	(174.6)	(17.94)	(191.8)
GDP Per Capita	0.0534	1.229***	0.00997	1.390***
	(0.115)	(0.370)	(0.0373)	(0.356)
FDI Stock	2.724***	35.13***	1.025**	18.62***
	(0.928)	(4.263)	(0.425)	(4.227)
Exchange Rate	0.439	3.171*	0.221	2.750**
	(0.356)	(1.760)	(0.156)	(1.324)
Tariff Rate	-609.2**	264.3	-73.91	429.2
	(258.9)	(753.1)	(48.08)	(721.2)
Openness	1.705	79.66*	2.317	53.10
	(7.683)	(41.49)	(3.095)	(34.29)
Population	0.0101***	0.0221**	0.00190**	0.0222***
	(0.00243)	(0.0105)	(0.000873)	(0.00781)
Distance	-0.164	-0.771	-0.132	-0.780
	(0.226)	(0.830)	(0.111)	(0.629)
Common Language	1,149	12,215*	1,336	9,849
	(1,975)	(6,606)	(813.6)	(6,310)
Constant	-4,967	-10,107	636.7	-12,896
	(4,102)	(9,432)	(974.8)	(10,363)
Observations	384	383	389	406
Number of countries	47	47	47	47
Number of Instruments	31	31	31	31
Hansen Statistic p-value	0.388	0.0600	0.323	0.150

Standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.13: Third Country Taxation Effect Weighted by the Inverse of Distance

VARIABLES	Local Sales	Sales to US	Sales to Other	
			Affiliated	Unaffiliated
Lag Local Sales	0.984***			
	(0.00612)			
Lag Sales to US		0.869***		
		(0.0143)		
Lag Sales to Other			1.057***	0.805***
			(0.0128)	(0.0145)
Tax Rate	49.64	-34.60***	-68.72***	-39.53*
	(41.00)	(11.02)	(19.27)	(20.92)
3rd Country Tax Rate	692.3***	-101.3	-179.0***	568.3***
	(238.6)	(64.26)	(63.30)	(124.7)
GDP Per Capita	0.0677	0.0121	0.0174	0.118***
	(0.0747)	(0.0162)	(0.0221)	(0.0277)
FDI Stock	3.977***	1.092***	0.205	3.476***
	(0.500)	(0.144)	(0.214)	(0.293)
Exchange Rate	-0.0603	0.298***	0.270**	-1.002***
	(0.226)	(0.0640)	(0.108)	(0.127)
Tariff Rate	-339.2**	-37.49	121.2***	-64.91
	(139.4)	(31.35)	(31.68)	(40.15)
Openness	-1.953	3.420*	1.071	4.075
	(5.663)	(1.840)	(2.169)	(3.298)
Population	0.00780***	0.00161**	-1.89e-05	0.00185
	(0.00151)	(0.000666)	(0.000485)	(0.00124)
Distance	0.0601	-0.225***	-0.0256	0.259***
	(0.149)	(0.0697)	(0.0204)	(0.0615)
Common Language	-705.1	1,977***	386.5	-1,880***
	(1,446)	(616.5)	(266.1)	(408.4)
Constant	-21,774***	3,850*	4,884**	-18,420***
	(7,323)	(2,169)	(2,215)	(3,906)
Observations	384	389	402	402
Number of countries	47	47	47	47
Number of Instruments	42	42	42	42
Hansen Statistic p-value	0.679	0.356	0.367	0.493

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 4

The Spillover Effect of Outward FDI on Home Countries: Evidence from the United States

4.1 Introduction

Policies that aim to attract Foreign Direct Investment (FDI) have been adopted in many countries as inward FDI has been shown to benefit a host country's economy in various ways. Multinational corporations (MNCs) make investments that boost national income and create employment opportunities in host countries. More importantly, MNCs typically cannot fully internalize their advantages in technology and managerial skills, which leads to indirect productivity spillovers to domestic firms. Therefore, most developed countries have adopted policies to attract FDI to promote economic growth. At the same time, many developed countries are not only large recipients but are also sources of FDI, but policies that directly promote outward FDI are largely absent. One reason that outward FDI promoting policies are not widely adopted is the fear that capital outflows might have adverse economic effects on home economies. Another reason is that there is no obvious evidence of positive spillovers from domestic MNCs to their home countries. Some researchers have argued that outward FDI is also an avenue to access foreign markets and assimilate advanced foreign technologies, which directly benefits the firms that become MNCs and generates indirect spillovers to other domestic firms. However, empirical evidence of home country spillovers from the FDI of domestic MNCs is quite limited. This paper tries to fill this gap by providing some evidence of FDI spillover effects on the productivity of home country firms.

Studies have shown that just like learning from exporting, more productive firms engage in FDI and these firms become more productive themselves through FDI. If there are more advanced technologies and better resources for production in foreign countries, accessing those productivity-enhancing elements through F-DI will make MNCs more competitive. Since MNCs often have close business relationships with firms in their home country, the gains obtained from their FDI may leak to other domestic firms through various channels.

The channels for home country spillovers are similar to those between foreign MNCs and host country firms. For instance, employees may obtain better skills as a result of their firm's overseas experience and transfer such skills to future employers through labor mobility. In addition, if MNCs become more productive through FDI, they will exert more competitive pressure on their domestic competitors and force these firms to improve productivity. When MNCs bring more efficient management strategies learned abroad to their home market, other domestic firms can learn through observation and imitation. However, as pointed out by recent studies on host country spillovers, MNCs have strong incentives to prevent knowledge leakage to other competing firms in the same industry, which reduces the possibility of intra-industry or horizontal spillovers which is also called horizontal spillovers. This might explain the failure to find positive spillover effects in most early studies.

MNCs have no incentive to limit spillovers through supplier-client relationships. When MNCs enter foreign markets, they may require their intermediate inputs suppliers to produce and deliver inputs in a more efficient manner. Sometimes MNCs will provide direct assistance to their suppliers to ensure high quality and on-time delivery of the inputs. Furthermore, if MNCs expand production after successfully tapping the foreign market, the demand for intermediate inputs from home country suppliers will also increase. Such an increase in demand will provide intermediate input producers in the home country an opportunity to take the advantage of economies of scale, which lowers costs and improves productivity.

Consider a U.S. toy manufacturer that invests in a plant in Asia to assemble the parts provided by another U.S. firm which produces plastic and rubber products. Because of the large market demand in Asia, the toy manufacturer needs the U.S. plastic and rubber product manufacturer to supply certain products specific to their toys for a long period of time. The U.S. plastic and rubber product manufacturer previously produced various kinds of plastic and rubber goods at some inefficient level. Now since there is a large increase in demand from the U.S. toy-making MNC, the U.S. supplier gains an opportunity to update their production lines to suit such demand and to specialize in the production of the certain intermediate inputs demanded by the MNC. The U.S. toy-making MNC may also send staff to the U.S. supplier to provide assistance in production efficiency and quality control. This type of inter-industry spillover from MNCs to their suppliers is usually called a backward spillover. There is also another type of inter-industry spillover, forward spillover, which refers to the case in which firms benefit as customers of MNCs. This type of spillover occurs when advanced technologies assimilated by MNCs' affiliates in foreign countries are transferred to home country customers through the supply of improved and higher-quality inputs.

Spillovers from MNCs to domestic firms in host countries have been extensively studied and recent studies have found supportive evidence of backward spillovers. This paper tries to complement the studies of FDI spillovers from the perspective of home countries. In addition to understanding whether spillovers from MNCs to home countries exist, policy makers are interested in the conditions under which positive spillovers are more likely to materialize. Therefore, this paper also investigates several characteristics of home country firms that might play critical roles in creating positive spillovers, such as absorptive capacity, firm size and exporting status. I find a significant and positive effect from multinational customers to the productivity of their suppliers using firm level information from Standard and Poor's Compustat data, which provides an evidence of backward spillovers. Moreover, exporting and small firms are more likely to receive positive spillovers from their multinational customers. No evidence of general spillovers is found for MNEs in the same industry and upstream industries. However, when the absorptive capacity of the recipient firms is accounted for, firms distributed at the two ends of the productivity spectrum are more likely to receive both horizontal and backward spillovers.

The rest of the paper is organized as follows. In the next section, reviews of literatures on host country spillovers and home country spillovers are provided. Section 3 discusses the data and the empirical method. Section 4 provides main results and section 5 concludes.

