Re-examination of FDI in Emerging Economies

Bin Ni

Union Press

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For the prosperity of emerging economies

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final stage of pursuing the degree.

Lastly, I am truly grateful to my parents for all their love and selfless support in all my pursuits. Thank you.

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List of abbreviations and acronyms

CEPT	Common Effective Preferential Tariff
CES	constant elasticity of substitution
CIPA	China Investment Promotion Agency
FDI	foreign direct investment
FTA	free trade agreement
GDP	gross domestic product
GIPB	Global Investment Promotion Benchmarking
GSO	General Statistics Office
IPAs	investment promotion agencies
ISO	International Organization for Standardization
IV	instrumental variable
JETRO	Japan External Trade Organization
MNEs	multinational enterprises
MOFCOM	Ministry of Commerce of the People's Republic of China
NBS	National Bureau of Statistics
OLS	ordinary least squares
PSM	propensity score matching
QCD	quality, cost and delivery
SEZs	special economic zones
SIPA	Shanghai Investment Promotion Agency
SOEs	state-owned enterprises
TFP	total factor productivity

2SLS	2-stage least squares
VSIC	Vietnam Standard Industrial Classification
WTO	World Trade Organization

About this book

This book is based on the contents of researches that I have done when I was a PhD candidate in Osaka University.

As is known to all, foreign direct investment (hereafter referred to as FDI) has been a major driving force of economic growth in developing countries. Thus, attracting FDI has become an important task for the governments of these countries. However, in reality, the inflow and outflow of FDI may differ greatly among different countries. Accordingly, we cannot help asking the following questions: for example, why is China so attractive to multinational companies? What are the main factors to attract FDI into China? Why is Vietnam becoming one of the most popular FDI destinations in the world? What benefits will the inward FDI into Vietnam bring about? And, will negative consequences come along?

To answer these questions, this book investigates the before and after of FDI processes in the context of developing countries, and provides hands-on evidence. A large number of previous studies have explored the mechanism of how countries attract FDI. From the objective perspective, macro-level factors, such as market size, growth potential, market openness, exchange rate, political stability, and institutional quality can be important determinants, whereas micro-level factors include the firm's productivity, firm size, R&D expenditure, quality of workers, etc. On the other hand, countries also make strategic policies to invite more FDI. The existing policy tools such as special economic

zone (SEZ) and export processing zone (EPZ) implemented by China are good examples of such effort. Recently, more proactive policies, such as investment promotion agency (IPA), have been conducted. The fundamental difference from existing policies is that such policies are designed to actively communicate to foreign investors the nature of the country's investment climate, and to persuade and assist them to invest in the country. However, for either type of strategic policies, most of the research is from the perspective of qualitative evaluation, while few empirical studies have attempted to examine their impacts. The first half of this book will be devoted to filling this blank.

The second half is concerned with how FDI can affect the targeting country from various aspects. Using the case of Vietnam, this book explores how FDI can benefit the local firms through the channel of technology spillover. Meanwhile, it can also cause environmental concerns of the home country. ISO14001, a voluntary international environmental standard is used to illustrate the mechanism of why FDI firms are more actively involved in corporation social responsibility, and how such an act can bring back more advantages in return.

Readers of this book possibly range from policy makers in developing countries to undergraduate students whose study interest lies in foreign direct investment in developing countries, and its influence. After reading, you will have a thorough and intuitive idea of how strategic policies are made to attract FDI, and how inward FDI affects the economy of the targeting countries from various aspects, such as technology spillover and environmental issues.

About the author

Dr. Bin Ni is an associate professor in the Faculty of Economics at Hosei University, Japan. From 2017 to 2018, he served as assistant professor in the Faculty of Business Administration at Toyo University, Japan, and he was a research associate in the Institute of Asia-Pacific Studies at Waseda University from 2016 to 2017. He has been teaching in the Tokyo Institute of Technology, Aoyama Gakuin University, Ibaraki University, and actively participating in international conferences and workshops. Meanwhile, he is also a project member at the Research Institute of Economy, Trade and Industry (RIETI), and a consultant at the Economic Research Institute for ASEAN and East Asia (ERIA).

He was born in China and he received a B.S. degree in Economics from Shanghai International Studies University in 2004. After working in the Bank of China for a short period of time, he came to Japan to pursue his studies and experience. Between 2007 and 2011, he worked in the private sector, where he served as a sales engineer. The responsibilities included, but were not limited to, the following: to take part in the planning of new projects (machine standardization); to help the company to expand global business; to collect data and conduct marketing in the disposable sanitary product industry, including information of both clients and competitors; sales-promotion to both domestic and overseas customers.

To further his studies, he returned to graduate school in 2011 and obtained an M.S. degree in International Public Policy from Osaka Uni-

versity in 2013. He received his Ph.D. degree in Economics from Osaka University in 2016. During graduate school, he worked as a research assistant in the UNESCAP, Bangkok in 2011, and visited the Department of Economics at Rutgers University, U.S.A. from 2013 to 2014. Since, he has been focusing on research into international trade, foreign direct investment (FDI), economic development, and environmental and labor issues in developing nations. In terms of methodology, he has been using both theoretical modeling and applied econometrics.

Dr. Bin's research interests cover aspects across the field of International Economics, with a special focus on international trade and foreign direct investment (FDI). In the past several years he has been working on economic research that is related to developing countries, especially policy-oriented issues. He has applied micro-data of China, Vietnam and Indonesia to investigate how developing countries can attract more FDI and also the post-impact of FDI. He is co-author of a book entitled "Consumer Perception of Food Attributes" (CSR Press, 2018), and he has published numerous academic papers in SSCI journals. Currently, he is conducting an inter-disciplinary study between international economics and labor economics; by using micro-level firm data, he is investigating how outward FDI from Japan affects the firm-level labor allocation in the home-country.

CHAPTER ONE

General introduction

Chinese economic development has cost many American workers their jobs. That's the price of progress.

P. J. O'Rourke

The quote by P. J. O'Rourke describes a vivid situation of how inward foreign direct investment (hereafter referred to as FDI) benefits the economy of developing countries, though it might pose a threat to the workers of the original nations where the foreign investors come from. This acts as the starting point of my overall study: what determines FDI in the developing world and what impact does it bring about?

As seen from Figure 1-1, foreign firms might choose to produce at home, export or make foreign direct investment based on their initial productivities (Melitz, 2003). In the context of FDI, existing literature can be divided into two categories by chronicle order, represented by process 1 and 2 respectively. Before the investment, macro-factors such as the business environment (infrastructure) and level of economic development (country or city size, GDP per capita), and policy-based determinants, such as tax exemption program and investment promotion institutions are thought to play an important role in inviting FDI.

In this book, I will pay special attention to the efficiency of such policy strategies. On the other hand, as indicated in process 2, FDI's impact on the host country may also be varied. In practice, I explore two types of impacts of FDI: technology spillover, which is thought to be a major

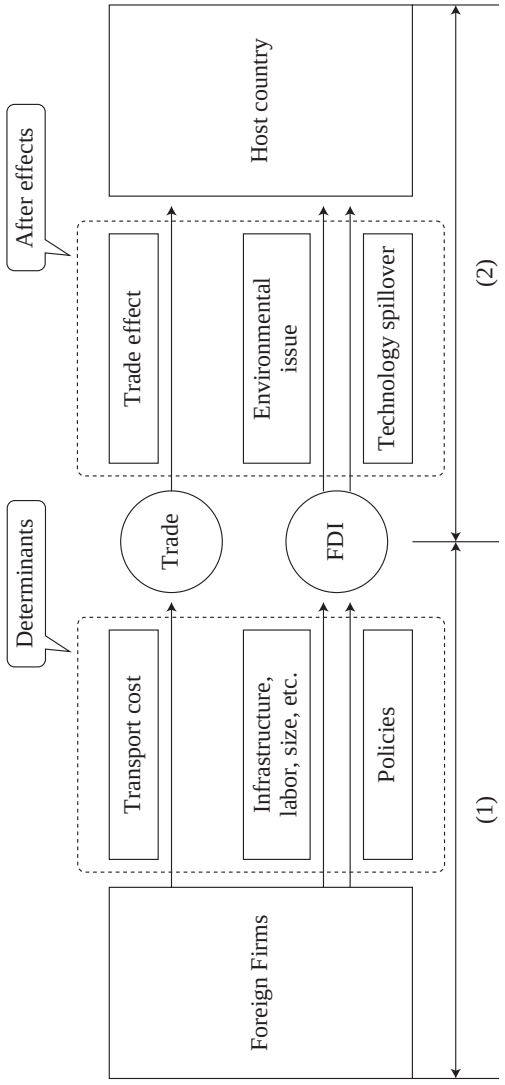


Figure 1-1 Concept flow of FDI-related studies

vehicle for economic growth of the developing countries, and environmental problems that FDI might incur.

Chapter 2 is based on joint research with Yasuyuki Todo [1] and Tomohiko Inui [2]. In this study, I use both firm- and city-level data from the Chinese National Bureau of Statistics and unique information on investment promotion agencies (IPAs) in China to evaluate whether IPAs affect FDI from the perspectives of both intensive and extensive margins, i.e., reinvestment of incumbent foreign-owned firms and new FDI inflows into the city, respectively. After controlling the determinants of FDI and correcting potential biases caused by endogeneity, I find that IPAs in general do not necessarily increase FDI in either case. However, IPAs are found to promote the re-investment of large foreign-owned firms. The results illustrate the difficulty in dissemination of information on the business environment to foreign investors.

Chapter 3 tries to verify the technology spillover induced by foreign firms from a novel perspective: how the origin of foreign investors affects the degree of horizontal and vertical technology spillovers, using firm-level panel data from Vietnam in 2002–2011.[3] To be specific, I use geographical distance to investigate whether being a member of the regional preferential agreement and sourcing pattern as the criteria to examine the differences in technology spillover.

The empirical analysis produces evidence consistent with our hypothesis: preferential treaties in general, promote spillover from multinational firms, while local procurement is the most important channel to incur vertical spillover. The results show a positive association between the presence of Asian firms in downstream sectors and the productivity of Vietnamese firms in the supplying industries, and no significant relationship in the case of European and North American affiliates. Within the Asian region, I find that FDI from East Asian firms, excluding Japan and South Korea, tend to have the largest vertical spillover impact on increasing Vietnamese suppliers' productivity. It coincides with the fact that multinational firms, whose origins are these two countries, tend not to source from local suppliers actively. In the horizontal way, FDI from the ASEAN, East Asian and European firms all show negative impact, indicating that FDI from these firms tends to drive Vietnamese counterparts away. Also, I find that firm size and location affect the extent of

spillover.

Chapter 4 looks into the potential environmental concerns. After investigating the positive influence that FDI has on the economic development of the host nations, I take a different perspective by examining the possible causality between FDI and environmental issues in the home country. Given the simultaneous rise in FDI and pollution level, critics have accused foreign investors of shifting their heavily-polluting activities to countries with lax regulations in search of "pollution-haven," however, empirical evidence to support this hypothesis is surprisingly rare (Cole, 2004). In fact, foreign firms are found to be more energy efficient compared to state-owned firms (Eskeland and Harrison, 2003; He, 2006). This might be due to the advanced waste-processing technology adopted by foreign firms and their stance to achieve corporate social responsibilities (Lyon and Maxwell, 2008).

To solve this puzzle, I focus on firms' participation in ISO14001, a voluntary environmental standard which measures how "green" a firm is. This to some extent captures how much awareness a firm has to be engaged in environment-friendly activities. A general equilibrium model is applied to theoretically show the mechanism of adoption: under optimal condition, highly productive firms can benefit more from the adoption. In the meantime, technology advancement potentially drives up the capital intensity of the firms, and this factor will also promote firms' incentive of adoption. Also, when controlling firms' idiosyncratic characteristics, foreign firms become more active to acquire ISO14001. The empirical analysis using the firm-level data in Vietnam verifies my predictions with robustness. In addition, I find that the phenomenon outlined above becomes even more obvious in the manufacturing sectors. Thus, this study shows that foreign firms are making more efforts towards corporate social responsibility, only conditional on the expectation of a larger long-term profit.

In accordance with the contents in Chapter 4, Chapter 5 empirically testifies the post- influence after firms adopt ISO14001. The results show that the adoption of such a voluntary standard can improve a firm's performance in terms of waste control, and increases its welfare and productivity level. This study provides robust evidence that firms' efforts toward corporate social responsibility eventually benefit themselves as

well.

Notes

1 Graduate School of Economics, Waseda University.
2 Preparatory Office for the Faculty of International Social Sciences, Gakushuin University.
3 This is also a joint work with Mariana Spatareanu & Vlad Manole (Rutgers University), Tsunehiro Otsuki & Hiroyuki Yamada (Osaka University at the time of writing).

CHAPTER TWO

How effective are investment promotion agencies?

Evidence from China

1. Introduction

Foreign direct investment (FDI) is considered to be a major driving force of economic growth in developing countries. Thus, attracting FDI has become an important task for the governments of many of these countries. Under such circumstances, numerous policy tools have been utilized to facilitate investment by foreign firms. Although an increasing number of studies have investigated the impact of these tools using macro-level data (Dean et al., 2009; Wang, 2013), the rigorous evaluation of this issue has been hampered by limited data availability (Harding and Javorcik, 2007).

This chapter aims to enrich the empirical studies on such policies by objectively evaluating the role of investment promotion agencies (hereafter referred to as IPAs) in the Chinese context. IPAs are relatively recent strategic endeavors used by governments to supplement foreign firms' investment in the host country. The purpose of IPAs is defined as "to communicate to foreign investors the nature of the country's investment climate and to persuade and assist these investors to invest or reinvest in the country" (Wint, 1993). The expected function of IPAs is different from that of the existing strategies, such as special economic zones (SEZs), which use policy packages such as tax incentives and property protection to attract FDI.

The evaluation will be conducted from both intensive- and exten-

sive-margin perspectives. In the intensive-margin analysis, we use firm-level data to examine the effect of IPAs in a particular city on the additional investment of incumbent foreign-owned manufacturing firms in the city. Among all IPAs, 86 percent of them target investors that are already present in the host country (UNCTAD, 2001), which provides us with the incentive to investigate the influence of IPAs on incumbent investors. In the extensive-margin analysis, we employ city-level data to examine the effect of IPAs in a particular city on total new FDI inflows to the city in all industries.

One challenge of our estimation is the potential selection of IPAs. The establishment of IPAs is typically not random. Some cities might set up IPAs before others because they have higher needs for governmental institutions to attract more FDI. The standard OLS will lead to inaccurate estimations of the impacts of IPAs. Therefore, we use instrumental variable (IV) estimations to alleviate this bias.

In contrast to previous studies (Morisset, 2003; Harding and Javorcik, 2011) that unanimously find positive impacts of IPAs on increasing FDI at the country level, we find that the existence of city IPAs is not significantly correlated with firm- or city-level inward FDI in that city. The same situation is found even when we use the number of IPAs as the measure. These results imply that city-level IPAs in China have not functioned well. This implication is confirmed by the reality that most city-level IPAs do not even have a decent website. It also indicates that despite the growing number of city-level IPAs, their decisive influence depends on their quality, not their quantity, as argued by Harding and Javorcik (2012). Therefore, further efforts should be made to enhance IPA performance to better attract foreign firms.

Meanwhile, we find that IPAs promote re-investment by incumbent foreign-owned firms (hereafter, foreign firms) when their sales are sufficiently large. The explanation for this result is probably because information about the business environment in a city provided by IPAs does not reach small foreign firms in China or firms in foreign countries.

This study differs from previous investigations in several ways. First, by constructing a unique dataset using city-level IPAs in China, this research attempts to fill the gap in the empirical evaluation of city-level IPAs rather than national organizations. Additionally, to the best

of our knowledge, this is the first to use firm-level data to analyze a policy's effect on attracting FDI.[1] Second, in addition to investigating the location choices of new entrants, this work examines how existing foreign firms make their incremental investment decisions.[2] Furthermore, few studies have evaluated how the performance of IPAs matters; in this study, we use various quantitative and qualitative measurements to thoroughly investigate IPAs.

The remainder of this chapter is organized as follows. Section 2 discusses the current situation of inward FDI and IPA establishment in China, and Section 3 introduces the relevant literature. Sections 4 and 5 describe the estimation strategy and data collection, respectively. Section 6 presents the estimation results, and Section 7 concludes.