4.2 Literature Review

4.2.1 FDI Spillovers on Host Economy

Early studies of FDI mostly focused on how foreign MNCs affect a host nation's economy. Theories have also been developed to explain how positive externalities might be generated from foreign firms that benefit domestic firms. Among the potential transmission channels through which spillovers occur between MNCs and domestic firms in the same industry (intraindustry spillover), three of them are discussed in the theoretical literature. The first channel is demonstration, which is described in Das (1987) and Wang and Blomström (1992). Domestic firms learn from foreign firms through observation and imitation when foreign firms enter the local market. Such learning occurs both at the production level when manufacturing processes are imitated through reverse engineering and at the management level when foreign firm's marketing and managerial strategies are observed. The second channel for intraindustry spillovers, labor mobility, is modeled by Fosfuri et al. (2001) and Glass and Saggi (2002). In these models, local production workers and managerial staffs in a MNC's subsidiary receive training to apply superior technology to local production. Domestic competitors have an incentive to hire these trained employees and positive spillovers take place when the MNC fails to provide a sufficient wage premium to keep its highly trained employees. The difficulty of tracking workers is the major obstacle in empirical studies of this particular channel. The third channel is competition. Foreign firms generate competitive pressure on indigenous firms, which stimulates the updating of technology and production processes used by local competitors. Even if domestic firms cannot update their production technology, they will try to use their existing resources more efficiently so as to compete with the more advanced foreign competitors (Glass and Saggi (2002); Markusen and Venables (1999)). The competition effect may also generate negative externalities to local firms when incoming foreign firms are so strong that they take over a large share of the market from local firms and drive some small local firms out of business.

The possibility that foreign firms bring not only new investment but also secondary spillovers which result in higher productivity growth to host nations has led many economists to search for empirical evidence of spillovers. However, only mixed results have been found due to a number of factors including use of improper statistical methods, the heterogeneity of spillovers and the lack of comprehensive firm-level data. Caves (1974) and Globerman (1979) are pioneering studies that empirically test for FDI spillovers on host country productivity. Their findings provide positive evidence that indigenous firms' productivity in Australia and Canada coincide with higher shares of foreign subsidiaries, although their conclusions are limited by their crude measure of foreign presence and the poor quality of data. Following their study, economists extended the empirical test of FDI spillovers to developing countries, panel data and firm level analysis, such as Kathuria (2000), Castellani and Zanfei (2003) and Barrios and Strobl (2002). The results from these studies are at best mixed. Kathuria (2000) shows that the presence of foreign firms is associated with negative spillovers in sectors where foreign-owned firms are close to the technological frontier. In Castellani and Zanfei (2003)'s study of manufacturing firms, positive spillovers exist in Italy but not in France and Spain. Barrios and Strobl (2002) also find that FDI spillovers only occur to domestic firms with an appropriate level of absorptive capacity. However, Keller and Yeaple (2009) use U.S. firm level data and a proper measure of total factor productivity and show that multinationals generate statistically significant productivity benefits to domestic firms in the same industry. Görg and Greenaway (2004) provide a comprehensive review of recent studies of intraindustry FDI spillovers and suggest that researchers should pay more attention to the conditions affecting the likelihood of positive FDI spillovers, including the form of entry (green field or acquisition), local economic environment and investment incentives provided by host governments.

Recent studies of FDI spillovers have shifted attention to evaluating the factors which induce FDI spillovers. One hypothesis that has drawn attention from researchers is that knowledge and technology spillovers are more likely to be found in vertical linkages between suppliers and clients in different industries than between competitors in the same industry. The reason that vertical spillovers might be more common than horizontal spillovers is that a multinational firm which brings its superior skills in production and management to a host country usually also takes actions to prevent such advantages from spilling over to local firms that compete with it. Nevertheless the multinational firm is willing to provide assistance to its local suppliers so as to ensure high quality and on-time delivery of inputs. Foreign firms also bring with them higher-quality products that can be used as intermediate inputs by their local customers in downstream sectors. Rodriguez-Clare (1996) provides theoretical support to the notion of vertical spillovers. His model suggests that when transportation and communication costs are high, the linkage effect from multinational customers to local suppliers is more likely to be materialized.

Empirical tests of vertical spillovers, especially backward spillovers, generally find more positive results than those of horizontal spillovers. For instance, Javorcik (2004), Liu (2008) and Blalock and Gertler (2008) all find statistically significant evidence of backward spillovers that local firms obtain productivity gains from supplying foreign firms but no horizontal spillovers. Empirical evidence of forward spillovers, on the other hand, is still limited.

The characteristics of the local firms also play an important role in determining whether empirical evidence of positive spillovers can be found. Domestic firms are heterogeneous and not all firms may receive the same spillovers. Barrios and Strobl (2002) show that exporting firms, because of their exposure to international competition, are more likely to absorb foreign technology and benefit from spillovers than non-exporting firms. Keller and Yeaple (2009) also show that firms in high-tech industries with intensive R&D activities receive stronger spillovers. They find no significant spillovers for low-tech firms.

Another intensively discussed characteristic that might affect a firm's ability to benefit from spillovers is its distance from the technological frontier and ability to internalize knowledge created by others-its absorptive capacity. Some authors such as Wang and Blomström (1992) have argued that the greater the gap between a firm's own technology and the technological frontier in its industry, the larger the opportunity for the firm to gain potential benefits. Kokko et al. (1996) claims that the gap cannot be too wide since domestic firms need some basic skills to assimilate foreign knowledge. In contrast, Marcin (2008) claims that firms near the technology frontier have greater absorptive capacity and are more capable of adopting transferred advanced technology. The literature of absorptive capacity shows that the effect of absorptive capacity on productivity may not be linear. Girma and Görg (2005) and Girma (2005) use nonlinear econometric methods and find that there is some threshold of absorptive capacity beyond which spillovers become stronger.

4.2.2 FDI Spillovers on Home Economy

FDI, like exporting, is a typical approach used by firms to access advanced technology and managerial skills in foreign countries. This type of FDI is sometimes called as "strategic asset seeking FDI"(Dunning and Narula (1995)) of which the major motivation is to access foreign technology. Fosfuri and Motta (1999) develop a model in which laggard firms use foreign affiliates to acquire location-specific knowledge, which provides a precondition for spillovers to other firms in home countries. Once multinational firms capture advanced foreign knowledge through FDI and transfer it to their home market, such knowledge may be assimilated by other firms in the home country through spillovers. However, unlike the prevalence of FDI attracting policies adopted worldwide, policies aimed at promoting outward FDI are relatively rare, especially in developing countries.[1]

[1] China, India, Thailand and South Africa are only a few examples of developing countries that have official policies or organizations that provide assistance to domestic outward investing firms.

This is probably because there is still a lot of debate over the effects of outward FDI on home economies. Although outward FDI may be beneficial to investing firms, it may also shift capital, tax revenue and employment opportunities abroad and create negative effects on the home country's exports as well as its balance of payment.[2]

Whether there are positive spillovers from outward FDI to firms in investors' home country, unlike its host country counterpart, has been rarely investigated by researchers. Of the limited studies on home country spillover effects, most of them focus on OECD countries since most less-developed countries are seldom a major source of FDI. Braconier et al. (2001) and Globerman et al. (2000) study the case for Swedish firms. The former shows no correlation between labor productivity and outward FDI using Swedish firm-level data while the latter shows that Swedish non-multinational firms' likelihood of citing patents is positively affected by Swedish outward FDI. Castellani and Zanfei (2006) study outward FDI in Italy and finds important external effects of an expansion of domestic multinationals on both employment and productivity of other domestic firms in Italy. Driffield et al. (2008) find positive spillovers of outward FDI on home country productivity but the data is at the industry level and the authors do not distinguish between domestic-owned and foreign-owned firms in the analysis. Vahter and Masso (2007) use enterprise-level data of Estonia and the results demonstrate that the productivity of parent firms which establish affiliates abroad is positively correlated with outward FDI activities, although no evidence of sector-wide spillovers is found for other purely national firms in Estonia. To date, no work that I am aware of has empirically tested whether there are productivity spillovers from U.S. MNCs to domestic firms in their home country, one of the

[2]See Kokko (2006) for a review of recent studies on the home country effect of outward FDI in developed economies and Globerman and Shapiro (2008) for outward FDI in emerging markets.

largest sources of outward FDI in the past few decades. This paper carries out an empirical test to fill the gap.

4.3 Data and Regression Strategy

The main data come from two sources. Firm level data on firm performance are from Standard and Poor's Compustat North America database which provides comprehensive information on firms in the U.S. and Canada. The industry level data of U.S. outward FDI activities are from the Bureau of Economic Analysis (BEA). From these two sources of data, I collect firm level information on U.S. domestic firms to obtain an estimate of firms' total factor productivity(TFP) and construct a measure of outward FDI activities in manufacturing industries (3111-3399) at the 4-digit NAICS industry level. The period is from 1999 to 2009 since the BEA changed its industry classification from SIC to NAICS in 1999. With the estimated TFP and measures of outward FDI activities, I can test whether there is evidence of productivity spillovers from U.S. outward FDI to domestic U.S. firms. Details of the definition and construction of the variables are provided in the appendix.

Although the Compustat dataset has detailed information on firms' income s-tatement and balance sheet, it does not provide information on foreign ownership. To focus on purely domestic U.S. firms, I delete firms that are either incorporated or have headquarters outside the U.S. in order to remove firms that may be MNCs themselves. In addition, I drop firms that either have foreign pretax income or have income taxes payable to foreign governments during the sample period. One caveat regarding this deletion is that it may over-delete firms from the sample as some firms only have warehouses abroad and receive income from the warehouse rather than actually engaging in FDI. Observations with missing values of employment, capital and value added are also deleted. Due to the panel structure and the estimation method adopted below, I also delete firms that have gaps in the sample period and those that appear in the sample for only one year.

The focus is on spillover effects on firms' productivity. However, Compustat does not have direct information regarding firms' TFP. Therefore, I constructe TFP as the Solow residual from estimating a Cobb-Douglass production function:

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + \omega_{it} + \eta_{it}$$

where y_{it} is the log of a firm's value added, l_{it} is the log of the number of employees, k_{it} is the log of the firm's capital stock, ω_{it} is a transmitted component that is observed by decision-makers but not the econometrician, and η_{it} is an $i.i.d.$ shock. Since ω_{it} affects firms' input decisions, simple OLS will generate biased estimates on labor and capital if an econometrician fails to recognize that a positive productivity shock leads to higher variable input.

To address the problem of the simultaneity of input choices, I apply the approach proposed by Olley and Pakes (1996) that accounts for not only simultaneity but also selection bias. Specifically, a firm will receive a liquidation value Φ if it chooses to exit the market and the firm maximizes its expected discounted value of future profits. The exit decision depends on whether current realization of ω_{it} is less than some threshold $\underline{\omega}_{it}(k_{it}, a_{it})$ which is a function of capital stock k_{it} and firm's age a_{it}. ω_{it} is assumed to follow a Markov process. If the threshold $\underline{\omega}_{it}(l_{it}, a_{it})$ is negatively related to capital stock as firms with higher capital stock have larger expected future profitability, then firms with small capital stock will exit the market. Such an selection process will lead to a downward bias on the coefficient on capital. To address the two problems, Olley and Pakes (1996) proposed assuming that investment i_{it} is a function of ω_{it}, k_{it} and a_{it} and it is strictly increasing in ω_{it}. Then we can invert the investment function and write ω_{it} as a function as follows

$$\omega_{it} = i^{-1}(i_{it}, k_{it}, a_{it}) = h(i_{it}, k_{it}, a_{it})$$

Consistent estimates of the coefficient on labor can be obtained from estimating the following equation with OLS since after controlling for the unobserved shock, the error term is not correlated with inputs:

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \phi(i_{it}, k_{it}, a_{it}) + \eta_{it}$$

where $\phi(i_{it}, k_{it}, a_{it}) = \alpha_0 + \alpha_k k_{it} + \alpha_a a_{it} + h(i_{it}, k_{it}, a_{it})$. In the above equation $\phi(i_{it}, k_{it}, a_{it})$ is approximated by a second-order polynomial of i_{it}, k_{it} and a_{it}.

After obtaining a consistent estimate of the coefficient on labor, the next step is to estimate the following nonlinear equation:

$$y_{it} - \hat{\alpha}_l l_{it} = \alpha_k k_{it} + \alpha_a a_{it} + g(\hat{\phi}_{t-1} - \alpha_k k_{i,t-1} - \alpha_a a_{i,t-1}, \hat{P}_{it}) + \xi_{it} + \eta_{it}$$

where $\hat{P}_{it}$ is the predicted probability of survival estimated from a Probit model. The Probit model is estimated on a second-order polynomial of capital, investment and age (lagged one period). In the above equation function g which is similar to the inverse Mill's ratio in a two-step sample selection model is also approximated by a second-order polynomial of $\hat{\phi}_{t-1} - \alpha_k k_{i,t-1} - \alpha_a a_{i,t-1}$ and $\hat{P}_{it}$. The above estimation technique corrects for the selection bias and gives consistent estimates of capital and age.

Using the Olley-Pakes method discussed above, I estimate labor and capital returns and predict TFP for each firm. Since different sectors do not necessarily have the same return to labor and capital, I allow the estimates to vary across the 2-digit NAICS sectors. The estimated return to labor and capital for NAICS sectors 31, 32 and 33 are reported in table 4.1 below. As shown in the table, the return to labor is approximately 0.7 and the return to capital is approximately

Table 4.1: Olley-Pakes TFP Equation Estimation

NAICS	31	32	33
Labor	0.688***	0.664***	0.758***
	(0.0568)	(0.0384)	(0.0365)
Capital	0.284***	0.299***	0.209***
	(0.0835)	(0.0661)	(0.0363)
Sum	0.972	0.963	0.967
Observations	664	1,280	2,677

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

0.3. The sum of the two coefficients are close to 1 for all sectors, exhibiting nearly constant returns to scale.

TFP for each firm can be calculated using the estimated coefficients on labor and capital from the table above. These TFP estimates are then regressed on some measure of outward U.S. FDI activities to examine the home country spillover effect. Equation (1) below shows an explanatory regression which is similar to those used in most early studies of FDI spillovers.

$$\ln TFP_{ijt} = \alpha + \beta Horizontal_{jt} + \alpha_j + \alpha_t + \epsilon_{ijt} \qquad (4.1)$$

$Horizontal_{jt}$ is a proxy for outward FDI in industry j. It captures the extent of foreign activities by U.S. MNCs and is defined as the ratio of U.S. affiliate sales abroad in industry j and domestic sales of industry j in the U.S. market. α_j and α_t are industry and time dummies.

Equation (1) is estimated with Ordinary Least Squares (OLS) and the results are reported in column 1 of table 4.2. According to the results in column 1, a U.S. domestic firm's productivity is positively correlated with U.S. outward FDI in the same industry. As discussed in Javorcik (2004), Liu (2008) and Blalock and Gertler (2008), in addition to intraindustry spillovers, there may be greater spillovers between industries through backward and forward linkages. To test potential interindustry spillovers I add measures of outward FDI in a firm's upstream and downstream industries to equation (1) and the results are shown in column 2 of table 4.2. The regression is shown below in equation (2).

$$\ln TFP_{ijt} = \alpha + \beta_1 Horizontal_{jt} + \beta_2 Backward_{jt} + \beta_3 Forward_{jt} + \alpha_j + \alpha_t + \epsilon_{ijt} \tag{4.2}$$

$Backward_{jt}$ is a proxy for outward FDI in industries that are supplied by U.S. firms in industry j. It captures spillovers from U.S. multinational customers to their suppliers in the U.S. and is defined following Javorcik (2004) as:

$$Backward_{jt} = \sum_{k \text{ if } k \neq j} \alpha_{jk} Horizontal_{kt}$$

where α_{jk} is the proportion of industry j's production purchased by industry k as intermediate inputs. To illustrate the vertical linkage represented by this variable, suppose that the steel industry sells 30% of its output to the machinery industry and the other 70% to the automobile industry. If the U.S. affiliate sales of steels aborad is 40% of the domestic sales of steels in the U.S. and the U.S. affiliate sales of automobiles aborad is the same as the sales of automobiles in the U.S., then the *Backward* variable is calculated as: $0.3 * 0.4 + 0.7 * 1 = 0.82$. Such a variable captures outward FDI activities in an industry's downstream industries, weighted by the fraction of the industry's sales to each of the downstream industries. α_{jk} is obtained from the 1999 input-output matrix published by the U.S. Bureau of Labor Statistics (BLS).[3] A nice feature of the BLS input-output matrix compared to other studies of interindustry spillovers is that the BLS input-output matrix is disaggregated at the 4-digit NAICS level which has approximately 200

[3]Although there are annual input-output matrices available from the BLS, a static input-output matrix is chosen to separate the effect of changes in outward FDI and changes the U.S. industry structures on domestic firms' productivity. Regressions using vertical linkages constructed from dynamic input-output matrices are also carried out and the results are similar.

sectors. If sectors are highly aggregated and the number of sectors is small, the supplier-customer relationship are mostly within sectors rather than between sectors, which represents only a small proportion of all possible vertical spillovers.

Similarly, $Forward_{jt}$ is a proxy for outward FDI in industries that supply industry j. It captures spillovers from U.S. multinational suppliers to their clients in the U.S. and is defined as:

$$Forward_{jt} = \sum_{m \text{ if } m \neq j} \sigma_{jm} Horizontal_{mt}$$

where σ_{jm} is the fraction of industry j's intermediate inputs supplied by industry m. σ_{jm} is also obtained from the BLS input-output matrix. $Forward_{jt}$ is a weighted average of outward FDI activities in an industry's upstream industries. All proxies for outward FDI are at the 4-digit NAICS industry level.