2. FDI and investment promotion agencies in China

The China Investment Promotion Agency (CIPA)[3] was established by the Ministry of Commerce of China in the 1980s to facilitate the promotion of Chinese investment in two directions: "inviting in" (i.e., attracting FDI into China) and "going global" (i.e., promoting outbound investment). In terms of "inviting in", however, the geographic scale of the country makes it impossible for CIPA to completely fulfill the responsibility in all regions, as each municipality has distinctive locational characteristics and idiosyncratic business environments. CIPA's inability to supervise the whole nation has fostered the growth of city-level IPAs,[4] which are expected to play major roles in inviting FDI within each particular area. Similar to existing FDI-inviting experiments such as SEZs, city-level IPAs have the goal of attracting more FDI into the city (regardless of the existence of SEZs). However, SEZs and IPAs differ in that SEZs apply policy packages through laws and regulations, whereas IPAs rely on actual promotion activities to enhance FDI (e.g., help new investors choose locations to establish factories and assist foreign firms with the relevant legal procedures). After China's entry into the World Trade Organization (WTO) in 2001, all of its major cities began to establish IPAs to increase their competitiveness. As shown in Figure 2-1, FDI inflow and the number of city IPAs have a positive correlation.

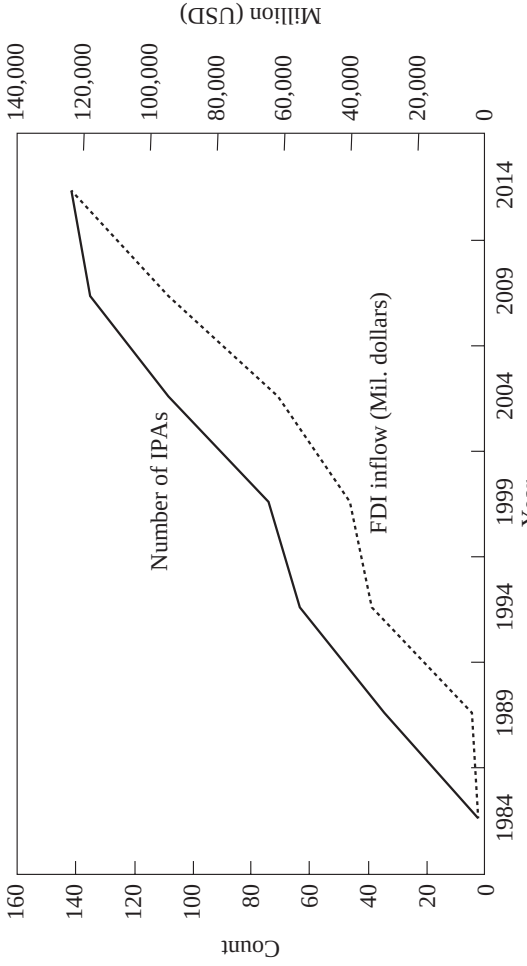


Figure 2-1 FDI inflow and IPA growth
Source: UNCTAD and "Invest in China."

Despite the rapid increase in the quantity of city IPAs, the efforts made by local governments vary substantially. For instance, the Shanghai Investment Promotion Agency (SIPA) can be regarded as a well-functioning institution, and its success is due to Shanghai's determination to maintain economic leadership in China. Thus, SIPA's administrative activities have gained the full support of the government in Shanghai. To share and better facilitate SIPA's responsibilities, other city-level IPAs have been formed, such as the "Shanghai investment service center" and the "Shanghai foreign investors' complaint center." These organizations work in complementary ways to maximize their functionality. Similar efforts are observed in other relatively open cities, such as Guangzhou, Qingdao and Shenzhen. However, the distribution of IPAs is uneven across China (see Figure 2-2).

Furthermore, we observe that the regions that are supposed to attract more FDI typically do not have adequate IPAs to help them achieve this goal. Taking Baoding in Hebei Province as an example, the city is famous for the development of new-energy automobiles and industrial machinery, and its Dian Gu district is often compared to Silicon Valley in the U.S.A. Nevertheless, when we attempted to access the website of the IPA in Baoding, we found an invalid link. We also failed to reach the representative of the city-level IPA. This situation is quite common among second- and third-tier cities, particularly in the inland area, even though FDI is desperately needed to promote these regions' local economic growth.

Thus, we have reasons to doubt whether city-level IPAs in China fulfill their responsibilities as expected. What if the positive correlation shown in Figure 2-1 is spurious? This research attempts to use rigorous methods to evaluate the impact of city-level IPAs.

3. Literature review

Although there has been a surge in the trend of using micro-level data to verify the potential determinants of FDI (Amiti and Javorcik, 2008; Liu et al., 2010), few empirical studies have attempted to examine the impact of government policies in China. Wang (2013) is the first to inten-

Figure 2-2 City-level IPAs' distribution in China (until 2014)

Source: "Invest in China".

Note: Dark areas are mainly coastal cities or the capital city of each province.

sively evaluate the impact of SEZs in attracting FDI into China. By using municipal-level data and a combination of matching and difference-in-differences, she shows that the application of an SEZ program not only increases the level of per capita FDI by approximately 20 % but is also associated with greater total factor productivity (TFP) growth.

Quantitative literature assessing the role of IPAs is surprisingly scarce. Morisset and Andrews-Johnson (2004) and Morisset (2003) use country-level data to support their hypotheses that the presence of IPAs exerts a positive influence; this result is supported by Charlton and Davis (2007). Harding and Javorcik (2011) show that the sectors supported by IPAs receive more investment in the post-service period, particularly in developing countries. Morisset (2003) finds that IPAs are not always effective and that their performance is positively correlated with the quality of the investment climate. He also finds that IPAs' functions and budget can determine their effectiveness. Using the index from Global Investment Promotion Benchmarking (GIPB), a recent study by Harding and Javorcik (2012) provides evidence that the quality of national IPAs is a decisive factor with regard to their performance. Not all IPAs perform equally well in information provision, and only IPAs with highly rated promotion tools, such as websites, translate directly into higher FDI inflows. However, no research has used micro-level data, even though such data can indicate firm heterogeneity and better capture the direct effect of how foreign firms react to the incentives provided by IPAs.

4. Estimation strategy

4.1 Firm-level analysis

To examine the effect of IPAs in attracting foreign capital, we conduct econometric estimations at the firm- and city-levels. In the firm-level estimation, we focus on IPAs' effect on re-investment by incumbent foreign firms because we do not have any prior information about firms before they invested in China. The basic empirical specification in the firm-level analysis takes the following reduced form:

$$lnFDI_{ict} = \alpha + \beta_{FDI} lnFDI_{ict-1} + \delta cIPA_{ct-1} + \beta_i x_{it-1} + \beta_c w_{ct-1} + g_t + \varepsilon_{ict} \quad (2.1)$$

The dependent variable FDI is measured by the absolute value of foreign capital in its log form within firm i in city c at time t. The first lag of the dependent variable is included to control for the impact of past investment history. IPA_{ct-1} is a dummy variable that specifies whether the city has an IPA by time $t - 1$. We use the first lag of the IPA dummy to incorporate possible time lags between information disseminated from IPAs and decisions about FDI. In addition to the IPA dummy, we also use the number of IPAs as an alternative measure of IPAs. Vector x_{it-1} indicates firm characteristics, including the firm age, sales, number of workers, and average wage per worker in year $t - 1$. Vector w_{ct-1} represents city characteristics including GDP, GDP per capita, road area per capita, public expenditures on education, the average wage, and a dummy for SEZs in year $t - 1$. Finally, g is a vector of year dummies, and ε is the error term.

One potential problem of estimating equation (2.1) is endogeneity due to the selection of IPAs. To address this endogeneity, we employ first-differenced 2-stage least squares (2SLS) estimations (hereafter referred to as the FD-2SLS estimations). More specifically, our actual estimation equation is the first difference of equation (2.1), or

$$\Delta lnFDI_{ict} = \beta_{FDI} \Delta lnFDI_{ict-1} + \delta_c \Delta IPA_{ct-1} + \beta_i \Delta x_{it-1} + \beta_c \Delta w_{ct-1} + \Delta g_t + \Delta \varepsilon_{ict} \quad (2.2)$$

where $\Delta x_{it-1} = x_{it-1} - x_{it-2}$ for any variable x. We use the first-difference approach rather than a fixed-effects approach because equation (2.1) includes the lagged dependent variable, and thus, fixed-effects approaches will lead to endogeneity of the lagged dependent variable (Roodman, 2009). Our instruments for ΔIPA_{ct-1} are Δw_{ct-2}, i.e., the first-differenced twice-lagged city variables defined above, which are expected to be correlated with the presence of IPAs in years $t - 1$ and $t - 2$ but not with the error term in years t and $t - 1$. Because the same argument can be applied to the lagged dependent variable, $\Delta lnFDI_{ict-1}$ is instrumented by $\Delta lnFDI_{ict-2}$. We will test the validity of the instruments using the Hansen overidentification test.

One problem of applying the FD-2SLS estimation is that the IPA dummy and the number of IPAs for most cities do not change much across years in the sample period. That is, the variation in ΔIPA_{ct-1} in our FD-2SLS estimations is often small. Therefore, as a robustness check, we also estimate the level equation (2.1) using the twice-lagged city independent variables as instruments. We hereafter call this method the level-2SLS estimation.

4.2 City-level analysis

The firm-level analysis above can examine the effect of IPAs on the re-investment by incumbent foreign firms (intensive margins) but not on investment by newly established foreign-owned firms (extensive margins). Therefore, we conduct estimations at the city-level to investigate the effect of IPAs on extensive margins of FDI inflows. Our estimation equation at the city-level is similar to equation (2.1), although the dependent variable is a measure of new FDI inflows to the city, as explained in detail in the next section, and firm-level variables are dropped from the set of independent variables. Following the firm-level analysis, our baseline estimation at the city-level is FD-2SLS, and we also run level-2SLS to check the robustness of the results.

5. Data

Our data covers the period from 2002–2007 due to data constraints. The data on three types of variables used—IPAs, firm characteristics, and city-level factors—are collected from three main sources. First, a unique list of city-level IPAs is constructed by combining the data from two websites, "Invest in China" and another developed by the China Council for International Investment Promotion (hereafter referred to as CCIIP), which is a non-governmental organization subject to the Ministry of Commerce of the People's Republic of China (MOF-COM). Among the 362 cities in China, 50 cities had at least one IPA during the sample period. The total number of IPAs is 142 because some cities had more than one IPA.

Second, firm characteristics are collected from the annual surveys

conducted by the National Bureau of Statistics (NBS). All state-owned enterprises (SOEs) and those non-SOEs with annual sales above 5 million Chinese yuan are included. These surveys collect detailed balance sheet information, ownership information, and amounts of total capital and foreign capital for firms in the manufacturing sectors. We define firm-level FDI as the reported amount of foreign capital, including capital from Hong Kong, Macao, and Taiwan.

Third, city-level variables are taken from the "China City Statistical Year book." The dependent variable in the city-level is either the log of the amount of new contracted foreign investments, the amount of new actual foreign investments, or the number of new foreign investments. It should be noted that foreign investments at the city-level include those in all industries including the service sector, whereas we focus on the manufacturing sector in the firm-level analysis. Therefore, comparisons between the firm- and city-level analyses requires great care.

Table 2-1 provides the definitions of the variables used in the estimations and their descriptive statistics. Panel A shows the firm characteristics, whereas Panel B presents the city variables used in both the firm- and city-level estimations. After removing negative values for key variables such as sales and firm age, there are a total of 236,936 observations for estimation during the period from 2002–2007. Because we employ a first-difference approach and use first-differenced twice-lagged variables as instruments, as explained in Section 2.4, the number of observations in the FD-2SLS estimations is reduced to 40,855, whereas there are 95,166 observations in the level-2SLS estimations.

6. Results

6.1 Firm-level analysis

Table 2-2 shows the main results from firm-level analysis in which we regress the dummy for any IPA (IPA) or the number of IPAs (#IPA) on the log of foreign capital of incumbent foreign-owned firms (lnFDI). Columns (1)–(2) are results from the FD-2SLS estimations, whereas columns (3)–(4) are from the level-2SLS estimations. The standard error is clustered at the city-level. City characteristics are not reported in the

Table 2-1 Statistical summary

Panel A: Firm characteristics

Variable	N	Mean	S.D.	Min.	Max.	Variable definition	Unit
lnFDI	236936	8.835	1.655	0	16.278	Log of amount of foreign capital	1,000 Yuan
lnL	236936	5.116	1.160	0	12.145	Log of the number of total employees	Persons
lnY	236936	10.509	1.406	–0.043	19.047	Log of sales	1,000 Yuan
lnWAGE	236936	2.800	0.657	–3.761	9.914	Log of wages per worker	1,000 Yuan
AGE	236936	7.287	5.579	0	125	Firm age	Year

Panel B: City characteristics

Variable	N	Mean	S.D.	Min	Max	Variable definition	Unit
lnGDP	1587	15.095	0.918	12.672	18.457	Log of total GDP	10,000 Yuan
lnGDPpc	1587	9.241	0.681	7.662	11.932	Log of GDP per capita	10,000 Yuan
lnROAD	1587	1.784	0.623	–1.966	4.159	Log of road areas per capita	m^2
lnEDUC	1587	10.481	1.161	6.816	14.536	Log of educational expenditures	10,000 Yuan
lnAveWAGE	1587	9.422	0.430	2.283	11.684	Log of average wage	Yuan
ln#NewFDI	1587	3.527	1.658	0	8.374	Log of the number of new FDI	Number
lnNewFDI (contract)	1587	9.196	1.900	2.303	14.281	Log of the amount of contracted new FDI	10,000 Yuan
lnNewFDI (actual)	1587	8.558	2.022	0.693	13.474	Log of the amount of actual new FDI	10,000 Yuan
IPA	1587	0.170	0.375	0	1	=1 if the city has any IPA	
#IPA	1587	0.374	1.025	0	8	Number of IPAs in the city	
SEZ	1587	0.167	0.373	0	1	=1 if the city has any SEZ	

Sources: Annual Enterprise Survey, National Bureau of Statistics of China. China City Statistical Yearbook, National Bureau of Statistics of China.

Table 2-2 Effects of IPAs at the firm level

	(1) FD-2SLS	(2) FD-2SLS	(3) Level-2SLS	(4) Level-2SLS
$lnFDI_{t-1}$	0.107***	0.103***	0.973***	0.973***
	(0.0348)	(0.0353)	(0.00275)	(0.00287)
IPA_{t-1}	0.197		−0.172	
	(0.696)		(0.202)	
$\#IPA_{t-1}$		0.173		−0.00834
		(0.184)		(0.00881)
SEZ_{t-1}	−0.189	−0.264	0.140	−0.00276
	(0.555)	(0.291)	(0.186)	(0.0178)
AGE_{t-1}	0.000971	0.000844	−0.00379***	−0.00369***
	(0.00233)	(0.00236)	(0.000419)	(0.000392)
lnY_{t-1}	0.00297	0.00263	0.0260***	0.0254***
	(0.00290)	(0.00281)	(0.00295)	(0.00319)
lnL_{t-1}	0.0478***	0.0476***	0.0156***	0.0156***
	(0.0102)	(0.0101)	(0.00367)	(0.00365)
$lnWAGE_{t-1}$	0.00983	0.00928	0.0185***	0.0190***
	(0.00813)	(0.00804)	(0.00491)	(0.00458)
Hansen stat. (p value)	0.174	0.293	0.382	0.118
Observations	40,855	40,855	95,166	95,166
R-square	−0.076	−0.074	0.896	0.896

Notes: Dependent variable: lnFDI. Clustered standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lagged city-level characteristics including total GDP, GDP per capita, road areas per capita, education expenditures, and average wage (all in log) and year dummies are included as independent variables, however, the results are not shown for brevity.

results due to space constraints. The p values from the Hansen overidentification test indicate that the instruments are valid in all regressions.