Equation (2) is also estimated using OLS accounting for possible heteroskedasticity. Corresponding results are shown in the second column of table 4.2. After adding in the measures of interindustry FDI proxies, the coefficient on horizontal FDI does not change much. The spillovers from MNC customers to home country suppliers are positive, which is consistent with theoretical assumptions of positive spillovers from FDI. However, the spillovers from MNC suppliers to home country customers are negative.

The OLS regression results suffer from a few econometric issues. First, there may be firm specific factors unknown to the econometrician but known to the firms which affect their productivity. Following Javorcik (2004) I assume that the unobserved heterogeneity across firms is time constant and use time differencing of the regression equation to eliminate such fixed firm-specific factors. A set of industry and time dummies are also added to the differenced equation to control for unobserved industrial, time and regional effects. Second, there are still some time-variant variables that affect a firm's productivity which are omitted in the

Table 4.2: Regression in Levels

	(1) TFP	(2) TFP
Horizontal	0.245***	0.264***
	(0.0532)	(0.0554)
Backward		0.485***
		(0.123)
Forward		-0.579***
		(0.138)
Constant	2.722***	2.758***
	(0.0387)	(0.0513)
Observations	3,896	3,896
R-squared	0.142	0.151

All regressions include industry and year dummies.
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

differenced equation. To better isolate the effect of outward FDI, I include a set of control variables that are potential determinants of the growth of TFP.[4] The additional control variables included in the regression are domestic demand for intermediate inputs calculated from the BLS input-output matrix and a measure of the degree of capital utilization in the industry. The former picks up domestic demand shocks to a firm and the latter may be part of the error that correlates with outward FDI. I also include a firm's market share and its markup in the control variables. A firm's market share in its industry and its markup pick up the degree of competition faced by that firm. The higher its market share and markup, the less competitive pressure a firm faces and it has less incentive to improve its production technology. Therefore, the signs of a firm's market share and markup on productivity are expected to be negative. Finally, in the standard OLS regression the standard errors of the estimates will be downward

[4]Note that after time differencing, the dependent variable is $\ln \frac{TFP_{ijst}}{TFP_{ijst-1}}$ which represents the growth rate of TFP.

biased if the micro units are correlated within groups in some way, which leads to spurious statistical significance of the estimated coefficients. To deal with potential correlations of the errors, I allow errors belonging to the same 3-digit NAICS industries to be correlated.

4.4 Model in Differences

4.4.1 Baseline Regression

After all the econometric improvements made to the OLS specification in equation (2), the following differenced equation is estimated with clustered standard errors:

$$\begin{aligned}\Delta \ln TFP_{ijt} =& \alpha + \beta_1 \Delta Horizontal_{jt} + \beta_2 \Delta Backward_{jt} + \beta_3 \Delta Forward_{jt} \\ & + \theta_1 fm_{ijt-1} + \theta_2 ms_{ijt-1} + \theta_3 ld_{jt-1} + \theta_4 cu_{jt-1} + \alpha_j + \alpha_t + \epsilon_{ijt}\end{aligned} \tag{4.3}$$

where ms and fm are market share and firm markup. ld and cu are the log of intermediates demand and the degree of capital utilization. α_i and α_t are industry and year dummies. Descriptive statistics of all the variables are provided in table 4.3.

Table 4.3: Descriptive Statistics

	Mean	Std. Dev.	Min	Max
TFP	35.255	47.960	0.120	792.548
Horizontal	0.395	0.314	0.003	2.712
Backward	0.315	0.180	0.010	1.636
Forward	0.305	0.155	0.059	1.374
Market Share	0.023	0.061	9.08e-06	0.719
Firm Markup	1.006	0.210	-3.634	4.170
Intermediates Demand	8.919	1.517	4.958	11.626
Capital Utilization	177.447	210.219	12.035	1520.81

Results from the differenced regression are shown in table 4.4. The first column shows the result when only horizontal FDI spillovers are considered. After controlling for unobserved heterogeneity across firms and other variables that affect TFP, the coefficient on horizontal FDI becomes negative and statistically insignificant. Similar to Kathuria (2000) and Javorcik (2004), no evidence of general intraindustry spillovers is found, which is consistent with the hypothesis that multinationals tend to prevent their advanced technologies from leaking to their competitors so as to protect their own market power. All of the other explanatory variables are statistically significant. The coefficients on market share and firm markup which measure the competitive pressure a firm faces are negative, which indicates that greater competitive pressure leads to faster growth. The degree of capital utilization is positively correlated with TFP while demand for intermediate goods is negatively correlated with TFP.

The second column in table 4.4 shows the results that add FDI spillovers from vertical linkages. The coefficient on backward FDI suggests that there is still evidence of spillovers from MNCs to their suppliers. Although the magnitude of the coefficient is smaller and the estimate is less significant, the coefficient is economically meaningful. A one-standard-deviation increase of outward FDI activities carried out by a firm's MNC customers (that is, an increase of 0.18 in the backward variable) is associated with a 2.8 percent increase in its TFP. The coefficient on forward FDI is still negative but not statistically significant. Comparing the results in the first two columns of table 4.4 with the results in table 4.2, we see the importance of controlling for firm-specific effects when evaluating FDI spillovers. The estimated coefficients from the OLS regression might be biased and their significance might be spurious. After correcting for such problems, no spillover is found from outward FDI in the same industry and in upstream industries. The significant and economically meaningful backward productivity

Table 4.4: Regression in First Difference

	(1)	(2)	(3)	(4)
	ΔlnTFP	ΔlnTFP	ΔlnTFP	Δ^2lnTFP
ΔHorizontal	-0.0394	-0.0517		0.163
	(0.110)	(0.0910)		(0.137)
Lagged ΔHorizontal			-0.0913	
			(0.169)	
ΔBackward		0.155*		0.264**
		(0.0853)		(0.124)
Lagged ΔBackward			-0.0588	
			(0.110)	
ΔForward		-0.194		-0.547*
		(0.286)		(0.263)
Lagged ΔForward			-0.460	
			(0.270)	
Firm Markup	-0.359***	-0.359***	-0.489***	-0.223
	(0.0968)	(0.0969)	(0.0777)	(0.133)
Market Share	-0.363***	-0.359***	-0.432**	-0.706**
	(0.107)	(0.105)	(0.158)	(0.257)
Intermediates Demand	-0.0200*	-0.0221**	-0.0124**	-0.0289**
	(0.00988)	(0.00830)	(0.00559)	(0.0125)
Capital Utilization	0.000230***	0.000230***	0.000125**	0.000347***
	(5.19e-05)	(5.17e-05)	(5.22e-05)	(0.000108)
Constant	0.480***	0.486***	0.604***	0.505***
	(0.159)	(0.143)	(0.130)	(0.150)
Observations	2,740	2,740	2,342	1,229
R-squared	0.048	0.049	0.057	0.077

All regressions include industry and year dummies.
Standard errors clustered at 3-digit NAICS industry levels are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

spillovers from MNCs to their home country suppliers are consistent with many of the recent studies on host country spillovers.

To test whether it takes time for spillovers to be realized for domestic firms, in column 3 of table 4.4 I use lagged FDI proxies instead of the contemporaneous ones. The signs of all the lagged FDI proxies become negative and none of the coefficients are statistically significant, which suggests that the spillovers occur rather quickly to receiving firms. In the last column of table 4.4, a specification with two-year differences is used to further reduce the noise in the regression at the expense of losing a large number of observations[5]. Now the coefficient on horizontal FDI becomes positive, although still not significant. The coefficients on backward FDI remain positive and become greater in magnitude and statistically more significant. This result again shows that spillovers from U.S. MNCs to their U.S. suppliers are more prevalent than spillovers to competing U.S. firms. The coefficient on forward spillovers becomes significant at the 10% level. The negative sign indicates that U.S. outward FDI might hurt firms that are supplied by U.S. multinationals.

4.4.2 Robustness Check

The Olley-Pakes method of estimating TFP requires some assumptions to produce consistent estimates. If there are substantial adjustment costs to investment, the investment function may have kink points and plants may not respond fully to ω_{it}. As a result, the correlation between inputs and the error terms still exists. The Olley-Pakes approach also needs plants to report non-zero investment for

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[5]Using two-year differences in column 4 of table 4.4 reduces the number of firms in the regression from 654 in column 2 to 504. I also regress the equation in column 2 with the 504 firms and the results are similar to the results in column 2. The firms dropped out from the sample because of taking longer differences do not have a significant impact on the baseline regression results in column 2.

TFP estimation. Levinsohn and Petrin (2003) propose using intermediate inputs such as materials, electricity or fuels which are less costly to adjust as proxies for unobserved productivity shocks. In this section, I will first discuss how to estimate TFP using the Levinsohn-Petrin method and then test outward FDI spillovers on TFP estimated from this approach.

The Levinsohn-Petrin approach assumes that the intermediate input m_{it} is a function of state variables k_{it} and ω_{it}. Under some mild assumptions, this function can be inverted so that $\omega_{it} = \omega_t(k_{it}, m_{it})$. The estimation of labor and capital elasticities takes two steps. The first step is to estimate the following equation:

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \phi(k_{it}, m_{it}) + \eta_{it}$$

where $\phi(k_{it}, m_{it}) = \alpha_0 + \alpha_k k_{it} + \omega_t(k_{it}, m_{it})$. $\omega_t(k_{it}, m_{it})$ is approximated by a third-order polynomial in k_{it} and m_{it}. From the first step, a consistent estimate of α_l is obtained.

In the second step, the estimate of α_k can be obtained from solving

$$\min_{\alpha_k^*} \sum_t (y_{it} - \hat{\alpha}_l l_{it} - \alpha_k^* k_{it} - E[\widehat{\omega_{it}|\omega_{i,t-1}}])$$

Assuming ω_{it} follows a first-order Markov process $\omega_{it} = E[\omega_{it}|\omega_{i,t-1}] + \xi_{it}$, then $E[\widehat{\omega_{it}|\omega_{i,t-1}}]$ is a nonparametric approximation to $E[\omega_{it}|\omega_{i,t-1}]$ which is obtained from the predicted value of the regression below

$$\hat{\omega}_{it} = \gamma_0 + \gamma_1 \hat{\omega}_{i,t-1} + \gamma_2 \hat{\omega}_{i,t-1}^2 + \gamma_3 \hat{\omega}_{i,t-1}^3 + \epsilon_{it}$$

where $\hat{\omega}_{it}$ is computed as $\hat{\omega}_{it} = \hat{y}_{it} - \hat{\alpha}_l l_{it} - \alpha_k^* k_{it}$ for any candidate value α_k^*.

Once the estimate of α_l and α_k are obtained, TFP can be calculated from the Cobb-Douglas production function. All regressions in table 4.4 are implemented again using TFP estimated from the Levinsohn-Petrin method to check the robustness of the results. Corresponding results are shown in table 4.5. As shown in the table, both the magnitudes and significance levels of all the coefficients

Table 4.5: Regression with TFP Estimation from the Levinsohn-Petrin Method

	(1) ΔlnTFP	(2) ΔlnTFP	(3) ΔlnTFP	(4) Δ^2lnTFP
ΔHorizontal	-0.0416	-0.0520		0.166
	(0.110)	(0.0911)		(0.136)
Lagged ΔHorizontal			-0.0877	
			(0.173)	
ΔBackward		0.158*		0.261*
		(0.0857)		(0.131)
Lagged ΔBackward			-0.0637	
			(0.111)	
ΔForward		-0.173		-0.544*
		(0.284)		(0.264)
Lagged ΔForward			-0.488*	
			(0.263)	
Firm Markup	-0.354***	-0.354***	-0.488***	-0.210
	(0.0971)	(0.0973)	(0.0786)	(0.136)
Market Share	-0.383***	-0.380***	-0.451**	-0.749***
	(0.110)	(0.108)	(0.162)	(0.257)
Intermediates Demand	-0.0206*	-0.0228**	-0.0128**	-0.0299**
	(0.0101)	(0.00862)	(0.00595)	(0.0134)
Capital Utilization	0.000228***	0.000229***	0.000121**	0.000343***
	(5.02e-05)	(5.00e-05)	(5.52e-05)	(0.000113)
Constant	0.485***	0.489***	0.605***	0.508***
	(0.160)	(0.145)	(0.134)	(0.154)
Observations	2,740	2,740	2,342	1,229
R-squared	0.049	0.050	0.058	0.080

All regressions include industry and year dummies.
Standard errors clustered at 3-digit NAICS industry levels are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

are only slightly changed. Only positive spillovers from MNC customers to their home country suppliers are found in the differenced equation. The conclusion that in general backward FDI spillovers on productivity are more likely to be realized is robust to TFP estimated from the Levinsohn-Petrin approach.

4.5 Determinants of Spillovers

4.5.1 Absorptive Capacity

The evidence of general spillovers shown in the previous sections is quite limited. It is possible that individual firms' heterogeneity may affect how much spillovers they receive. A key factor that might determine whether and how much a firm would receive spillovers from FDI activities is its absorptive capacity (AC) which is usually defined as the gap between its own productivity and the leading firm's productivity in its industry.

There are two contradicting views regarding how absorptive capacity affects a firm's ability to benefit from other MNCs' activities. On one hand, Findlay (1978) and Wang and Blomström (1992) argue that the more backward a firm's technological level, the greater potential opportunities for the firm to benefit from assimilated advanced technologies. According to this view, firms with the largest gap from the technological frontier are the most likely to receive positive spillovers. On the other hand, Glass and Saggi (2002) and Kinoshita (2001) suggest that technology diffusion is not automatic and firms need to possess a basic technological base to adopt advanced technology. In accordance with this view, firms near the technological frontier have greater capacities to make the best use of other firms' technology.

Empirical studies on how absorptive capacity affects spillovers from FDI find evidence supporting both views (Griffith et al. (2002) and Castellani and Zanfei

(2003) are consistent with the former and Girma et al. (2001) with the latter). I assume that the effect of a firm's technological gap is not necessarily monotone on the spillovers it obtains from MNCs. Firms with a large gap have greater potential for productivity growth and can assimilate less complex knowledge which gives specific benefits to themselves. Firms that are already in advanced technological positions have little room for drastic improvement but can assimilate more complex knowledge as they have sufficient absorptive capabilities. If we allow the effect of absorptive capacity to be nonlinear on FDI spillovers, the two seemingly contradicting views can be combined into one specification as follows:

$$\begin{aligned}\Delta \ln TFP_{ijt} = \alpha &+ (\beta_{11} + \beta_{12} AC_{ijt} + \beta_{13} AC_{ijt}^2)\Delta Horizontal_{jt} \\ &+ (\beta_{21} + \beta_{22} AC_{ijt} + \beta_{23} AC_{ijt}^2)\Delta Backward_{jt} \\ &+ (\beta_{31} + \beta_{32} AC_{ijt} + \beta_{33} AC_{ijt}^2)\Delta Forward_{jt} \\ &+ \theta_1 ms_{ijt} + \theta_2 fm_{ijt} + \theta_3 ld_{jt} + \theta_4 cu_{jt} + \theta_5 AC_{ijt} + \alpha_j + \alpha_t + \epsilon_{ijt}\end{aligned} \tag{4.4}$$

In the above equation, absorptive capacity (AC_{ijt}) is defined as a firm's TFP at period t-1 divided by the maximal TFP of the firm's industry at period t-1. A large value of AC_{ijt} implies that a firm is near the technological frontier and vice versa. The effects of outward FDI depend on both the level and the square of the absorptive capacity of the U.S. firms. Such a nonlinear specification allows more flexibility in how a firm's absorptive capacity affects the spillovers it receives from MNCs.

The results of the regression with absorptive capacity are show in table 4.6. The first column shows the result when only the AC variable is added to the regression. The negative and significant coefficient on AC is consistent with the

Table 4.6: FDI Spillovers with Absorptive Capacity

	(1)	(2)	(3)
	ΔlnTFP	ΔlnTFP	ΔlnTFP
Absorptive Capacity	-0.722***	-0.729***	-0.794***
	(0.130)	(0.130)	(0.116)
ΔHorizontal	-0.00467	-0.125	0.283
	(0.0772)	(0.233)	(0.204)
ΔHorizontal*Absorptive Capacity		1.026	-5.603*
		(1.601)	(2.909)
ΔHorizontal*Absorptive Capacity^2			12.57**
			(5.582)
ΔBackward	0.180**	0.314***	0.542***
	(0.0826)	(0.108)	(0.174)
ΔBackward*Absorptive Capacity		-0.700	-3.393**
		(0.403)	(1.264)
ΔBackward*Absorptive Capacity^2			4.673**
			(1.961)
ΔForward	-0.215	-0.274	-0.0361
	(0.277)	(0.276)	(0.344)
ΔForward*Absorptive Capacity		0.0490	-3.231
		(0.887)	(2.640)
ΔForward*Absorptive Capacity^2			6.927
			(6.036)
Firm Markup	-0.271***	-0.272***	-0.259***
	(0.0637)	(0.0651)	(0.0651)
Market Share	-0.199	-0.192	-0.185
	(0.148)	(0.149)	(0.177)
Intermediates Demand	-0.0205*	-0.0212*	-0.0194
	(0.0111)	(0.0116)	(0.0124)
Capital Utilization	0.000330***	0.000332***	0.000376***
	(8.44e-05)	(8.39e-05)	(0.000102)
Constant	0.458***	0.465***	0.429**
	(0.133)	(0.141)	(0.153)
Observations	2,740	2,740	2,740
R-squared	0.072	0.073	0.079

All regressions include industry and year dummies.
Standard errors clustered at 3-digit NAICS industry levels are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

catch-up effect — firms lagged further behind tend to grow more rapidly. Compared to the second column of table 4.5, the coefficients on the other variables do not change much after including the AC variable. In the second column of table 4.6, interactions of the AC and FDI variables are allowed. I first include the product of the AC variable and FDI presences to test whether spillover effects are affected linearly by the level of absorptive capacity. As show in the table, none the interaction terms with the three types of FDI is statistically significant.