In Table 2-2, neither the dummy for IPAs nor the number of IPAs has any significant effect on the foreign capital of foreign-owned firms. These results reveal that the existence of city-level IPAs in China fails to promote re-investment by incumbent foreign firms in general. This observation contrasts with the findings reported in existing literature that demonstrate positive effects of national IPAs (Morisset, 2003; Harding and Javorcik, 2011). In addition to the main variables of interest, the coefficient of the first lag of the dependent variable exhibits its expected sign and is significant. This result confirms that a firm's past investment history will have a strong influence on new investment by the firm. The effect of the dummy for SEZs (SEZ) is not significant.

To check the robustness of the results, we experiment with several alternative specifications. First, we include the R&D intensity (the ratio of R&D expenditures to sales) and the corporate tax rate at the firm-level, following Cho and Tung (1998). Because these additional variables are missing for some years, there are fewer observations. Second, we include as an independent variable firms' TFP, which is constructed using the method developed by Olley and Pakes (1996). Third, we replace the dependent variable with the share of foreign capital of total capital. We avoided using this variable in the baseline specification because it is 100 % and does not change over time for many incumbent foreign firms. Finally, we re-define FDI by excluding capital from Hong Kong, Macao, and Taiwan because FDI from these three regions may have a different motivation to FDI from other countries. All of these attempts do not change the main results that IPAs do not have a significant effect on FDI inflows.

6.2 City-level analysis

In this subsection we use city-level data to examine effects of IPAs on FDI inflows by new foreign investors, rather than re-investment of incumbent foreign-owned firms. Table 2-3 presents the results from the FD-2SLS estimation where the dependent variable is either the log of the contracted amount of new FDI, the log of the actual amount of new

Table 2-3 Effects of IPAs at the city level

Dependent variable	(1) lnFDI (contracted)	(2) lnFDI (actual)	(3) ln#FDI	(4) lnFDI (contracted)	(5) lnFDI (actual)	(6) ln#FDI
$lnFDI(contract)_{t-1}$	0.275* (0.148)			0.270* (0.142)		
$lnFDI(actual)_{t-1}$		0.169 (0.154)			0.163 (0.157)	
$ln\#FDI_{t-1}$			0.232 (0.170)			0.281* (0.156)
IPA_{t-1}	4.665 (8.010)	–0.715 (6.046)	–7.948 (5.885)			
$\#IPA_{t-1}$				0.194 (2.163)	–0.843 (1.754)	–2.252 (1.642)
SEZ_{t-1}	0.413 (0.950)	2.530*** (0.718)	0.108 (0.716)	0.393 (0.909)	2.539*** (0.729)	0.165 (0.685)
$lnROAD_{t-1}$	0.0307 (0.137)	–0.0328 (0.107)	–0.0399 (0.104)	0.0268 (0.132)	–0.0251 (0.110)	–0.0240 (0.101)
$lnGDPpc_{t-1}$	0.330 (0.440)	0.195 (0.333)	0.271 (0.331)	0.432 (0.386)	0.196 (0.310)	0.132 (0.291)
$lnGDP_{t-1}$	–0.400 (0.519)	0.0684 (0.414)	0.161 (0.390)	–0.415 (0.512)	0.123 (0.435)	0.301 (0.385)
$lnEDUC_{t-1}$	–0.0568 (0.0572)	–0.0786* (0.0454)	0.0230 (0.0429)	–0.0526 (0.0729)	–0.0966 (0.0593)	–0.0248 (0.0549)
$lnAveWAGE_{t-1}$	–0.144* (0.0821)	–0.0503 (0.0714)	–0.134** (0.0651)	–0.145* (0.0791)	–0.0446 (0.0735)	–0.130** (0.0629)
Hansen stat. (p value)	0.923	0.608	0.914	0.862	0.658	0.885
Observations	729	729	729	729	729	729
R-squared	–0.292	–0.064	–0.781	–0.184	–0.097	–0.634

Notes: This table shows results from the FD-2SLS estimation. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummies are included as independent variables, however, the results are not shown for brevity. FDI refers to new FDI inflow into the city.

FDI, or the log of the number of new foreign investments. The results indicate that the presence of IPAs in any of the regressions has no significant effect on new FDI, suggesting that the establishment of IPAs does not attract new FDI inflows or cross-border inbound M&A into the city. We also conduct the level-2SLS estimations as a robustness check and obtain similar results. SEZ is positive, but not robustly significant.

6.3 Heterogeneous effect of IPAs

IPAs might have different impacts based on their own quality. For example, among all 142 city IPAs in China, only 64 had a valid website, and 34 had an informative English version as of April 2015. Without a website in English, IPAs cannot effectively disseminate information about the business environment in the city to foreign investors. Another source of heterogeneity is that the effect of IPAs on re-investment by incumbent foreign firms may be different depending on the firms' characteristics. Most notably, larger firms are more likely to receive useful information from IPAs and thus to re-invest more.

To check whether the quality of IPAs determines the IPAs' effects on the re-investment of foreign capital, we construct a new dummy variable for IPAs that have a valid website, *IPAweb*, to partially control for the quality of IPAs. Because we cannot check whether IPAs had a website in each year during the sample period from 2002–2007, we further assume that any IPA has or has not had a website since its founding until 2015. In addition, to examine whether the size of the incumbent foreign firms changes the effect of IPAs, we utilize an interaction term between the IPA variables and the log of sales at the firm-level as an independent variable in the firm-level analysis. In the city-level estimations, we interact *IPAweb* with the log of the city's GDP.

The results from the FD-2SLS at the firm- and city-levels are shown in columns (1)–(3) and (4)–(6) of Table 2-4, respectively. Columns (3)–(6) indicate that the effect of IPAs with websites is insignificant, which suggests that even IPAs of high quality do not promote FDI inflows in general. However, the interaction term between one of the IPA variables and firm-level sales has a positive and highly significant effect in columns (1)–(3). This result suggests that IPAs promote re-investment

Table 2-4 Heterogeneous effects of IPAs

Dependent variable	(1) lnFDI	(2) lnFDI	(3) lnFDI	(4) lnNewFDI (contracted)	(5) lnNewFDI (actual)	(6) ln#NewFDI
IPA	0.140 (0.719)					
#IPA		0.162 (0.180)				
IPAweb			0.257 (0.322)	–3.216 (8.485)	–4.283 (6.854)	–6.410 (6.291)
IPA*lnY	0.0189*** (0.00499)					
#IPA*lnY		0.00271** (0.00119)				
IPAweb*lnY			0.00824*** (0.00257)			
IPAweb*lnGDP				0.0252 (0.0561)	0.0203 (0.0451)	0.0234 (0.0411)
Hansen stat. (p value)	0.429	0.400	0.536	0.893	0.708	0.759
Observations	40,839	40,839	40,839	729	729	729
R-squared	–0.076	–0.075	–0.075	–0.245	–0.162	–0.632

Notes: This table shows results from the FD-2SLS estimation. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Firm- and city-level variables used in Table 2 are included in columns (1)–(3), whereas city-level variables used in Table 3 are included in columns (4)–(6). Year dummies are also included in all estimations, however, the results are not shown for brevity.

by large incumbent foreign firms, probably because larger firms obtain information from IPAs more easily than small firms.

6.4 Conclusion

The aim of this study is to address whether IPAs can affect foreign firms' decisions to invest in China. We apply a first-difference 2SLS approach to correct for potential biases due to the arbitrary selection of IPAs and show that city-level IPAs typically fail to attract investment by new foreign investors and re-investment by incumbent foreign-owned firms. Our estimation results indicate that while IPAs promote re-investment by large incumbent foreign firms, they fail to promote any other type of FDI. These results imply that although the major role of IPAs is to disseminate information on the business environment and available policy support in a city, the information reaches large foreign firms within the city but not small foreign firms or firms in foreign countries. It is therefore suggested that additional efforts should be made by the Chinese government to increase the effectiveness of IPAs.

One caveat of this study is that we evaluate the quality of IPAs only by whether they have a website. There are several other possible channels to disseminate information about a city to foreign investors, including investment seminars in foreign countries and inviting foreign investors and officials to the city. Because of data limitations, we cannot examine the effects of such efforts by IPAs. Therefore, although we found that the current IPAs are ineffective, we are still not certain what efforts should be made in practice other than building informative websites. We will leave these issues for future study.

Notes

1 Lu et al. (2015; 2017) also use firm-level data but focus on firms' performance such as employment and output. Inada (2013) finds spillover effects of FDI regulations using industry-level data.
2 Head et al. (1995), Head and Ries (1996) and Guimaraes et al. (2000) use a different term, "agglomeration effect," and indicate that existing FDI attracts further FDI.

3 See the webpage of CIPA for details. http://tzswj.mofcom.gov.cn/.
4 Regional IPAs include provincial and city-level IPAs. In this study, we focus on city-level IPAs.

CHAPTER THREE

How does the origin of FDI affect domestic firms' productivity?

Evidence from Vietnam

1. Introduction

Recent empirical studies using firm-level data have investigated the mechanism as to how foreign direct investment (FDI) incurs technology spillover to domestic firms through both horizontal and vertical linkages (e.g., Blomstrom and Kokko, 1998; Gorg and Greenaway, 2004). Meanwhile there have been a number of studies to investigate how the origin of FDI might have heterogeneous influence on domestic firms' productivity, most of which try to examine the impact from empirical perspectives. The targeting home countries of investigation consist of the EU (Javorcik and Spatareanu, 2011; Ayyagari and Kosova, 2010; Monastiriotis and Alegria, 2011), the U.S.A. (Chen, 2011) and China (Ito et al., 2012; Kamal, 2014). They all show that the origin of foreign investors does lead to a different spillover effect while the signs of the effect vary.

This research investigates the technology spillover effect of FDI on firms in Vietnam while paying attention to its varying effect across the origins of investors. Studies that examined the technology spillover effect of FDI on firms in newly emerging economies have been limited. Compared to China, Vietnam has been positioned as a new investment target in Asia. Its FDI inflow keeps rising in recent years and the development is undergoing a transitional period towards a market-driven economy. Foreign investors crowd into Vietnam in pursuit of cheap la-

bor and huge business margin. Although there are several studies which examined the technology spillover effect of FDI in Vietnam (Thuy, 2007; Nguyen, 2008; Anwar and Nguyen, 2014), this is the first one to investigate the variation of the technology spillover effect of FDI from the perspective of the origins of investors. It also differs from existing literature in that it tries to verify the potential new channel—sourcing pattern, through which the backward vertical spillover is likely to occur.

With their close partnership with Vietnam and their notable penetration in the Vietnamese economy, FDI from East Asian countries are expected to affect more local firms' performance than that from Europe and other regions. As shown in Figure 3-1, seven of the ten largest investor countries of FDI in Vietnam are in East-Asia, namely Taiwan, South Korea, Singapore, Japan, Hong Kong, Malaysia and Thailand.[1] Furthermore, there may be a significant difference in FDI spillover even among those major investor countries as they are thought to vary in relationship with Vietnam in terms of investment treaties, and trade agreements which can affect sourcing patterns of investors. Thus, an analysis of FDI spillover with meaningful disaggregation of FDI's origins is needed to understand the systematic tendencies in FDI spillover.

Egger and Pfaffermayr (2004), Rosendorff and Shin (2012) demonstrated bilateral investment treaties (BIT) positive impact on promoting FDI in general. The firms from BIT-signed countries with Vietnam will enjoy more benefits such as protection from expropriation, free transfer of means and plenty of other resources. As a consequence, these firms will have more incentive to increase investment in Vietnam. Since more investment indicates foreign investors' deeper interaction with domestic partners, because more local resource and labor shall be involved, we assume that the firms from BIT-signed countries will affect domestic firms in a different way from those from non-BIT-signed countries.

Foreign firms' sourcing patterns can also affect spillover. Saggi (2002) indicated that in developing countries, suppliers of intermediate goods are more likely to benefit because foreign firms transfer zero defect procedure and production audits to domestic suppliers, thus increasing the productivity of the latter. However, such backward spillover might only occur when there is sufficient interaction between local suppliers and foreign end users, which is to be verified in this research. Even though

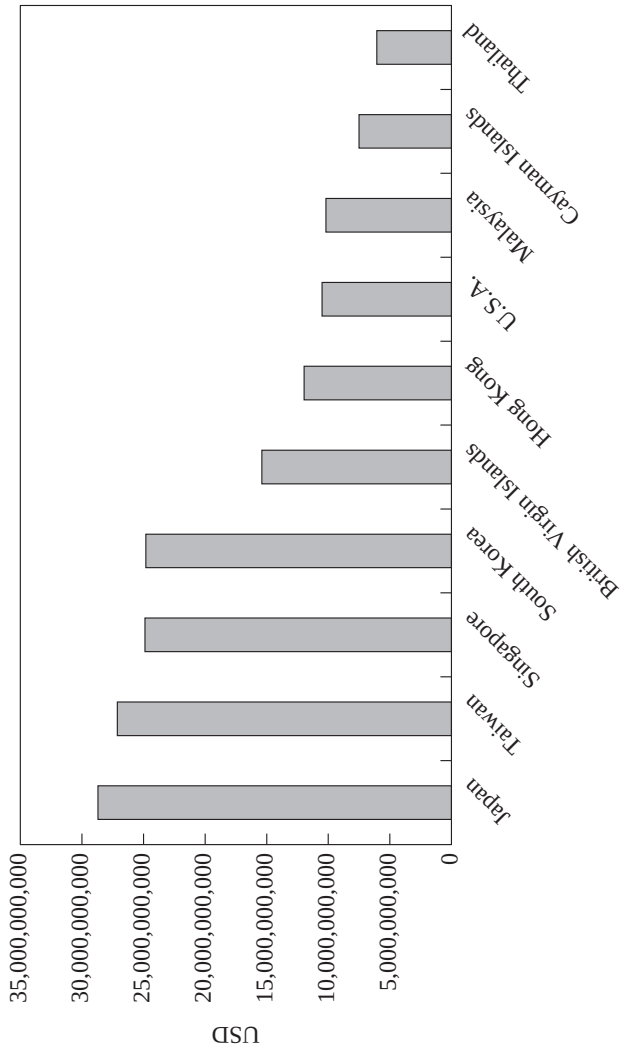


Figure 3-1 The cumulative amount of registered FDI in Vietnam by country at the end of 2012 (USD)

Source: Vietnam Industrial Investment Report (VIIR) 2012 of Vietnam Ministry of Planning and Investment.

East Asian firms are found to invest the most, we can observe the diversity in the way that firms from different countries apply resources. Japanese firms, for instance, tend to insist on using the suppliers from their own country because Vietnamese suppliers usually cannot meet their requirements on quality, cost and delivery (QCD). While Chinese investors tend to choose local suppliers to minimize costs. The frequency of corporation with local firms will affect the degree of the knowledge that local firms can learn from their foreign investors (Rodriguez-Clare, 1996; Markusen and Venables, 1999). Therefore, we also examine the effect of sourcing pattern on FDI spillover by disaggregating origin countries in consideration of relative easiness to procure inputs between domestic procurement and import. This criteria leads us to focus on ASEAN as the most important trade arrangement to Vietnam. According to the ASEAN FDI database 2006 of the ASEAN Secretariat (2006), the total intra-ASEAN inward FDI to the manufacturing sector has been stably increasing since 1999. However, due to the relatively low tariff rates for members under the Common Effective Preferential Tariff (CEPT) scheme, ASEAN countries have the option not to source inside Vietnam because the intermediate inputs required for production such as parts are cheap to be imported from their home countries due to the preferential tariff. This might potentially reduce the local sourcing for ASEAN investors. For this reason, we make an individual group for only ASEAN investors.

Our study relies on a firm-level panel dataset build based on the Vietnam's Enterprise Survey data during the period 2000–2011. We firstly examine how the geographical characteristics of foreign investors influences domestic firms' total factor productivity (TFP) as a measure of firms' technological level, and group their source countries into Asian, European and American ones. Then, we group source countries according to BITs in which Vietnam is a member since the spillover effect of the investor's source countries is expected to be affected by the bilateral or multi-lateral relationships (Javorcik and Spatareanu, 2011) between Vietnam and other countries due to tax exemption or reduction incentives. Finally, we group the investors by their sourcing patterns and examine if the variation of spillover exists.[2]

The results suggest that FDI from Asian firms most prominently in-

cur spillover to domestic suppliers in Vietnam. Within the Asian area, East Asian firms, excluding Japanese and Korean ones, contribute more to vertical spillover impact. The result also provides strong evidence that sourcing pattern is the most important channel to induce vertical technology spillover while horizontal FDI negatively affect the productivity of domestic competitors.

This chapter is organized as follows. Section 3.2 describes the situation of FDI in Vietnam. Section 3.3 summarizes previous literature concerning the spillover effect of FDI. Section 3.4 describes the data and estimation strategy. Section 3.5 presents the results, and examines the robustness. Section 3.6 concludes.

2. Background

Vietnam has experienced remarkable economic growth due mainly to two major events—the adoption of a major economic reform called Doi Moi in 1986, and accession to the World Trade Organization (WTO) in 2006. A high growth rate of around 7 % was observed from the late 1990s to the late 2000s, and this period is characterized as being a period of rapid growth in inward FDI to the country. Vietnam has become one of the most attractive destinations in the world for FDI during the last decade primarily due to its cheaper labor among East Asian countries. China had been the world's most popular destination for FDI for a long time, however since the 2000s, the emerging South-East Asian countries have become attractive destinations. Vietnam has been one of the most successful countries in the region in attracting FDI from countries worldwide both because of its substantially lower wages and because of the success of Doi Moi in liberalizing trade and investment. In the case of the apparel industry, for example, Vietnamese wages were approximately half those in China (Wall Street Journal, May 1st, 2013). Also, Samsung is shifting their production base to Vietnam in order to maintain profit margins by saving labor costs as growth in sales of high-end handsets has slowed down, according to a Bloomberg report in December 2013 (Lee and Folkmanis, 2013).

FDI has recently accounted for an increasingly large part of invest-

ment in Vietnam. The share of implemented FDI in Vietnam's GDP rose from 0.3 % in 2000 to 1.2 % in 2007 (General Statistics Office, Vietnam). The number of FDI projects in 2007 was five times as many as in 2000 and the total implemented capital of these projects had increased nearly four times, amounting to around USD 80 billion (Figure 3-2). Meanwhile, according to the recent "Vietnam Industrial Investment Report 2011" (hereafter referred to as VIIR), the sectorial composition of FDI is mainly concentrated in manufacturing and real estate. At the end of 2011, these two sectors accounted for around 67 and 77 % of total FDI projects and registered capital, respectively. Further, FDI has been highly concentrated in a limited number of cities, namely, Ho Chi Minh City, Hanoi, Dong Nai, Baria-Vung Tau, and Binh Duong. These cover nearly 60 % of all the FDI inflows at the national level.

The amount of FDI does not only matter to spillover, but the way in which foreign investors source their intermediate inputs is also expected to affect the pattern of technological spillover. For example, even though ASEAN investors are assumed to invest more in Vietnam than non-ASEAN investors, the former can also import the intermediate inputs from their home countries directly. In this way ASEAN investors' interaction with local suppliers might not be as strong as that of the non-ASEAN investors. Thus, we would like to take into account foreign investors' sourcing pattern when investigating the degree of spillover.

3. Literature review

This research aims to investigate the mechanism by which differences in the origin of foreign investors affects the productivity of domestic firms in Vietnam. First, we review the studies that generally elaborate on how FDI promotes spillover through both horizontal and vertical channels. Then, we pay particular attention to the case of Vietnam, followed by investigation into the relationship between the investors' country of origin and heterogeneous spillover effects. Finally, we review some factors, such as preferential agreement, that might affect the spillover incurred by firms from different countries of origin.

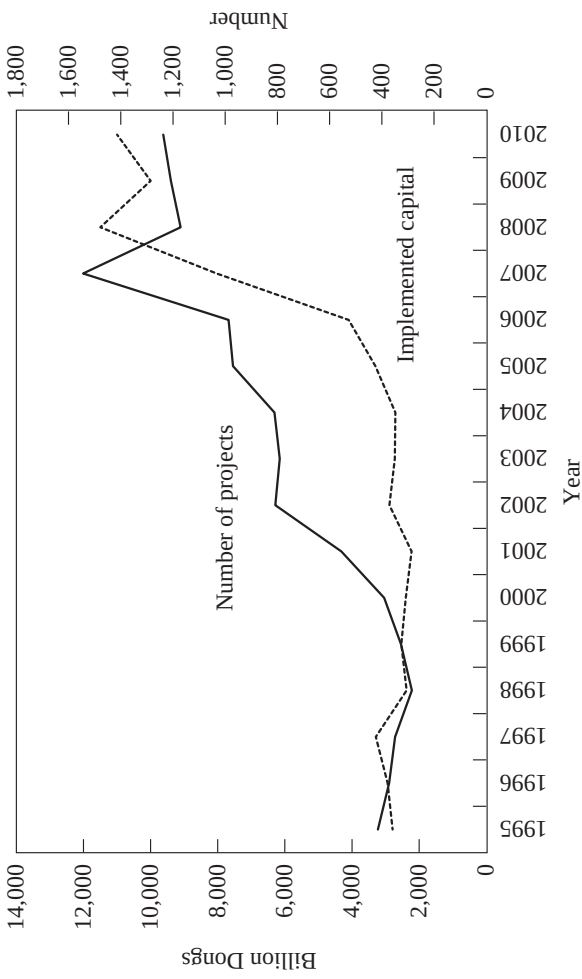


Figure 3-2 Number of FDI projects and implemented FDI (Bill. Dongs) in Vietnam
Source: GSO Vietnam.

3.1 FDI spillover

3.1.1 Mechanism of technology spillover through FDI

The results regarding FDI's impact on horizontal spillover are mixed due to two counteracting effects: the "demonstration effect" and the "crowding out effect". Liu (2008) proposed a model to explain the former. He extended Ehrlich et al.'s (1994) model of firm productivity gap to demonstrate the mechanism through which FDI causes positive technology spillover. He argued that the dominance of foreign investors in terms of technology promotes domestic firms to increase their productivity, and empirically demonstrated that the productivity gain to domestic firms is positively correlated with technology gap.[3] Empirical evidence provided in Blomstrom and Wang (1992), Markusen and Venables (1999), and Glass and Saggi (2002) generally support Liu (2008)'s theory. The local partners in developing countries have an incentive to absorb the technology of foreign affiliates with superior technology through training provided by the foreign affiliates or learning by imitation in order to compete with their rivals. This happens when the competition is intense and domestic firms have to use their resources in a more efficient way or adopt new technology (Blomstrom and Kokko, 1998).

On the other hand, competitors in the same industry can also cause a "crowding-out" effect (Caves, 1996; Backer and Sleuwaegen, 2003), and this may result in a lower average productivity of the industry. The protection of intellectual property and higher wage paid by foreign affiliates causes the operation costs of domestic firms to increase, thereby driving local firms out of the market. If the crowding-out effect offsets the demonstration effect, the net impact of FDI may become negative. This may explain why previous empirical studies on this topic showed ambiguous results (Aitken and Harrison, 1999; Haskel et al., 2007; Monastiriotis and Alegria, 2011).

In contrast to horizontal spillover, foreign affiliates also generate vertical spillover when they deal with both the local suppliers and domestic buyers. This kind of spillover takes place more frequently through: (1) direct knowledge transfer from multinational firms to local suppliers; and (2) stricter requirements for product quality and on-time

delivery by multinational firms (Javorcik, 2004). Thus, in this research we would like to pay attention only to the influence that foreign customers have on local suppliers (or backward vertical spillover).

3.1.2 Heterogeneity of spillover effects across origins of FDI

Despite the large body of literature that concentrates on the presence of FDI and technology spillover, there have been only a few studies, to the best of our knowledge, to investigate the relationship between the origin of FDI and its spillover impact from a theoretical point of view. Evidence relies solely on empirical studies.

Monastiriotis and Alegria (2011) focused on European firms' investment in Bulgaria, but only in the case of horizontal spillover. Their finding was that, compared to the strong spillover from Greek FDI, the impact of FDI from other European firms' impact was fairly small. Ayyagari and Kosova (2010) found horizontal spillovers in the Czech Republic are driven by FDI from EU firms, but not from non-EU firms. They provided an insight into why spillover does not exist in the manufacturing industry; manufacturing firms tend to protect their knowledge more than firms in the service sector. Although the impact in manufacturing and services might be different, the opposing effects will simply cancel out when the full sample is used.

Javorcik and Spatareanu (2011) used firm-level panel data from Romania to examine whether the origin of foreign investors affects the degree of vertical spillover from FDI. They found that the distance between the host and the source economy positively affects the share of intermediates sourced locally by multinationals. They also found that the sourcing pattern is likely to be affected by preferential trade agreements. In their research, FDI from American firms is found to have more backward spillover effect on domestic firms in Romania than that from European firms.

Chen (2011) evaluated the casual relationship between the source of FDI origin and performance of target firms in the U.S.A. She divided foreign investors into OECD and non-OECD, finding that FDI from OECD firms causes target firms to gain more labor productivity after M&A. The same findings were made by Vega et al. (2011), Ito et al. (2012)

and Kamal (2014).

3.2 Spillover on domestic firms' productivity in Vietnam

At the macro-level, Thuy (2007) used industry-level data from 1995 to 2002 in Vietnam to examine if FDI's linkage with domestic firms has a positive impact on the latter's labor productivity. Since the Vietnamese Enterprise Survey became available, there have been an increasing number of studies on the analysis of spillover impact at a micro-level. Nguyen (2008) examined both the horizontal and vertical spillover effect of FDI on TFP in several regions in Vietnam. He found a positive effect for both horizontal and vertical spillover for Vietnamese manufacturing industries, but that the effect varies across regions and types of firms. Anwar and Nguyen (2014) supported his claim by testing the FDI spillover effect in eight regions of Vietnam. They found a strong positive impact of FDI on TFP through backward linkages in some regions but a negative impact in other regions.

3.3 Sourcing pattern, preferential agreement and spillover

Xuan and Xing (2008) shed light on the fact that investors from Asian countries, such as Japan and Singapore, tend to consider Vietnam as a production base for their exports, for the purpose of reducing production costs. They argued that a free trade agreement (FTA) might enhance inward FDI because tariff exemption encourages foreign investors to shift their production activities to Vietnam and export back to the home countries (or export directly to other countries). Examples can be found where, after Vietnam signed FTAs with Japan, the U.S.A., and ASEAN countries, the FDI flow into Vietnam from these areas all increased. We follow their approach to separate samples according to agreement-based groupings. Since we are interested in how the origin of each individual country matters, in practice we will also use bilateral preferential agreement as the criterion.

4. Data and estimation strategy

4.1 Data

This research uses a panel dataset constructed from the Vietnam Enterprise Survey at firm-level. The Vietnam Enterprise Survey data is collected annually by the General Statistics Office (GSO) of Vietnam for all industrial sectors as of March 1st of each year. The general objectives of this survey are: (1) to collect business information needed to compile national accounts; (2) to gather up-to-date information on business registrations; and (3) to develop a statistical database of enterprises. This panel dataset covers ten years, from 2002 to 2011, in which Vietnam experienced two major economic changes, namely WTO accession and the global economic crisis. The majority of the firms in the dataset can be found in the list of Vietnam Standard Industrial Classification (VSIC) codes,[4] including all 22 manufacturing sectors out of 42 in total. Profiles of firms concerning ownership, labor, capital stock, turnover, assets, FDI, wage, materials inputs and other information are provided.[5] In the estimation model, we measure capital and labor by fixed asset and total labor at the end of year. Output and capital are deflated using annual GDP.[6] Above that, the GSO surveyed all multinational enterprises (MNEs), which are defined as firms that have foreign capital.[7] An advantage of this dataset is that the country that represents the ownership of the firm is also reported. Each firm is given a unique "enterprise code", and it is used together with the province code to identify firms and construct the panel dataset.

The number of observations in each year is presented in Table 3-2.[8] Incomplete information about exports and imports, missing data for materials, and non-conformity of units among different years, lead to a reduction in observations that can be used in the analysis. We eliminate the missing observations in calculating firm's productivity, and delete outliers.[9] In the end, 1,272,058 observations remain.

4.2 Estimation of firm productivity

TFP is the most commonly used measure of the effect of FDI spillover on firm's performance in literature (see, for example, Haskel et al.,

Table 3-1 Statistical summary on the variables used for the production function estimation

Variable	Mean	S.D.	N
Material	3.746	2.346	553993
Labor	2.385	1.287	1367707
Output	6.382	2.238	1318029
Capital	5.182	1.936	1197153
Investment	5.223	1.928	472853

Note: All variables are in the form of logarithm (2002–2011).

Table 3-2 The number of foreign firms by continent (samples used for estimation).

Year	Asia	Europe	North America
2002	1,687	278	71
2003	1,611	208	56
2004	2,379	327	109
2005	2,707	394	138
2006	2,662	336	116
2007	3,703	449	179
2008	4,134	528	210
2009	4,751	623	246
2010	4,974	662	265
2011	5,739	734	322

Source: Annual Enterprise Survey, GSO Vietnam (2002–2011).

2007; Javorcik 2004). Although there are many ways to estimate TFP, we choose two alternative approaches that are suitable to the data situation, namely stochastic frontier estimation, and Levinsohn and Petrin's (2003) firm-level productivity estimation. The former has the advantage of isolating statistical noise from genuine productivity, whereas the latter has the advantage of incorporating explicitly the correlation between unobservable productivity shocks and input levels.

Let us begin by using the traditional econometric approach to estimate TFP to illustrate the advantages of the approaches. The Cobb-Douglas production function is written as:

$$lnY_{it} = \alpha + \beta_k lnK_{it} + \beta_l lnL_{it} + \varepsilon_{it} \quad (3.1)$$

where Y_{it} stands for firm i's net revenue in year t. K and L represent capital and labor respectively, ε_{it} is the unobserved error term. Once this model is estimated using ordinary least squares (OLS), TFP is calculated by normalizing the exponential transformation of the residual.[10] The well-known drawback of this approach is its inability to isolate genuine productivity from statistical noise.

The stochastic frontier analysis overcomes this drawback by including two error components representing both (the inverse) technical efficiency and statistical noise. According to Aigner et al. (1977) and Kumbhakar and Lovell (2000), the model is specified as:

$$lnY_{it} = \beta_0 + \sum \beta_n lnx_{ni} + v_i + u_i \quad (3.2)$$

where x_{ni} is a vector of inputs. v_i is the noise component and u_i is the non-negative technical inefficiency component. Here, technical efficiency derived by inverting the technical inefficiency estimate is the measure of TFP. A half normal, exponential and Gamma distributions are often assumed on ui to ensure non-negativity of productivity estimates, whereas a full normal distribution is assumed on v_i as is common for random noise. The conditions for the error components for the normal-half normal model are: (1) $v_i - iid\ N\ (0, \sigma v^2)$ (2) $u_i - iid\ N + (0, \sigma_v^2)$ (3) v_i and u_i are distributed independently of each other, and of the regressors.

This model is estimated by maximum likelihood estimation. Once

estimates of u_i are obtained from the residual of the model, the technical efficiency of the firm can be obtained by:

$$TE_i = exp\{-\hat{u}_i\} \tag{3.3}$$

where $\hat{u}_i$ is $E(u_i \mid \varepsilon_i)$.[11] Alternative distributional assumptions on u_i can be accommodated simply by replacing (2).

The concern about the bias caused by correlation between unobservable productivity shocks and input levels motivates us to use a line of structural approaches that can handle the endogeneity of input selection, proposed originally by Olley and Pakes (1996) and improved by later studies such as Levinsohn and Petrin (2003). Olley and Pakes assume that labor is the only (freely) variable input, and thus is likely to be affected by productivity shocks. Levinsohn and Petrin add greater flexibility to the Olley and Pakes model by assuming an intermediate input to a variable input as well, while both assume that capital is a state or quasi-fixed variable. Consider the following econometric specification:

$$lnY_{it} = \alpha_i + \beta_k lnK_{it} + \beta_l lnL_{it} + \beta_m lnM_{it} + \omega_{it} + \varepsilon_{it} \tag{3.4}$$

where K_{it}, and L_{it} denote capital and labor, respectively, and M_{it} denotes intermediate input such as materials. The term ω_{it} represents the productivity that is assumed to be observable to the firm. Levinsohn and Petrin use the intermediate input to invert ω_{it}, thus reducing endogeneous bias, in comparison to OLS estimation.[12]

We employ both the stochastic frontier analysis and the structural approaches because each has advantages and weaknesses in different aspects. The former is robust against the effect of statistical noise, but is not suited to handle the input-productivity correlation. On the other hand, the latter is robust against the input-productivity correlation, but is likely to be influenced by statistical noise. Furthermore, the latter is data demanding as it requires data on intermediate input and lagged input variables.