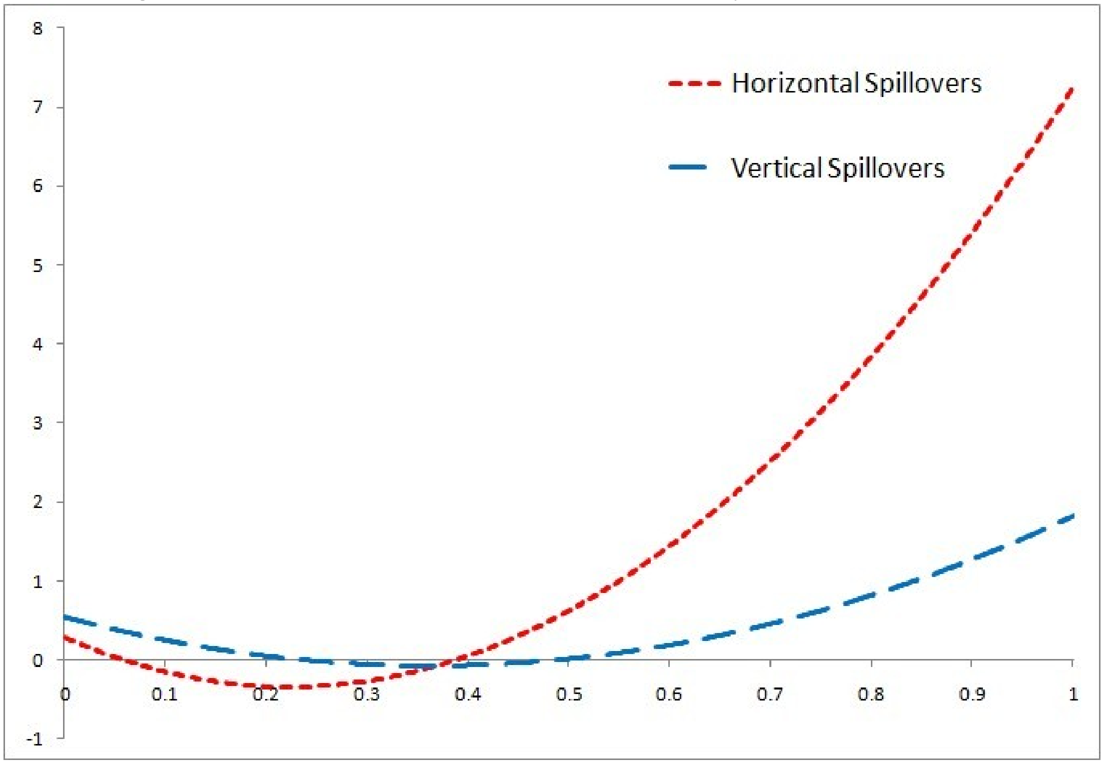
The effect of absorptive capacity on FDI spillovers may be nonlinear. Firms at the two ends of the spectrum of productivity distributions have different ways to use external knowledge. Therefore in the third column of table 4.6, both the level of the AC variable and its square are interacted with the FDI variables to allow a quadratic effect of the absorptive capacity on spillovers.

The coefficients on the interactions of the squared absorptive capacity and FDI are statistically significant at 5% level for both horizontal and backward FDI, which confirms the nonlinear effect on spillovers. The signs of the coefficients are positive, implying a U-shape function of absorptive capacity. However, I find no evidence of significant spillovers from downstream FDI to home country suppliers even if I control for the absorptive capacity of the firms. The U-shape function found for horizontal and backward FDI combines the two views regarding absorptive capacity discussed above. For firms with a low level of technology, the further they are from the technological frontier the greater the benefits they receive from outward FDI in the same industry and downstream industries. This is probably because those firms have greater potential for growth and the external knowledge from MNCs is of greater value to those firms once assimilated. For firms with an advanced level of technology, the closer they are to the technological frontier the more spillovers they receive from outward FDI in the same industry and downstream industries. The reason for this type of firms to enjoy extra benefits is probably because they possess greater technology know-how which enables them to be more capable of making good use of the external knowledge from MNCs.

Figure 4.1 shows how the spillover effect depends on a firm's absorptive capacity using the estimated coefficients in column 3[6]. Quantitatively, horizontal spillovers increase (decrease) with respect to a firm's absorptive capacity for firms with an absorptive capacity greater (less) than 0.223. The intraindustry spillovers are also positive for firms with an absorptive capacity less than 0.058 (135 firms on average) and greater than 0.388 (88 firms on average), which accounts for more than 30% of the 654 firms in the sample. Backward spillovers increase (decrease) with respect to a firm's absorptive capacity for firms with an absorptive capacity greater (less) than 0.363. The interindustry spillovers are also positive for firms with an absorptive capacity less than 0.237 (444 firms) and greater than 0.489 (41 firms), which accounts for more than 70% of the firms in the sample. Using the more flexible specification of absorptive capacity, I find a nonlinear effect of the absorptive capacity on the benefits firms receive from outward FDI. Such a nonlinear effect indicates that firms at the two extreme of the distribution of technology levels (either those near the technological frontier or those with a large technological gap) will enjoy the greatest benefits of outward FDI activities in the same industry or downstream industries.

[6]The two lines in figure 4.1 are the point estimates of the spillovers from horizontal and vertical FDI as a function of firms' absorptive capacity. In the appendix, I also show the standard deviation of the point estimates of the spillover effect at each value of firms' absorptive capacity.

Figure 4.1: The Effects of Absorptive Capacity on FDI Spillovers



4.5.2 Exporters v.s. Non-Exporters

Another characteristic of home country firms that might affect the spillovers they receive is their exporting experience. Firms that are exporters have more knowledge and experience about foreign markets, which makes them more capable of understanding and absorbing technologies related to foreign markets obtained by U.S. MNCs. In addition, firms that have exporting experience are also more likely to be chosen by MNCs as suppliers to their foreign affiliates and therefore have a better chance to receive assistance from multinational customers.

Compustat has a segment in which firms' export sales are reported. I use this information to differentiate exporters and non-exporters. An exporting firm is defined as a firm which has at least one year of positive export sales during the sample period. Using this standard, there are 217 firms that are exporters and 432 firms that are non-exporters in my sample.

Table 4.7 shows the results when the sample is divided between the two types of firms. In column (1) and (3) the first differenced equation (3) is regressed for exporting and non-exporting firms, respectively. The coefficients on FDI are all positive for exporting firms and statistically significant on backward FDI. For non-exporting firms, the coefficients are negative on horizontal FDI and forward FDI. Only the coefficient on backward FDI is positive while not significant.

The differences between column (1) and (3) are consistent with the view that U.S. firms with exporting experience are more likely to receive positive spillovers from U.S. MNCs. Exporting firms in general receive benefits from outward FDI, especially from their MNC customers. Their experience in dealing with foreign customers and exposure to foreign competition enable thems to better absorb and make use of the advanced technologies possessed by MNCs. On the other hand, firms that have not exported do not receive productivity gains from MNCs and may even get hurt.

Column (2) and (4) in table 4.7 show the difference between exporters and non-exporters when I account for absorptive capacity. In coloumn (2), where spillover effects are allowed to depend on absorptive capacity, absorptive capacity has a nonlinear U-shape effect on horizontal spillovers. Although on average non-exporters do not receive positive spillovers in column (3), their absorptive capacities do have a impact on spillovers. The effects of absorptive capacity are significant and also of a U-shape for horizontal and backward FDI, indicating that non-exporting firms that are lagged further behind or closer to technological frontier are more likely to receive productivity spillovers. This again confirms the importance of taking into account firms' heterogeneity into account when evaluating the spillover effect. In sum, exporting experience helps a firm to better absorb potential spillovers from MNCs, especially when they have MNCs as clients.

Table 4.7: FDI Spillovers for Exporters and Non-Exporters

	Exporter		Non-Exporter	
	(1)	(2)	(3)	(4)
ΔHorizontal	0.165	0.888**	-0.345**	-0.190
	(0.255)	(0.365)	(0.141)	(0.211)
ΔHorizontal*Absorptive Capacity		-9.097**		-4.253
		(3.325)		(2.453)
ΔHorizontal*Absorptive Capacity^2		13.59***		14.39**
		(4.106)		(6.443)
ΔBackward	0.164*	0.279***	0.180	0.811***
	(0.0891)	(0.0861)	(0.114)	(0.215)
ΔBackward*Absorptive Capacity		-1.314		-4.852***
		(1.561)		(1.274)
ΔBackward*Absorptive Capacity^2		1.800		6.490***
		(3.392)		(1.876)
ΔForward	0.176	0.472	-0.518	-0.377
	(0.362)	(0.495)	(0.385)	(0.442)
ΔForward*Absorptive Capacity		-2.922		-4.323
		(2.695)		(3.770)
ΔForward*Absorptive Capacity^2		6.194		6.895
		(5.404)		(9.451)
Absorptive Capacity		-0.523***		-0.972***
		(0.144)		(0.166)
Firm Markup	-0.378***	-0.297***	-0.354**	-0.248**
	(0.0497)	(0.0405)	(0.128)	(0.0956)
Market Share	-0.0733	-0.0313	-0.365***	-0.120
	(0.272)	(0.452)	(0.103)	(0.198)
Intermediates Demand	-0.00742	-0.00218	-0.0331***	-0.0312**
	(0.00468)	(0.00672)	(0.00875)	(0.0141)
Capital Utilization	0.000150**	0.000326*	0.000283***	0.000409***
	(6.70e-05)	(0.000167)	(7.11e-05)	(9.14e-05)
Constant	0.248**	0.148	0.601***	0.578***
	(0.0902)	(0.0865)	(0.143)	(0.159)
Observations	995	995	1,745	1,745
R-squared	0.055	0.076	0.054	0.096

All regressions include industry and year dummies.
Standard errors clustered at 3-digit NAICS industry levels are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.5.3 Small Firms v.s. Large Firms

The size of a firm may also affect the likelihood of receiving positive spillovers. Aitken and Harrison (1999) find negative spillovers on small domestic plants in Venezuela but not on large plants and claim that this is because small plants cannot compete as effectively with foreign MNCs as large plants. However, Sinani and Meyer (2004) find small firms may enjoy more spillovers as they are less bureaucratic, making it easier to adjust to new technologies.

To test whether outward FDI affects equally the small and large U.S. firms I divide my sample into small and large firms according to the criterion of U.S. Small Business Administration (SBA). According to the SBA rule, firms with less than 500 employees are considered as small firms in most industries. Equation (3) and (4) are regressed for small and large firms and results are shown in table 4.8. From the first and third column we can see that only small-sized firms receive positive spillovers from outward FDI in downstream industries. When the absorptive capacity of the recipient firms is taken into account, a U-shape effect of absorptive capacity is found on horizontal and backward FDI for small firms. In general, all the results found in the mixed sample still hold on the sample of small firms. No general spillover effect is found for large firms. However, an interesting result is found for large firms when their absorptive capacity is interacted with FDI presence. The last column shows that absorptive capacity has a U-shape effect on forward spillovers but no effect on the other two spillovers for large firms. This suggests that small firms and large firms not only are affected unequally by outward FDI but also receive different impacts of absorptive capacity on potential spillovers.

Table 4.8: FDI Spillovers for Small and Large Firms

	Small		Large	
	(1)	(2)	(3)	(4)
ΔHorizontal	0.0186	0.315	-0.317	-0.739
	(0.0938)	(0.198)	(0.344)	(1.532)
ΔHorizontal*Absorptive Capacity		-5.732*		3.174
		(3.208)		(10.40)
ΔHorizontal*Absorptive Capacity^2		12.82**		-2.339
		(5.706)		(15.04)
ΔBackward	0.245*	0.651***	0.0917	0.207
	(0.132)	(0.216)	(0.140)	(0.202)
ΔBackward*Absorptive Capacity		-5.598***		0.512
		(1.511)		(1.826)
ΔBackward*Absorptive Capacity^2		10.40***		-2.415
		(1.846)		(2.917)
ΔForward	-0.164	-0.176	-0.371	-0.191
	(0.368)	(0.312)	(0.358)	(1.024)
ΔForward*Absorptive Capacity		-0.150		-5.258
		(3.912)		(4.904)
ΔForward*Absorptive Capacity^2		-1.059		13.76*
		(8.907)		(6.635)
Absorptive Capacity		-0.921***		-0.765***
		(0.142)		(0.120)
Firm Markup	-0.369***	-0.263***	-0.290	-0.179
	(0.104)	(0.0694)	(0.254)	(0.179)
Market Share	-0.801***	-0.581	-0.272*	-0.192
	(0.162)	(0.434)	(0.135)	(0.162)
Intermediates Demand	-0.0178*	-0.0158	-0.0402***	-0.0384***
	(0.00979)	(0.0142)	(0.0130)	(0.0130)
Capital Utilization	0.000266***	0.000461***	0.000198**	0.000255***
	(5.29e-05)	(0.000130)	(7.28e-05)	(6.27e-05)
Constant	0.340**	0.280	0.680*	0.664*
	(0.141)	(0.168)	(0.377)	(0.316)
Observations	1,930	1,930	810	810
R-squared	0.050	0.081	0.101	0.166

All regressions include industry and year dummies.
Standard errors clustered at 3-digit NAICS industry levels are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.6 Conclusion

Many studies have searched for evidence of productivity spillovers from MNCs to host country firms. In this paper, I explore the other side of the issue by examining spillovers from U.S. MNCs to domestic firms in their home country, the United States. Using firm level data from the Compustat dataset, I calculate firms' TFP using the Olley-Pakes method which accounts for simultaneity of input choices and selection bias. A measure of U.S. outward FDI in a domestic U.S. firm's own industry is constructed using data from the BEA to capture intraindustry spillovers. To further explore the possibility of interindustry spillovers, FDI activities in a firm's upstream and downstream industries are also constructed using the input-output matrix from the BLS.

Similar to evidence found in most studies of host country spillovers, no general benefit from FDI in the same industry and in upstream industries is found for home country firms. However, significant spillovers on productivity is found from a multinational firm to its home country suppliers. This is also consistent with the host country spillover literature that positive spillovers are more likely to take place between domestic firms and their multinational clients since they are not competing with each other, which makes the MNCs less likely to prevent knowledge leakage. The magnitude of spillovers from FDI in downstream industries is also economically significant. A one-standard-deviation increase of outward FDI activities is on average associated with a 2.8 percent increase in a home country firm's TFP.

I also find that a firm's absorptive capacity, measured as the technological gap between a firm the leading firm in its industry, plays a critical role in determining spillovers. Unlike most of the previous studies that assume a linear effect of absorptive capacity on spillover effects, I allow a non-linear specification of the dependence of spillovers on absorptive capacity and find a U-shaped effect of absorptive capacity on horizontal and backward spillovers. Such nonlinearity indicates that firms with either low levels or high levels of productivity are more likely to enjoy positive spillovers than those with medium levels of productivity. This is probably because firms with low levels of productivity have greater potential for productivity growth and firms with high levels of productivity are more capable of adopting the complex technologies possessed by MNCs. Besides absorptive capacity, there are two other characteristics of the recipient U.S. firms that affect the spillovers they obtain. In general, exporting and small firms are more likely to receive positive spillovers from outward FDI in downstream industries. The effect of absorptive capacity on spillovers also depend on the exporting status and size of the recipient domestic firms.

The policy implications of these results are complex. Opponents of outward FDI argue that MNCs export domestic jobs to foreign countries, shift productive capital abroad and generate no benefit to the home country. The findings in this paper imply that there do exist benefits from outward FDI to other domestic firms, especially to their domestic suppliers. Policies can be made to strengthen the vertical linkage between domestic suppliers and the outward MNCs so that there will be more opportunities for these domestic suppliers to obtain positive spillovers through the interaction with their MNC customers.

The result also point out that absorptive capacity plays a critical role in affecting the spillovers to the recipient firms. For firms that are lagged behind, policies should aim to help identify, process and assimilate external knowledge that is suitable to their needs as these firms can grow quickly with the absorbed advanced technology. For firms that are close to the technological frontier, policies should aim to help provide more opportunities to interact with domestic MNCs since these firms are more capable of learning and absorbing external knowledge.

If policies are appropriately designed to promote spillovers from outward MNCs, this work suggests that outward FDI can be of great benefit to home countries.

There are a number of extensions that could be made to this study. As suggested in the host country spillover literature, spillovers from MNCs not only affect firms' productivity but also other factors such as employment and exporting decisions. Future studies on home country spillovers can further investigate spillovers in other aspects of the receiving firms. Other than characteristics of home country firms, the characteristics of outward MNCs may also be critical to the realization of spillovers. However, the outward FDI data from the BEA do not provide information that is detailed enough to explore the characteristics of the U.S. MNCs. If in the future more detailed data on the U.S. outward MNCs become available, it would be interesting to examine what type of FDI is more likely to bring spillovers to home countries. In addition, most studies on FDI spillovers are for developed countries partly because the majority stock of outward FDI in the world comes from wealthy nations. But some developing countries such as China are now becoming an important sources of outward FDI and future studies can examine the home country spillovers on developing countries. In sum, given the large literature on host country spillovers, this study provides evidence that FDI also leads to positive spillovers on domestic firms in investors' home countries. Such evidence may help policy makers to design better FDI related policies as promoting domestic firms to invest abroad is also an approach to boost domestic productivity growth other than attracting advanced foreign firms.