The lack of data on intermediate input, in particular, is a critical constraint when we estimate the Levinsohn and Petrin model. There is no direct measure of intermediate input, however, we use "work-in-

process" as a proxy variable for intermediate input. "Work- in-process" is an appropriate proxy because products that are uncompleted in the previous period are to be brought into the production line in the current period and to be completed. Also, it has to be noted that we interpolate input variables to avoid losing too many observations due to the use of the lagged inputs in the Levinsohn and Petrin model. These caveats are thought to reduce reliability of the estimation using this structural approach. Thus, we would rather use this model as a robustness check for the stochastic frontier analysis. As discussed later, both estimations are reasonably similar, and therefore, we claim that the stochastic frontier analysis yields fairly reliable results.

4.3 Estimating spillover effect

Now we proceed to the methodology to estimate the effect of FDI on the estimated TFP. We use a standard panel regression where TFP is regressed on measures of the influence of FDI and other covariates. The FDI spillover variables are built based on the influence of FDI within the same industry and downstream industries. The former captures the horizontal spillover effect, and the latter captures the backward vertical spillover. The origins of FDI are also distinguished in the FDI spillover variables. The estimation model becomes:

$$\begin{aligned} lnTFP_{ijt} = {} & \alpha_i + \beta_1 Horizontal_{jt-1} + \beta_2 Vertical\_Asia_{jt-1} \\ & + \beta_3 Vertical\_Europe_{jt-1} + \beta_4 Vertical\_NorthAmerica_{jt-1} \\ & + \beta_5 Herfindal_{jt-1} + \beta_i X_{it} + \eta_t + u_{ijt} \end{aligned} \tag{3.5}$$

$lnTFP_{ijt}$ is the logarithm of TFP of firm i, in sector j at time t. $Horizontal_{jt}$ is defined as the share of sector j's output produced by foreign firms at time t.[13] *Vertical_Origin* is the measure of foreign presence in the downstream industries. These variables are constructed by adopting the formula developed by Javorcik and Spatareanu (2011), which are an origin-differentiated version of the variables proposed by Javorcik and Spatareanu (2004). Since there might be a time lag for spillover to occur, we use the one-year lags of each variable as independent variables. Apart from covariates X_{it}, we also include the Herfindahl index. Time

dummies are included to control for time specific shock η_t. The fixed effect model is used to control for the firm-industry pair effect α_{ij} by assuming that $u_{ijt} = \alpha_{ij} + \varepsilon_{ijt}$. The variable *Vertical_Origin* is defined as:

$$Vertical\_Origin_{jt} = \sum_{k \neq j} \alpha_{jkt} Horizontal\_Origin_{kt} \quad (3.6)$$

where *Horizontal_Origin* is defined as the share of the output produced by foreign firms within sector k in year t, and α_{jkt} is the coefficient representing the proportion of sector j's output used by sector k in year t.[14] The coefficients are taken from the Vietnamese Input-Output Table (IO Table) 2007.

For the industry classification, we follow that of the IO Table 2007 because it is necessary to explore the industry linkage to construct vertical spillover variables. However, because the Enterprise Survey follows VSICcode industry classification it was necessary to match the industries in the dataset with those used in the IO Table. In the end, the industry categories were reduced from 138 to 42 (see detailed categories in Appendix. Furthermore, the VSICcode system changed from VSICcode1993 to VSICcode2007 in year 2007, therefore, the industry codes used prior to 2007 are converted in accordance with VSICcode2007 by using a 1993–2007 concordance table.[15]

As indicated in Javorcik and Spatareanu (2011), because of the advantage in technology, foreign buyers usually require high-quality inputs, thus imposing pressure on their upstream local suppliers. Accordingly, it is more reasonable to observe that the spillover incurred backwardly to the suppliers. In the following sections, we only focus on backward linkage and use $Backward\_Vertical\_Origin_{jt}$ to represent vertical spillover from sector j to sector k. It is used to capture the potential interaction between foreign firms in j and local suppliers in k. This index was first developed by Schoors and van der Tol (2001). In the baseline estimation, we include *Vertical_Continent* (Asia, Europe and North America) first, and use a different grouping method to investigate other topics of interest. All specifications are estimated using "cluster" in the industry-level.

4.4 Grouping of origin countries of foreign investors

4.4.1 Baseline grouping—continent

The categorization in this research is based on the geographic location of the firms. The baseline model adopts the grouping of origin countries of foreign investors according to Javorcik and Spatareanu (2011): namely, Asian, European, and North American firms.[16] These regions account for 90 % of the origin countries of foreign investors in the sample.

4.4.2 Alternative grouping

4.4.2.1 Bilateral investment treaty (BIT) blocs

Egger and Pfaffermayr (2004) and Rosendorff and Shin (2012) demonstrated the positive impact of BITs on promoting FDI in general. Rosendorff and Shin (2012) pointed out that it is especially the case for countries that need institutional improvement the most. Although the political partnership between Vietnam and its foreign investors is beyond the scope of discussion in this study, most of previous studies reach a consensus that BITs lead to greater FDI inflows. Thus, we examine the effect of BITs by applying an alternative grouping in terms of BITs to the vertical spillover variables.[17] We group countries depending on whether they have signed BITs with Vietnam during the period of estimation according to the criteria of the United Nations Conference on Trade and Development.

4.4.2.2 Alternative grouping—FTA-based grouping

We mentioned previously that the sourcing pattern of foreign firms is also likely to be affected by preferential trade agreements. Because of the existence of the AFTA within ASEAN, we expect that the firms based in the member countries that are benefiting from this agreement have a different way to procure their resources from that of the investors from outside ASEAN. Because ASEAN firms have higher average productivity than their Vietnamese counterparts do,[18] upon entering the market, they tend to be huge rivals to Vietnamese domestic firms. Thus, we expect the horizontal spillover effect from FDI from ASEAN firms to be negative.

4.4.2.3 Consideration of Japan and Korea

Japan and Korea are Vietnam's two most important business partners among the country's BIT partners after the year 2000. These countries have close ties with Vietnam, and have been the largest investors in recent years. By the end of 2010, as far as investment amount is concerned, Japan was amongst the top four countries of origin in Vietnam, with the other three being Taiwan, Korea and Singapore (MPI, 2011).

Nevertheless, Japanese manufacturers' procurement ratio in Vietnam is quite low, compared to the other ASEAN countries. According to the Japan External Trade Organization (JETRO), the local procurement ratio of Japanese manufacturing firms in 2004 was 47.9 % in Thailand, 45.0 % in Malaysia, 38.3 % in Indonesia, and 28.3 % in the Philippines, while this number was 22.6 % in Vietnam (JETRO, 2005). As Mori (2006) argues, most Japanese investors in Vietnam do not have sufficient information on where productive Vietnamese suppliers are located. Even though the localization rate has been rising in recent years, locally procured products are still limited to low-value parts. In contrast, investment from Korean firms in the first quarter surpassed Japan in June 2014, and accounted for 22.9 % of the entire investment amount in Vietnam.[19] Samsung and LG electronics are the main driving force of this investment surge. However, Samsung Vietnam still prefers Korean suppliers to local firms because "the quality of local parts is below standard."[20] Their localization rate was 16 % in Vietnam during 2012 compared to 40 % in China.

While we witness Japanese and Korean firms' large investment in Vietnam, it is not certain whether it can still cause a significant spillover effect when less interaction with local suppliers is involved. Thus, it is worthwhile to examine a grouping that isolates Japan and Korea from the Asian country group: Japanese & Korean, non-JK Asian, European and North American.

5. Estimation results

5.1 Total factor productivity

We rely mainly on the stochastic frontier analysis in the estimation of

Table 3-3 Production function parameters

Model variables	(1) OLS log y	(2) FE log y	(3) SF log y	(4) LP log y	(5) SF log y
log k	0.105*** (0.00257)	0.217*** (0.00168)	0.297*** (0.00155)	0.183*** (0.00466)	0.257*** (0.000902)
log l	0.611*** (0.00434)	0.707*** (0.00241)	0.635*** (0.00213)	0.645*** (0.00281)	0.677*** (0.00137)
log m	0.00135 (0.00178)	–0.0187*** (0.00116)	–0.0415*** (0.00106)	0.0645*** (0.00861)	
Observations	513,913	513,913	513,913	513,913	1,272,074
R-squared	0.120	0.117			
Wald Test P value			0.000	0.000	0.000

Notes: Standard errors in parentheses, calculated with cluster option. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3-4 TFP comparison

(a) Summary statistics for various TFP scores

TFP scores	N	Mean	S.D.	Max.	Min.
FE	513,913	0.003	0.008	1	0
OLS	513,913	0.001	0.004	1	0
SF with intermediate input	513,913	0.513	0.165	0.810	0.008
SF without intermediate input	1,272,074	0.577	0.119	0.787	0.043
LP	513,913	0.028	0.046	1	0

(b) Correlation of TFP scores

	FE	OLS	SF with intermediate input	SF without intermediate input	LP
FE	1				
OLS	0.929	1			
SF with intermediate input	0.065	0.047	1		
SF without intermediate input	0.045	0.034	0.988	1	
LP	0.007	0.017	0.573	0.553	1

(c) Correlation of TFP rank

	OLS with FE	OLS without FE	SF with intermediate input	SF without intermediate input	LP
FE	1				
OLS	0.993	1			
SF with intermediate input	–0.018	–0.021	1		
SF without intermediate input	–0.054	–0.053	0.996	1	
LP	–0.026	–0.018	0.986	0.993	1

Source: Based on the author's calculation (2002–2011).

TFP due to its modest data requirement. We then examine its robustness by comparing it with alternative methods, primarily, Levinsohn and Petrin (LP) structural approach. We also estimate the production function by OLS and fixed effects model to derive TFP for comparison purposes. We include "intermediate input" (proxied by "work-in-process") in the OLS, the fixed effect model (FE), and the stochastic frontier models (SF) as well. TFP scores from OLS and FE are normalized to follow the range from 0 to 1. The parameter estimates of the production function for each model are presented in Table 3-3, and the statistical summary on TFP scores are presented in Table 3-4. Although there are moderate differences between the parameters of alternative models, the relative magnitude between the coefficients of capital and labor can be said to be reasonably similar. On the other hand, the coefficients for the intermediate input are substantially different across the models; most importantly, between the full SF and LP models. The low correlation between SF and OLS/FE implies the disadvantage of OLS/FE estimation of mixing random noise with genuine TFP.

This concern about the robustness of parameter estimates leads us to examine robustness by directly comparing the TFP scores across models. Table 3-4(b) shows the pair-wise correlation between TFP scores under alternative models. The moderate correlation between TFP scores under LP and two SF models motivates us to examine TFP scores in terms of ranking. Table 3-4(c) shows that the rank-based correlations between any of the two SF models and LP are nearly one. This justifies the use of SF based TFP scores in the subsequent analysis of FDI spillover although we should examine robustness of the results between SF and LP.

5.2 Baseline estimation result

The baseline results for FDI spillover based on equation (3.5) are shown in Table 3-5. The baseline estimation applies stochastic frontier TFP.[21] We observe negative and significant signs for *Horizontal_Asia* throughout the models, and this indicates the presence of a strong replacement effect by FDI from the Asia region. This result is consistent with Caves (1996) and Blomstrom et al. (2000) who found a tendency of MNCs

Table 3-5 Result of FDI spillover with region-based groupings (baseline)

Dependent Variable: Ln_TFP (SF)	(1)	(2)
Herfindal	–0.0967*** (0.0295)	–0.0976*** (0.0295)
Horizontal_total	–0.0299*** (0.00983)	
Vertical_total	0.0228* (0.0119)	
Vertical_Asia		0.0353** (0.0170)
Vertical_Europe		–0.0416 (0.100)
Vertical_NorthAmerica		–0.291 (0.549)
Horizontal_Asia		–0.0370*** (0.00881)
Horizontal_Europe		–0.0205 (0.0187)
Horizontal_NorthAmerica		–0.0153 (0.0598)
Observations	1,272,058	1,272,058
R-squared	0.052	0.052
Number of id	569,507	569,507

Notes: All control variables are in the form of one period lag. Robust standard errors in parentheses, calculated with cluster option. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummy is included; firm-specific characteristics are controlled (fixed effect).

to "crowd out" local firms in the same industry in developing countries. *Horizontal_Europe* and *Horizontal_NorthAmerica* however, are not robustly significant.[22] This phenomenon might be due to the fact that Asian firms have relatively closer technology to domestic firms than European or North American firms do. Thus, Asian firms pose a greater threat to the local competitors. The result also implies that, if Vietnamese firms are to compete with foreign firms in the same industry, a greater effort in product diversification or product differentiation through greater R&D would be necessary.

Vertical spillover [23] from FDI from the Asia region, *Vertical_Asia*, always has a positive sign and in most cases it is significant.[24] This supports our hypothesis that higher penetration of Asian FDI does have positive spillover on Vietnamese suppliers. Concerning FDI from European and North American firms, however, no consistent results are found. This indicates that a potential technology gap, on its own, might not necessarily lead to spillover.

5.3 Result for alternative groupings

Table 3-6 indicates that a greater vertical spillover on domestic suppliers seems to be generated by investors from countries that have signed BITs whereas the direction of the effect is mixed in the case of the non-BIT investors. These unstable results for the non-BIT investors may be explained by greater investment barriers for investors from counties without BITs. On the other hand, the significantly negative sign of horizontal spillover shows that investors with BITs tend to suppress the development of their domestic competitors in the same industry.

Columns (1) and (2) in Table 3-7 show the result for grouping with Japanese and Korean firms and non-JK Asian firms, thus demonstrating how the spillover effect differs among different degrees of interaction with local suppliers. They support our prior hypothesis that Japanese and Korean firms do not have any vertical spillover effect. Asian investors, excluding these two countries, still show positive spillover impact in the vertical direction. At the same time, *Horizontal_nonJK_Asia* always has a negative sign, implying that investment from this region is suppressing the productivity growth of Vietnamese firms in the same

Table 3-6 Result of FDI spillover with BIT-based groupings

Dependent Variable: Ln_TFP	(1)	(2)
Herfindal	–0.120***	–0.123***
	(0.0337)	(0.0336)
Horizontal_total	–0.0305***	
	(0.00983)	
Vertical_BIT	0.0354**	0.0348**
	(0.0153)	(0.0149)
Vertical_non-BIT	–0.0150***	–0.0148***
	(0.00490)	(0.00488)
Horizontal_BIT		–0.0413***
		(0.00844)
Observations	1,272,058	1,272,058
R-squared	0.052	0.053
Number of id	569,503	569,503

Notes: All control variables are in the form of one period lag. Robust standard errors in parentheses, calculated with cluster option. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummy is included; firm-specific characteristics are controlled (fixed effect).

Table 3-7 Result of FDI spillover with region-based groupings (alternative)

Dependent Variable: Ln_TFP (SF)	(1)	(2)	(3)	(4)
Herfindal	–0.0549***	–0.0538***	–0.0659*	–0.0650*
	(0.0199)	(0.0195)	(0.0389)	(0.0393)
Horizontal_total	–0.0308***		–0.0312***	
	(0.00982)		(0.00993)	
Vertical_Europe	–0.0424	–0.0343	–0.0361	–0.0257
	(0.0978)	(0.0979)	(0.0986)	(0.0969)
Vertical_NorthAmerica	–0.363	–0.180	–0.376	–0.241
	(0.543)	(0.546)	(0.546)	(0.539)
Vertical_JK	0.0258	0.0299	0.0193	0.0287
	(0.0244)	(0.0221)	(0.0221)	(0.0200)
Vertical_non-JK_Asia	0.0562***	0.0479**		
	(0.0214)	(0.0209)		
Vertical_ASEAN			–0.0370	–0.0210
			(0.0433)	(0.0419)
Vertical_other Asia			0.133***	0.106**
			(0.0450)	(0.0412)
Horizontal_Europe		–0.0262*		–0.0236
		(0.0146)		(0.0149)
Horizontal_NorthAmerica		0.0107		0.0277
		(0.0582)		(0.0611)
Horizontal_JK		0.00329		–0.00395
		(0.00917)		(0.00928)
Horizontal_non-JK_Asia		–0.0788***		
		(0.0151)		
Horizontal_ASEAN				–0.116***
				(0.0272)
Horizontal_other Asia				–0.0518***
				(0.0139)
Observations	1,272,058	1,272,058	1,272,058	1,272,058
R-squared	0.052	0.053	0.053	0.054
Number of id	569,505	569,505	569,507	569,507

Notes: All control variables are in the form of one period lag. Robust standard errors in parentheses, calculated with cluster option. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummy is included; firm-specific characteristics are controlled (fixed effect).

industry. Meanwhile, we find that FDI from European investors also has a "crowding out" effect, although it is not the case for North American investors.