4.7 Appendix

Variable Definition, Sources and Data Construction

- Value Added (y_{it}): Net sales from Compustat minus materials; deflators are from Bartelsman and Gray (2001). Unit: million.

- Labor (l_{it}): Number of employees, from Compustat. Unit: thousand.

- Capital (k_{it}): Value of property, plant, and equipment, net of depreciation, from Compustat; deflators are from the BEA fixed asset and chain-type quantity index. Unit: million.

- Material (m_{it}): Cost of goods sold from Compustat plus administrative and selling expenses from Compustat minus depreciation from Compustat and labor expenses. Labor expenses is measured as labor multiplied by average wage of production workers from Bartelsman and Gray (2001); deflators are from Bartelsman and Gray (2001). Unit: million.

- Investment (i_{it}): Capital expenditure, from Compustat; deflators are from Bartelsman and Gray (2001). Unit: million.

- Age (a_{it}): A firm's birth year is approximated as the earliest of: (a) the year in which the firm is first listed on CRSP; (b) the year in which the firm is first listed on Compustat; (c) the year in which there is a link between CRSP and Compustat. Then a firm's age is defined as the difference between its birth year and the year when the firm is observed (plus one to avoid zero age).

- Exit Dummy: Compustat reports the reason for and date on which a company is deleted from the database. An exit dummy is equal to 1 if a firm is deleted because of acquisition and merger, bankruptcy or liquidation.

- Market Share (ms_{it}): The ratio of net sales from Compustat over industry sales from Bartelsman and Gray (2001).

- Firm Markup(fm_{it}): The ratio of net sales over net sales minus profits. Profits is approximated by net income from Compustat.

- Capital Utilization (cu_{it}): The ratio of capital stock over the total production workers' hours at 6-digit NAICS industry level, from Bartelsman and Gray (2001).

- Intermediate Demand (id_{jt}): $id_{jt} = \sum_k \alpha_{jk} * Y_{kt}$ where α_{jk} represents the unit of good j needed to produce one unit of good k from the BLS input-output matrix. Y_{kt} is industry k's output from the BLS input-output data at 4-digit NAICS industry level. Unit: million.

The Standard Deviations of Horizontal and Vertical Spillovers as a Function of Absorptive Capacity

The solid lines in figure 4.2 and 4.3 show the point estimates of the horizontal and vertical spillover effect at each value of firms' absorptive capacity. The distance between the solid line and the two dotted lines in each figure represents the standard deviation of the point estimate which also depends on the value of absorptive capacity.

Adding the standard deviations to the two types of spillovers supports the results found in section 4.5.1. Firms distributed at the two ends of the spectrum of absorptive capacity tend to receive positive spillovers.

Figure 4.2: The Effects of Absorptive Capacity on Horizontal Spillovers

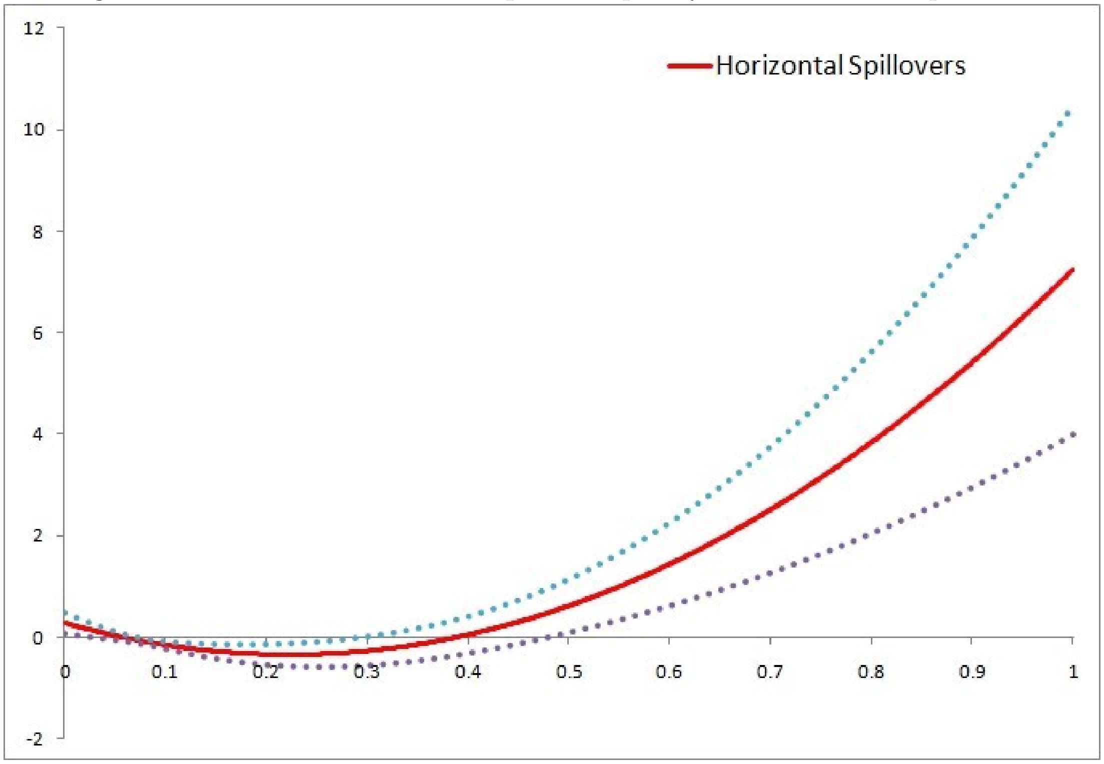
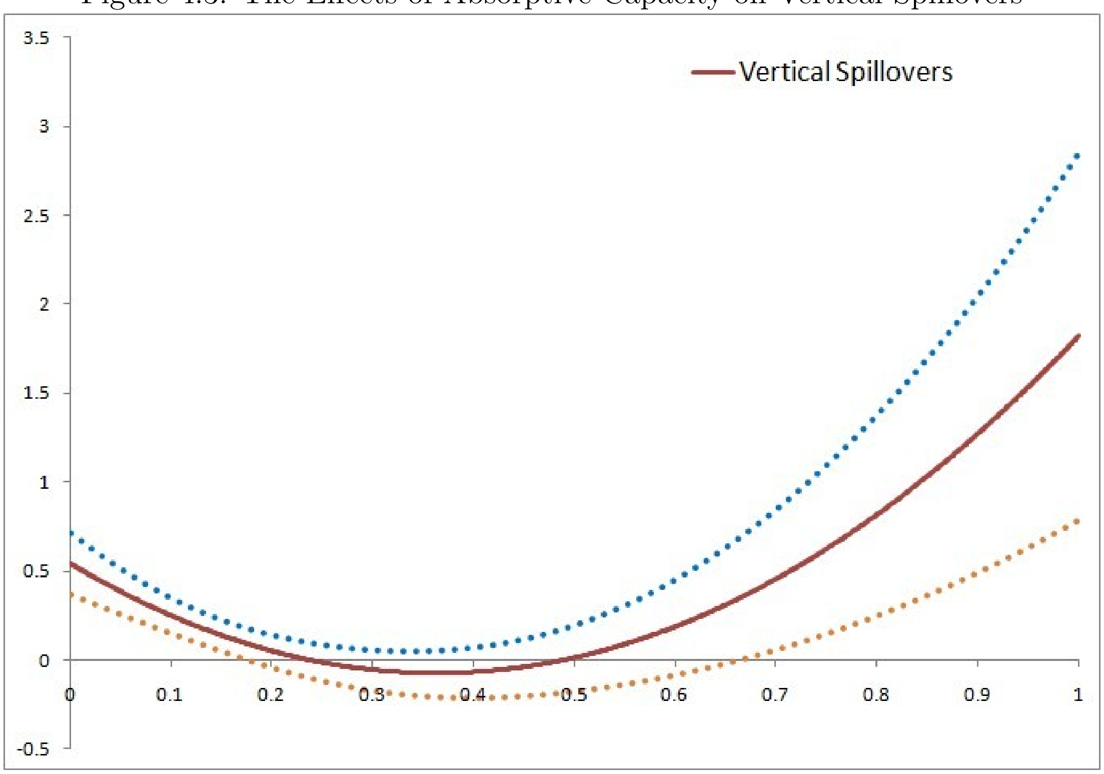


Figure 4.3: The Effects of Absorptive Capacity on Vertical Spillovers



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