Columns (3) and (4) in Table 3-7 show the different spillover effect when we take into account both FTA and foreign investors' interaction with local suppliers. *Vertical_otherAsia* (Backward) is always positive and significant, which indicates that the FDI from Asian firms leads to positive spillover on Vietnamese firms' productivity, and it is mainly caused by East-Asian firms, except Japanese and Korean ones. A possible explanation would be that investors from countries such as Taiwan, Hong Kong and China have more advanced technology than Vietnamese firms. Furthermore, these firms have more incentive to source locally because of the imposed tariff on imported parts from outside ASEAN. In comparison, the lack of sourcing by Japanese and Korean firms in local areas prevents their technology from being spread to the domestic suppliers. On the other hand, horizontal indicators alway show negative signs except for *Horizontal_NorthAmerica*. Among them, *Horizontal_ASEAN* and *Horizontal_otherAsia* are significant in all cases. This provides strong evidence that foreign firms' entry in the same industry prevents domestic competitors from increasing their productivity.

5.4 Robustness check

5.4.1 Higher foreign share cutoff

As indicated by Javorcik and Spatareanu (2011), small ownership share gives foreign investors little power to take control of the firm and lowers the possibility of technology spillover led by foreign shareholders. Since, in our baseline estimation, foreign firms are defined as the ones with foreign share regardless of the percentage, we would like to check the robustness of the results in the previous sections by increasing the cut-off value. We decide to use 50 % foreign equity share as the cut-off value to conduct the examination.[25] As shown in column (1) of Table 3-8, this attempt does not change the qualitative prediction.

Table 3-8 Robustness check

Dependent Variable: Ln_TFP (SF)	(1)	(2)	(3)	(4)	(5)
	50 % cutoff	Location	Firm size		Heterogeneity
			< 10 person	> 10 &< 50	
Herfindal	–0.0940**	–0.0955***	–0.0528	–0.00844	0.00457
	(0.0427)	(0.0337)	(0.0510)	(0.0418)	(0.0196)
Vertical_Asia	0.0353**	0.0417**	0.0671***	0.0189***	0.0484**
	(0.0167)	(0.0206)	(0.0225)	(0.00719)	(0.0243)
Vertical_Europe	0.0264	–0.0413	–0.155	–0.0426	0.0793
	(0.0837)	(0.101)	(0.157)	(0.0455)	(0.147)
Vertical_NorthAmerica	–0.400	–0.375	–0.131	–0.514*	–0.0925
	(0.478)	(0.511)	(0.827)	(0.297)	(0.623)
Vertical_TFP					–0.348***
					(0.0930)
Horizontal_Asia	–0.0350***	–0.0449***	–0.0672***	–0.0131***	–0.0561***
	(0.00816)	(0.00783)	(0.0124)	(0.00409)	(0.0116)
Horizontal_Europe	–0.00251	–0.0208	–0.00349	–0.0223**	–0.00473
	(0.0247)	(0.0193)	(0.0222)	(0.00877)	(0.0192)
Horizontal_NorthAmerica	–0.0482	–0.00611	–0.0552	–0.0132	0.0381
	(0.0644)	(0.0699)	(0.0814)	(0.0359)	(0.0702)
Observations	1,272,058	339,800	720,748	374,874	1,166,855
R-squared	0.052	0.048	0.115	0.019	0.060
Number of id	569,506	141,553	396,548	189,884	579,298

Notes: All control variables are in the form of one period lag. Robust standard errors in parentheses, calculated with cluster option. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year dummy is included; firm-specific characteristics are controlled (fixed effect).

5.4.2 Location effect

Due to the geographical inequality in economic growth inside Vietnam, we are motivated to investigate how foreign firms in different regions have a distinctive impact on domestic firms' TFP. The centrally administered provinces in Vietnam can be roughly divided into 6 major socio-economic districts: the Red River Delta, Midlands and Northern Mountainous Areas, Northern and Coastal Central Regions, Central Highlands, Southeastern Area, and Mekong Delta. Thus, we divide the full sample by region and see if there is any variation among different groups. We try to identify the location of each firm by "province" code.[26] Column (2) in Table 3-8 shows the result for the Red River Delta analysis. The significant and positive sign of *Vertical_Asia* (Backward) shows that FDI from Asian firms has more impact on promoting the productivity of domestic firms. Considering that the Red River Delta is the most economically developed region in Vietnam, it can be inferred that FDI from Asian firms is more likely to lead to spillover in the areas where economic development is more active and prosperous.

5.4.3 Firm size effect

We further investigate if the size of the domestic firms affects the way they receive FDI spillover. To do this, we divide all domestic firms into three groups: small (< 10 persons), medium (10 to 50 persons), and large (50 persons or more) firms. Then we conduct the same estimation as in equation (3.5) based on the samples in each group. As shown in columns (3) and (4) of Table 3-8, Asian investors cause positive vertical spillover to their domestic suppliers when domestic firms are of small and medium size, while this impact is not found when only large firms are concerned.[27] This implies that spillover from FDI from Asian firms is more possible in relatively small-scale firms because such firms are flexible in absorbing new technology and staff from outside. By contrast, it will take time for large firms to adapt themselves to different technology systems. On the other hand, *Horizontal_Asia* is negatively significant for small firms, while both *Horizontal_Asia* and *Horizontal_Europe* play negative roles for medium firms. We do not observe any consistent results for large firms.

5.4.4 Controlling for heterogeneity of foreign firms

One might argue that our previous findings are caused by the idiosyncratic characteristics of different foreign investors. MNCs from different countries will usually have different productivities (see Appendix Table 3-9). This variation in productivity may be a factor in affecting the degree of spillover because firms with more sophisticated technology will require more refined inputs from their local suppliers. On the other hand, if the TFP of foreign firms is far superior to that of domestic suppliers, it is difficult for domestic firms to catch up and more likely that the presence of FDI will not bring any spillover effect to the upstream suppliers. To verify whether foreign firms' TFP heterogeneity matters, and following Javorcik and Spatareanu (2011), we generate a new control variable *Vertical_TFP*.[28] The estimation result is presented in column (5) of Table 3-8. *Vertical_TFP* is always negative and significant. This indicates that the more sophisticated the foreign firms in downstream sectors are, the more difficult it is for these firms to be able to transfer knowledge to their local suppliers. Meanwhile, adding this term does not change our previous conclusions.

6. Conclusion

By far the spillover impact of FDI has been widely investigated. In this research, we examine how the origin of foreign investors affects the degree of horizontal and vertical technology spillovers, using firm-level panel data from Vietnam in 2002–2011. In general, FDI does not bring horizontal spillover to domestic firms, which is in contrast to Nguyen (2008). However, in the vertical way, FDI is positive and significant, conditional on the region. This finding is in accordance with Anwar and Nguyen (2014).

Deviating from previous studies, we examine if the investment from different continents might have a different impact on domestic firms' productivity. We first group the origins of multinational firms according to geographical regions into East-Asia, Europe and North America. Second, given the fact that the sourcing pattern of multinational firms is likely to be affected by preferential trade arrangements or investment

agreements, we examine alternative groupings which incorporate preferential trade arrangement and investment arrangements. To be specific, we subdivide Asian countries according to the ASEAN membership, BITs and sourcing tradition.

The empirical results provide solid evidence of Asian firms' positive spillover in Vietnam, and it shows that this spillover is mainly generated through the channel of local sourcing. In general, a positive relationship is observed between the presence of Asian firms in downstream sectors and the productivity increase of Vietnamese firms in the supplying sectors. Also, no robust result is found when European or North American firms are supplied by Vietnamese firms. Furthermore, we find that FDI from Japanese and Korean firms do not induce positive spillover to domestic suppliers despite their large investment in Vietnam. In contrast, firms in the rest of East-Asia are the most likely to induce spillover to the local suppliers because of their closer interaction. In the horizontal perspective, ASEAN, East-Asian and European firms all exhibit a negative productivity effect, implying that they tend to restrain the productivity growth of Vietnamese firms in the same industry. Apart from the above, we conduct a robustness check by investigating the factors of higher foreign share cutoff value, the size of domestic firms, location and foreign firms' heterogeneity. The Asian vertical variable is robust across all specifications while horizontal variables present consistent results as in the previous analysis.

Thus, our findings support the view that, in addition to preferential investment agreement, interaction with local firms through sourcing is likely to be the most decisive channel to incur vertical spillover. Since Japanese or Korean investors' reluctance to local procurement prevents Vietnam from grasping potential benefit from high-tech FDIs, the government should provide multinational firms with a better investment environment; for example, by providing information on local supplies. At the same time, the Vietnamese government should foster Vietnamese firms to improve their technology level and to devote to product upgrading in order to catch up with foreign investors.

Notes

1 In the figure, the FDI is calculated as the total accumulated capital of effective FDI projects in Vietnam.
2 In our research, sourcing pattern specifically refers to the pattern of suppliers' procurement of the inputs in terms of domestic or foreign sources.
3 See Liu (2008) for detailed proof.
4 We use the first 2-digits indicated in VSICcode2007 and VSIC-code1993 to identify industries. For simplicity we aggregate some sectors. See Appendix for details.
5 Census is taken for firms with more than 10 employees (over 20 employees in 2010 and 2011).
6 Producer Price Index in the sector level is a preferred deflator but such data is not available for Vietnam.
7 The sampling methods varied for private firms across years.
8 We only count the one with the largest share. If Japan's share of investment is the largest, we consider the firm to be a Japanese-invested firm.
9 Firms in the top and bottom one percentile of all firm-specific output and input variables (in the means of annual growth) were deleted from the sample. Also the top and bottom 1 % of output/capital and output/labor are excluded.
10 The intercept is usually corrected to make the estimated TFP to fall within the appropriate range.
11 $E(u_i \mid \varepsilon_i) = \mu_i^* + \sigma^* \frac{\phi(-\mu_i^*/\sigma^*)}{1-\phi(-\mu_i^*/\sigma^*)} = \sigma^* \left[\frac{\phi(\varepsilon_i\lambda/\sigma)}{1-\phi(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma} \right]$, σ and λ are σ_u and λ_v; ϕ and Φ are density and cumulative density functions respectively.
12 Olley and Pakes use "investment" to invert ω_{it}.
13 In practice, we use horizontal index categorized by continent as well, but there is no statistically significant difference between the aggregated and disaggregated ones.
14 When we calculate α_{jkt}, sector j's output sold for final consumption was excluded.
15 The table is made based on the content description of the sector.

16 Though firms with multiple investors are rarely the case in Vietnam, we delete these observations for simplicity.
17 In fact, BITs might indirectly affect the sourcing pattern as well. For example, some Canadian BITs prescribe mandatory sourcing from local suppliers. See "Agreement Between the Government of Canada and The Government of The Republic of Trinidad and Tobago For the Reciprocal Promotion and Protection of Investments," Article 2.
18 ASEAN firms' average TFP is 0.64, whereas that for Vietnam firms is 0.58, when we calculated TFP using stochastic frontier method. The result is similar when we apply Levinsohn and Petrin method.
19 Quoted from BusinessKorea, June 20, 2014. http://www.businesskorea.co.kr/article/5112/largest-investor-south-korea-becomes-biggest-investor-vietnam-beating-japan.
20 Tuoitrenews, July 24, 2013. http://tuoitrenews.vn/business/11689/samsung-vietnam-uses-korean- suppliers-as-local-firms-below-standard.
21 We also calculated LP TFP in the rest of the analysis, and it does not change our qualitative predictions.
22 Although *Horizontal_Europe* is negative and significant when LP TFP is applied. This is consistent with the results in later sections.
23 In the following context of the chapter, vertical spillover only refers to backward spillover brought to upstream suppliers.
24 We obtain similar results when we limit the samples to domestic firms.
25 When we use 10 % foreign equity share as the cut-off, there are only 51 firms out of 42,142 foreign firms in total (over ten years), while nearly 80 % of the pool are wholy-foreign-invested firms (33,000).
26 There was a reform of the provinces of Vietnam in 2004, when some provinces were merged to others and the codes were changed accordingly. We will only focus on the firms using the new province code.
27 We do not report the results because of space constraint. The result is available upon request.
28 Please see their original paper for more details.

Appendix

Table 3-9 Statistical summary by continent

Continent	Variable	Mean	S.D.	N
Asia	TFP_OLS	0.015	0.024	14,667
	TFP_SF	0.600	0.095	34,347
	TFP_LP	0.032	0.049	14,667
	Net turnover	149697.300	1025113.000	34,347
	Invest total	23201.910	124191.900	21,402
	Labor	4.600	1.591	34,347
	Output	8.998	1.985	34,347
	Capital	8.062	2.244	34,347
	Investment	6.788	2.271	16,254
Europe	TFP_OLS	0.014	0.018	1,412
	TFP_SF	0.624	0.091	4,539
	TFP_LP	0.039	0.054	1,412
	Net turnover	198516.300	1102810.000	4,539
	Invest total	33042.240	217019.700	2,923
	Labor	4.223	1.611	4,539
	Output	8.925	2.218	4,539
	Capital	7.358	2.685	4,539
	Investment	6.394	2.513	2,281
North America	TFP_OLS	0.011	0.013	486
	TFP_SF	0.608	0.098	1,712
	TFP_LP	0.038	0.055	486
	Net turnover	100671.800	311122.700	1,712
	Invest total	14796.780	66136.600	1,070
	Labor	4.142	1.482	1,712
	Output	8.618	2.067	1,712
	Capital	7.218	2.466	1,712
	Investment	6.231	2.319	810

Note: Output, capital and investment amount are deflated by GDP deflator.

Table 3-10 Two-sample t test on coefficient of spillover variables by continent

Spillover variable	Europe & North America	Asia & Europe	Asia & North America
Vertical Asia	Different	Different	Different
Vertical Europe	Different	Different	Different
Vertical North American	Different	Different	Not Different
Horizontal total	Different	Different	Different

Note: For all results with "different" conclusion, $p < 0.01$.

Table 3-11 Statistical summary on spillover variables

Variable	Mean	S.D.	Obs.
Vertical_Asia	0.169	0.092	1369286
Vertical_Europe	0.044	0.018	1369286
Vertical_NorthAmerica	0.007	0.004	1369286
Vertical_ASEAN	0.039	0.023	1369286
Vertical_EastAsia	0.073	0.043	1369286
Vertical_Japan	0.054	0.042	1369286
Vertical_NonJa_Asia	0.115	0.060	1369286
Herfindal	1.591	0.231	1369267
Horizontal_total	0.144	0.178	1369267
Horizontal_Asia	0.103	0.143	1369267
Horizontal_Europe	0.029	0.065	1369267
Horizontal_NorthAmerica	0.005	0.009	1369267
Horizontal_ASEAN	0.029	0.044	1369267
Horizontal_EastAsia	0.049	0.093	1369267
Horizontal_Japan	0.024	0.057	1369267
Horizontal_NonJapan_Asia	0.079	0.114	1369267

Source: Annual Enterprise Survey, GSO Vietnam (2002–2011).

CHAPTER FOUR

Productivity, capital intensity and ISO14001 adoption

Theory and Evidence from Vietnam

1. Introduction

Due to a rising awareness of environmental protection, there has been increasing literature to study the determinants of ISO14001, a voluntary environmental management program. Research on external factors indicates that pressure from environmentally conscious customers plays an important role in firms' adoption of ISO14001 (Nishitani, 2010). Whereas internal determinants such as firm size, the status of having a quality management system, and market scope of the industry that the firm belongs to are shown to be important factors (Arimura et al., 2008; 2011; Nakamura et al., 2001; Welch et al., 2002).

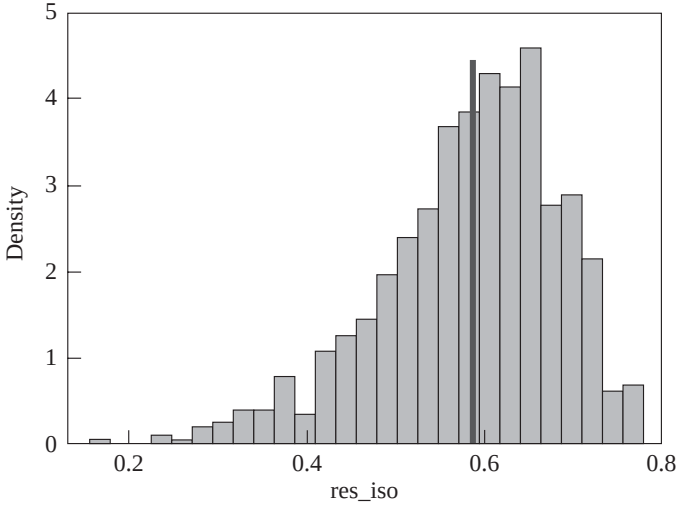
Nevertheless, all these studies try to locate the determinants of ISO14001 adoption from a relatively objective perspective. From the point view of the firms themselves, what are the systematic incentives for them to incur substantial cost on adopting this standard when it is voluntary rather than compulsory? What is the starting point at which firms begin to think about the adoption? It is natural to assume that when firms are struggling technologically, they usually cannot afford to spend extra money on self-regulated environmental activities. In other words, firms with technology advancement will be more likely to engage in environmental protection activities. In fact, recent studies by Levinson (2009), Shapiro and Walker (2015) have shown a negative relationship between firms' productivity (technology) and pollution in-

tensity in the U.S.A.

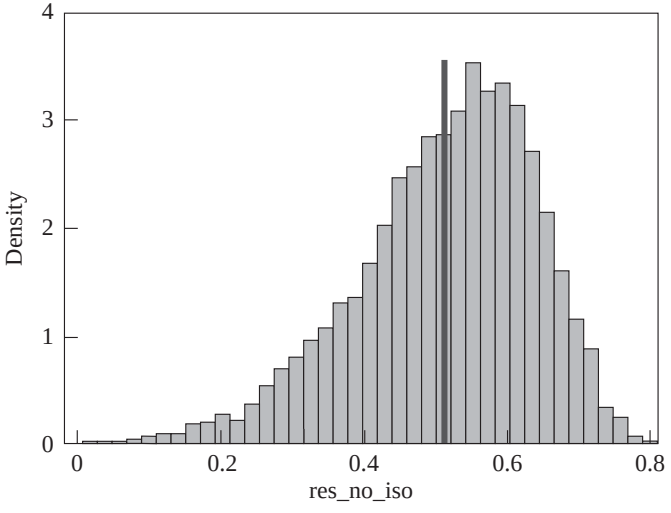
Following this logic, we pay special attention to the relationship between firms' initial technology level and their participation rate in the voluntary environmental program. Drawn from the firm-level survey data in Vietnam, Figure 4-1 indicates the difference in total factor productivity (TFP) for different groups of companies prior to ISO14001 adoption. As we can see, the average TFP for ISO14001 adopted firms is higher than that for non-ISO14001 adopted ones. Consistent with previous studies, it occurs to us that the heterogeneity in TFP tends to be an important decisive factor for firms to adopt the standard.

On the other hand, factor endowment hypothesis, brought forward by Copeland and Taylor (2004), presents another interesting theory that describes the relationship between factor intensity and pollution behavior in the context of international trade.[1] However, research on the direct relationship between a firm's factor intensity (we focus on capital intensity in this research) and its decision to engage in environmental protection, is very scarce. Some of the existing studies mention the positive correlation between capital intensity and pollution (Mani and Wheeler, 1997), however none has taken a step further to investigate how capital intensity matters for firms' commitment to environmental protection. Our interest thus lies in the question that, under the same pollution level, will capital-intensive firms have higher or lower incentive to participate in environmental protection programs voluntarily?

As seen from Figure 4-2, we use the real data to present the relationship between ISO14001 adoption and firms' capital intensity level. The upper figure shows the trend during the period 2007–2009, when information was available. Y axis indicates the adoption rate, defined as the ratio of the number of ISO14001-adopted firms to the total number of firms in Vietnam. Whereas X axis is scaled by the quartile level of a firm's capital intensity, which is defined as capital/labor ratio. A clearly positive relationship can be seen between the two variables of interest. Meanwhile, in the lower figure, despite some variation among different years, we can still observe that ISO14001 adoption rate is increasing in the level of capital intensity within the same year. It seems to signal that ISO14001 adopters are endowed with higher capital intensity. Starting from the above phenomenon, we would like to apply a more rigorous



(a) Pre-TFP for ISO14001-adopted firms

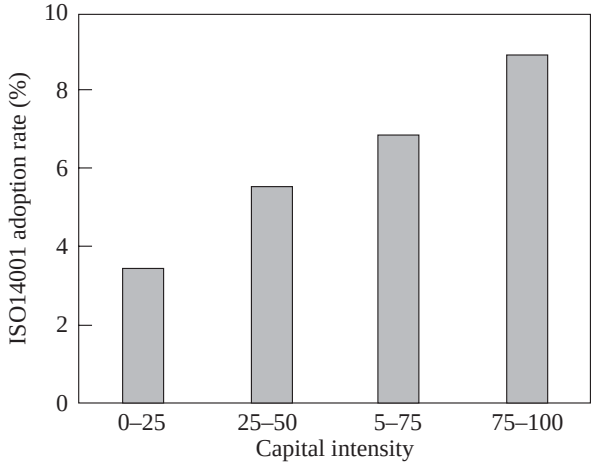


(b) Pre-TFP for non-ISO14001-adopted firms

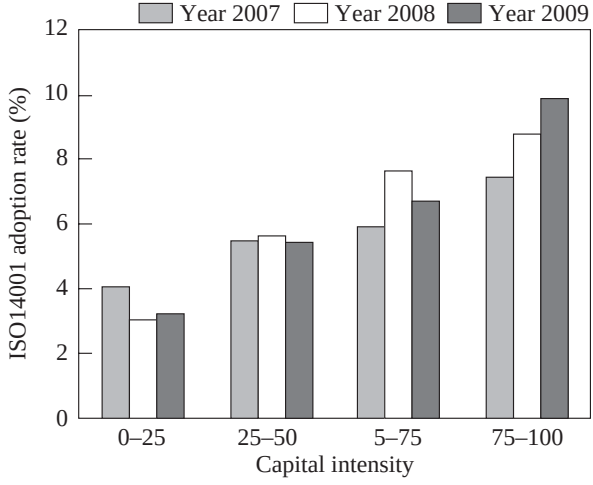
Figure 4-1 The difference in firms'TFP in Vietnam

Source: Annual Enterprise Survey, GSO Vietnam (2007–2009).

Note: TFP is calculated using Stochastic Frontier Method.



(a) Year 2007–2009 in total



(b) Each year

Figure 4-2 Correlation between ISO14001 adoption rate and capital intensity

Source: Annual Enterprise Survey, GSO Vietnam (2007–2009).

method to verify this correlation.

To answer these questions and make clear the interrelationship among firms' productivity, capital intensity and their adoption of ISO14001, we employ an analytical general equilibrium model. Driven by the stylized fact as in Figure 4-1, we put an additional assumption on firms' heterogeneity, which is modeled by their different productivities. Each firm draws a unique productivity level, which leads them to differ in their equilibrium price markup and expected total profits. Meanwhile, the equilibrium productivity level will affect the capital intensity of a firm,[2] and ultimately affects the firm's decision of adopting ISO14001. We then apply the model to the data. Relying upon the detailed firm-level data taken from the annual enterprise survey in General Statistics Office in Vietnam, we find that productive firms and capital-intensive firms have higher incentives to adopt ISO14001, which is consistent with the predictions from our theoretical model. Other control variables, such as firm size and foreign capital share, also play significant roles in shaping the decision on ISO14001 adoption. In the subgroup estimation, we find that the influence of productivity and capital intensity becomes stronger for manufacturing firms to adopt ISO14001 than for non-manufacturing ones. Whereas the impact of foreign capital share turns out to be insignificant for non-manufacturing firms to make the decision.

Our research contributes to existing literature in several ways. First, the theoretical model weaves together the factors from industrial organizations and environmental economics, using the framework of international trade literature. To the best of our knowledge, it is a pioneer of its kind. Second, we concentrated on analyzing the role of the productivity and capital intensity in shaping a firm's decision-making of ISO14001 adoption. This is one of the few studies that attempts to clarify the mechanism behind firms' participation in a voluntary environmental program. Third, there has been no research to study the determinants of ISO14001 in the context of Vietnam. We aim to fill in this blank by making use of the firm-level information in Vietnam.

The chapter is organized as follows: in the next section we talk briefly about the ISO14001 and why it is important to be concerned about environmental protection in the context of Vietnam. Literature review comes after. In section 2.4 we apply a theoretical model to show how

firms' decisions are made. In section 2.5 we describe the data and estimation strategy, followed by a robustness check and findings. The final section concludes.

2. Background

2.1 About ISO14001

The International Organization for Standardization (ISO) was founded in 1946, which currently has 162 member countries,[3] each representing a country. It is the most prominent developer of standards in the world. In the 1980s, ISO introduced ISO9000 standards for quality manufacturing practices. Building upon this system, ISO set up ISO14001 environmental standards in 1996.[4] According to the definition by ISO, this standard enables firms to adopt the policy following legal requirements and provides them with updated environmental information. In other words, it forces the organizations to raise self-awareness of maintaining an effective environmental system and thus contributing to a healthy environment. The benefits of ISO14001 include, but are not limited to: reduced cost of waste management and distribution; savings in consumption of energy and materials; improved corporate image among regulators, customers and the public (ISO Homepage). Despite all the merits, ISO14001 does not come for free. Due to complicated application procedures, the standard practice is to entrust an ISO-accredited third party with all the evaluations and paperwork. According to Jiang and Bansal (2003), the initial consulting fee usually ranges from 24,000 to 128,000 USD. Additional costs will include training expenses, application fee, auditing fee, etc. Although the total cost varies from country to country, it can become quite a burden, especially for small and medium sized firms. Thus, firms need to weigh the benefits against the expenditure discreetly before making the decision to adopt.

2.2 Why is the issue important in Vietnam?

The pollution level in Vietnam is highly proportionate to its economic growth that depends on fast industrialization. From Figure 4-3, we can see that the total pollution in Vietnam has risen by nearly 150 percent

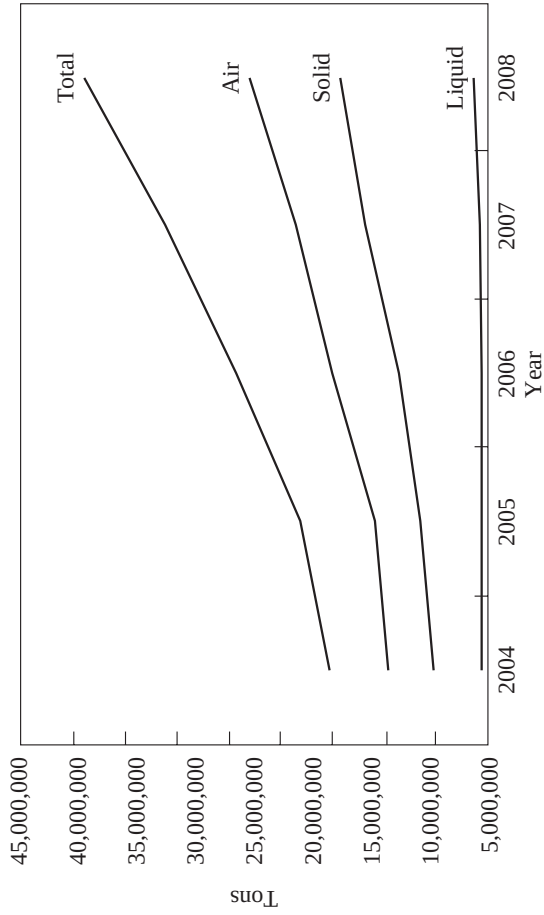


Figure 4-3 Pollution level in Vietnam (tons)
Source: GSO, Vietnam and World Bank IPPS.

over five years (2004–2008). Taking a further look, we find that most of the increase comes from air and solid waste, and most of the discharge comes from industrial activities. Take air pollution, for example, nearly half of nitrogen dioxide (NO_2) emission is due to industrial development. When it comes to sulfur dioxide (SO_2), the manufacturing industry turns out to be the major source (Vietnam: Air Quality Profile 2010). These two kinds of pollutants are detrimental to both human health and the environment.

Pollution in Vietnam is on the verge of eruption and urgent solutions are sought to prevent the situation from becoming worse. By investigating and determining the most important factors that affect firms' engagement in ISO14001, an international standard proved to be effective in curbing the pollution behavior of firms (Arimura et al., 2008; 2011; 2014), we can expect to gain some inspiration that would help raise the corporate awareness of environmental protection in Vietnam.

3. Literature review

There have been quite a few of studies to investigate the determinants of ISO14001 adoption, mainly from two perspectives: external and internal. External factors are usually derived from the demand side, such as pressure from stakeholders, customers and government, or societies' environmental preference. Signaling theory, by Potoski and Prakash (2005), states that firms are joining voluntary environmental management programs to show their capability of dealing with environmental pollution. Representative empirical studies all indicate a positive relationship between foreign stakeholders and firms' earlier adoption of ISO14001. Chiristmann and Taylor (2001) with Chinese firm data, Wu et al. (2007) with Taiwanese manufacturing firm data, Arimura et al. (2008) and Nishitani (2009) with Japanese firm data all verify this finding. On the other hand, in terms of environmental preference, Nishitani (2010) used a sample of 155 countries over eight years to show that customers in environmentally conscious markets are more likely to influence suppliers to adopt ISO14001.

Internal factors refer to firms' internal competence, which can also

promote firms' engagement in environmental protection. Arimura et al. (2008; 2011), Nakamura et al. (2001), Welch et al. (2002) reached a unanimous conclusion that the size of the firm, whether or not firms have quality management systems, and knowledge of the wider market scope of the industry where the firms are located, are all important determinants that are associated with the firms' capability. In addition, foreign ownership is found to have a positive connection with energy efficiency (Eskeland and Harrison, 2003; He, 2006; Wang and Jin, 2007). This is interpreted by the advanced waste-processing technology adopted by foreign firms and their higher awareness to achieve corporate social responsibilities (Lyon and Maxwell, 2008). Recent studies, such as Tambunlertchai et al. (2013) and Arimura et al. (2014), used Thai and Malaysian firm data respectively to show that foreign direct investment (foreign-owned firm or not) is positively related with firms' adoption of ISO14001. A similar result is achieved (Potoski and Prakash, 2006) at the macro-level verification. On the other hand, capital- intensive industries are relatively pollution-intensive, thus firms in such industries are faced with more scrutiny from their customers and the local government (Mani and Wheeler, 1997; Gallagher, 1999). Acquiring ISO14001 might help signal pollution-intensive firms' environmental capability and maintain their company image.

However, few studies have attempted to elaborate on the real source of incentive for firms to rush to this standard in spite of its high cost. Levinson (2009) used data in the U.S.A. to show that most firms' improvement in environmental protection activities comes with technological progress. While Copeland and Taylor (2003) verified that firms with more advanced technology tend to engage in more environment-friendly activities. Evidence seems to point in the direction that the difference of technology (or firm's productivity) is the key to the variation in firms' behaviors. Taking advantage of the voluntary nature of ISO14001 adoption, we want to make clear what is behind the scene.

The first of its kind, this research is positioned to study the real determinants of firms' strategic decision to participate in this voluntary environmental program. We will start with an analytical general equilibrium model which can lead to our estimable predictions.

4. Theoretical model

4.1 General setting

In this section we outline a simple model of firms that produce differentiated goods and are faced with the choice of adopting ISO14001 while realizing the costly nature of this environmental standard. The basic settings are analogous to the standard models in literature of international trade, such as Melitz (2003), Bernard et al. (2007), Bernard et al. (2010; 2011) (BRS hereafter), but differ in that firms have new alternatives: apply or not apply for ISO14001. In contrast to the single-factor endowment setting in these studies, we assume there are two kinds of input used for production to rationalize our empirical prediction. Since our purpose is to introduce a simple and practical model that can lead to data analysis, we try to simplify several assumptions. For example, we ignore the product heterogeneity and firms' trade status, since such information is not available in the actual dataset. Our model can be extended to the open economy case if trade information is to be included.

4.2 Endowments and preference

Consumers with identical preferences try to maximize their utility by consumption over a continuum of differentiated products $i \in [0,1]$:

$$U = [\int_0^1 (C_i)^\rho di]^{\frac{1}{\rho}}, \; 0 < \rho < 1 \tag{4.1}$$

where $\sigma = 1 / (1 - \rho)$ is the constant elasticity of substitution (CES) across products.

In accordance with the domestic-export decision-making literature that emphasizes firms' heterogeneity in ability, we assume that firms differ in their productivity. In a monopolistic competitive market with free entry and exit, a firm draws its productivity φ randomly from a pareto distribution $g(\varphi)$ upon paying the fixed cost (sunk) f_e to start production regardless of its ownership (foreign or domestic). For simplicity, we think of φ as firm-specific and constant across industries. Meanwhile,

a firm has the right to acquire the environmental standard ISO14001 by paying a larger cost which is proportionate to its total production cost, i.e. it is the linear combination of the fixed consulting cost f_x which includes the consulting fee and application fee, and the unit cost of the input. We can also regard the extra expense as the preparation fee used on additional personnel and capital to apply for the standard. To cover the extra expenditure, ready-to-adopt firms have the incentive to raise the price of the product. And, since ISO14001-adopting firms spend more efforts on improving the "corporate image" of the products, they are justified to set the new price as p_x^* (where $p_x^* = \tau \bullet p_x$, p_x is the price of the same product before the firm with same productivity applies for ISO14001).[5] We model the extra cost in such a manner that it can be comparable to the iceberg transportation cost used in international trade. Thus, if the productivity draw φ_x is large enough, so that the firm has enough capacity to cover the extra cost used for ISO14001 acquirement and still make profit, the firm will have more incentive to adopt ISO14001 actively.

To take into account capital intensity, we need to deviate from existing literature that focuses on labor input only. Firms use two kinds of factors for manufacturing: labor and capital input. Following BRS, we assume that their supply is inelastic. The unit price for each factor input are w and r, whereas w stands for wage rate and r represents rental rate. Based on the modeling method used in Ma et al. (2014), we assume the total cost of the firm is:

$$TC_e = \left[f_e + \frac{q_e}{\varphi_e} \right] w^{1-s} r^s \tag{4.2}$$

For simplicity, we omit the superscript for the firm. We choose w as the numeraire ($w = 1$). s indicates the capital intensity and we will consider two cases. In the first case, we do not impose any assumption on s and regard it as exogeneous. The second case is that we assume s is increasing in a firm's productivity. Since $\varphi_x > \varphi_e$, $s(\varphi_x) > s(\varphi_e)$ and the inequality still holds in equilibrium. We will discuss the scenario in the first case and come back to the second one. The profits for a firm to produce with or without ISO14001 respectively are:

$$\pi_e = p_e q_e - r^s \left(f_e + \frac{q_e}{\varphi_e} \right) \tag{4.3}$$

$$\pi_x = p_x q_x - r^s \left(f_x + \frac{q_x}{\varphi_x} \right) \tag{4.4}$$

Firm profit maximization helps us derive the optimal price setting in the status before and after acquiring ISO14001: $p_e = \frac{r^s}{\rho \varphi_e}$ and $p_x = \frac{\tau r^s}{\rho \varphi_x}$. Thus, the cutoff productivity π_e^* (before acquiring ISO14001), above which the firm keeps producing, is determined by the zero-profit condition:

$$\pi_e^* = \left(\frac{r^s}{\rho \varphi_e^*} \right)^{1-\sigma} P^{\sigma-1} \frac{R}{\sigma} - r^s f_e = 0 \tag{4.5}$$

where R is the total expenditure used for production and P is the aggregated price index of p_e. In the same way, we can derive the cutoff productivity π_x^* above which the firm chooses to adopt ISO14001 and continues producing:

$$\pi_x^* = \frac{r^s}{\varphi_x^*} \left(\frac{\tau}{\rho} - 1 \right) R \left(\frac{\tau r^s}{\rho \varphi_x^*} \right)^{-\sigma} P^{\sigma-1} - r^s f_x = 0 \tag{4.6}$$

4.3 Equilibrium conditions

In equilibrium, we can derive the cutoff value φ_e^* and φ_x^*, and the relationship between the two can be expressed as:

$$\varphi_x^* = \Lambda \varphi_e^*, \ \Lambda = \rho \bullet \left(\frac{f_x}{\sigma f_e \left(\frac{\tau}{\rho} - 1 \right) \left(\frac{\tau}{\rho} \right)^{-\sigma}} \right)^{\frac{1}{\sigma - 1}} \tag{4.7}$$

Apart from the zero-profit condition, the free entry condition should also be cleared. In other words,

$$f_e = [1 - G(\varphi_e^*)], \frac{\bar{\pi}_e + \bar{\pi}_x}{\delta} = 0 \tag{4.8}$$

where $G(\varphi)$ is the cumulative distribution function of $g(\varphi)$, and δ is the surviving rate. For the convenience of calculation, we assume that it takes a specific form such that $G(\varphi) = 1 - (\frac{\varphi_0}{\varphi})^k$, and $k > 1$. This is a standard function form of Pareto Distribution. $\bar{\pi}_e$ and $\bar{\pi}_x$ each stands for the expected average profit of a firm, conditional on the status before and after adopting ISO14001. Because of the law of large number, $\bar{\pi}_e$ and $\bar{\pi}_x$ can be represented as the function of φ_e^* and φ_x^* respectively.[6] Thus, we can solve two unknowns with two equations (4.7) and (4.8), and the difference is:

$$\bar{\pi}_x - \bar{\pi}_e = r^s \left[F(\varphi_x^*) - F(\varphi_e^*)\right] \tag{4.9}$$

where $F(\bullet)$ is the expected average profit excluding the factor of r^s in equilibrium. From the assumed function form of equations (4.7) and (4.8), we can derive $F(\bullet)$ as an monotonically increasing function in φ_i^*, $i \in \{e, x\}$, because $\sigma - 1 > 0$. For a firm to apply for ISO14001, given the higher fixed cost, it is reasonable to expect that $\bar{\pi}_x > \bar{\pi}_e$, thus $F(\varphi_x^*) > F(\varphi_e^*)$. Together with the increasing nature of $F(\bullet)$, we can conclude that $\varphi_x^* > \varphi_e^*$. In other words, it is the difference in the expected equilibrium productivity under a different status (non-adopted and adopted) that leads to firms' incentive to acquire the standard.[7]

On the other hand, when the impact of productivity gap is excluded and ceteris paribus, the difference between $\bar{\pi}_x$ and $\bar{\pi}_e$ solely depends on r^s. Since we have defined w as 1 and capital input is basically more costly than labor input, we can assume that $r > 1$. As s increases, the expected profit gain after the adoption of ISO14001 will be enlarged, this gives the firm more incentive to apply for this standard. Based on the above arguments, we give the following proposition, which will be verified in the empirical estimation section.

Proposition 1: In a closed economy, holding other characteristics unchanged, higher productivity will increase a firm's willingness to adopted ISO14001.[8] In the meantime, the more a firm is capital intensive, the more likely it is to adopt ISO14001.

4.4 Other control variables

Although not the key focus of this research, we would like to discuss briefly how to model other factors that might affect a decision to adopt ISO14001. We have mentioned in an earlier section that foreign-owned firms care more about their corporation social responsibility because the effort towards environmental protection will in fact affect the company image. Empirical evidence can be found in Prakash and Potoski (2011).[9] In the meantime, foreign-owned firms are faced with more scrutiny from foreign shareholders who have a higher preference of "green" products (Bui and Kapon, 2012). Therefore, the more foreign capital a firm has, the more cost it is willing to spend on environment-friendly activities, including ISO14001 adoption. Apart from that, the size of the firm and the waste management department might also matter.

In the previous section, we have assumed that τ is exogenous. Suppose τ in fact consists of the potential determinants outlines above, and an unobserved term. From equation (4.7) and derivation in Appendix A-3, we know that:

$$\varphi_x^* = \varphi_e^* \frac{r_s(\varphi_e^*)}{r_s(\varphi_x^*)} \bullet \rho \bullet \left(\frac{f_x}{\sigma f_e \left(\frac{\tau}{\rho} - 1 \right) \left(\frac{\tau}{\rho} \right)^{-\sigma}} \right)^{\frac{1}{\sigma - 1}}$$

Using some algebra and $\frac{\varphi_e^*}{\varphi_x}$ can be approximately expressed as:

$$\frac{\varphi_e^*}{\varphi_x} = r^{s(\varphi_x^*) - s(\varphi_e^*)} \bullet \kappa \bullet \tau \ (\textit{FDI share}, \textit{firm size}, \textit{waste management}, \textit{unobserved})$$

where $\kappa = F(\rho, \sigma, f_e, f_x)$ and is constant. Since the probability of adopting ISO14001 is $\left(\frac{\varphi_e^*}{\varphi_x}\right)^k = \left(r^{s(\varphi_x^*) - s(\varphi_e^*)} \bullet \kappa \bullet \tau\right)^k$, we take logarithms on both sides and come up with the expression which leads to our emipirical estimation:

$$\begin{aligned} ln \frac{\varphi_e^*}{\varphi_x} &= ln\kappa + \beta_1 \bullet lnr^{s(\varphi_x^*) - s(\varphi_e^*)} + \beta_2 \bullet ln(FDI) \\ &+ \beta_3 \bullet ln(\textit{firm size}) + \beta_4 \bullet ln(\textit{waste management}) + \varepsilon \end{aligned} \tag{4.10}$$

where the last term is the unobserved firm characteristics that might affect a firm's decision of ISO14001 adoption. In the next section, we will use matched data from Vietnam to estimate equation (4.10). β_1 and β_2 are of our research interest. β_1 is expected to have a positive sign, and the signs of $\beta_2 - \beta_4$ are to be determined via empirical tool.

5. Estimation strategy and data

5.1 Data

This research uses a panel dataset, constructed from the Vietnam Enterprise Survey at firm-level. The data was collected by the General Statistics Office of Vietnam for all sectors and industries on March 1st annually. It covers all 22 manufacturing sectors out of the total 42. Since most ISO14001 adopters are concentrated in manufacturing industries (81 %), we will limit our analysis to manufacturing firms only. Company characteristics such as ownership, labor, capital stock, turnover, assets, FDI share, average wage rate, intermediate materials are also available. Apart from the above, GSO has taken a census of all multinational enterprises (MNEs), which are defined as firms that have foreign capital, regardless of the share. The advantage is that investment behavior of these foreign capitalized firms can be captured over time. Census is also taken for firms with more than 10 employees. Each firm has an exclusive enterprise code. We use it together with a province code to identify the firms.

Another uniqueness of this dataset is that it collects information on firms' engagement in environmental protection, including the cost spent on environmental protection, whether the firm carries out an environmental management system, whether it follows the clean manufacturing process, etc., and above all, whether the firm has ISO14001 certification is recorded. Since it is a relatively objective criterion that is free of measurement error, we use it to create our ISO adoption dummy. Unfortunately, the ISO information is only accessible from 2007 to 2009, so we have to limit our analysis to this time period.

There are also some limitations concerning the data; for instance, the incomplete information about export and import, missing data for

materials and other variables, inconformity of units among different years, etc. As a result, we have to deal with unbalanced panel data here. We remove the missing observations, and delete outliers. After these arrangements, the total number of observations for estimation is 28274 over three years.

In practice, we will replace capital intensity and foreign capital share with their one period lag respectively to alleviate reverse causality concern. We will change the specifications to see how robust it is.

5.2 Baseline estimation and results

The dependent variable is a binary choice. Thus, in the baseline estimation we apply the random-effect panel Logit or Probit, and model a firm's decision making of ISO14001 adoption as the conditional mean of the firms' observed idiosyncratic characteristics. In practice, to alleviate the reverse causality concern, we replace the variables of interest with their one period lags.

In the first two columns of Table 4-2, we would like to verify the sole influence of a firm's productivity on its decision making, as predicted in the first part of Proposition 1. Since we do not have enough information on the intermediate goods, Levinsohn and Petrin style TFP cannot be fully applied. As an alternative, we adopt the stochastic frontier method. See the details in Lovell and Kumbhakar (2000). We only include year dummy, industry dummy and waste department dummy as control variables. In either specification, TFP is positive and strongly significant. Though the coefficient varies between models, the robustness provides sufficient evidence that it is one of the most important determinants for a firm to adopt ISO14001.

We show the results of estimating equation (4.10) in columns (3) and (4). While productivity maintains its significancy, *foreign capital share*, *total employment*, *waste department dummy* and *capital labor ratio*, are all statistically significant at the 1 % level. The estimated coefficient of *foreign capital share* is positive, which means that firms with foreign capital actively adopt ISO14001. The positive sign of *total employment* indicates that the larger a firm is, the more likely it is to adopt ISO14001. One explanation might be that larger firms have more capacity to par-

Table 4-1 Statistical summary

Variable	N	Mean	S.D.	Min.	Max.	Definition
Liquid	28274	19.95423	26.67161	0	100	Treated liquid waste/total liquid waste (%)
Solid	28274	23.00456	24.83821	0	99.90	Treated solid waste/total solid waste (%)
Total_employment	28274	236.2577	873.1979	1	61297	Number of employees at the beginning of the year (Person)
ISO14001	28274	0.058216	0.2341556	0	1	Whether the firm has ISO14001
FDI_capital_share	28274	17.57954	37.33238	0	100	Foreign capital/total capital (%)
Capital_labor_ratio	28274	167.0986	1096.249	0	98623.28	The ratio of capital/total employment
Profit before tax	28274	6271.221	80387.85	–862949	6512972	The profit before tax for the main business (Mill. Dongs)
Food_manufacturing dummy	28274	0.1333734	0.3399839	0	1	If the firm is in the food-manufacturing industry, it takes 1
Manufacturing dummy	28274	0.5108934	0.4998902	0	1	If the firm is in the food-excluded-manufacturing industry, it takes 1
Totalcost_environment	28274	1199.974	120352.4	0	20100000	Total costs for environmental protection (Mill. Dongs)
Waste_department dummy	28255	0.2725535	0.4452809	0	1	Whether the firm has environmental protection department
Environmental_system	28268	0.2772747	0.4476612	0	1	Whether the firm carries out environmental management system
Environmental_standard	28265	0.2619848	0.4397222	0	1	Whether the firm meets requirements of environmental standard

Source: General Statistics Office, Vietnam.

ticipate in such voluntary programs. In accordance with our theoretical prediction, *capital labor ratio* is positive, implying that capital-intensive firms have more incentive to adopt ISO14001.

5.3 Robustness check and further issues

5.3.1 Robustness check

Another factor that needs to be taken into account is the cost of ISO14001 adoption with respect to the overall revenue of the firm. However, due to data availability, we do not have the direct measurement of this term. Instead, we can control the profitability of a firm, since it is in proportion to the firm's capability to engage in an extra voluntary program other than its main business activities. We add "profit before tax from business" to equation (4.10) for confirmation, and this does not change the final results, as shown in columns (5) and (6) of Table 4-2.

We make additional efforts to test the robustness of other control variables as well. Apart from applying *waste department dummy* as the determinant of ISO14001 adoption, we use *total cost environmental* and *environmental system* as proxies alternatively. Furthermore, to disentangle the potential impact that the existing pollution level might have on firms' willingness to apply, we include the amount of liquid and solid waste discharge as additional control variables. Such practice does not change the qualitative results concerning the roles that capital intensity and foreign capital share of a firm play.

Furthermore, though reverse causality is considered in the baseline estimation, another source of endogeneity might arise: the sample selection. It is natural to assume that firms with higher productivity (or capital intensity) might select to adopt ISO14001 to gain further profits, and the selection bias will affect an estimation of the coefficients of the variables. To alleviate the bias, we adopt the "ivprobit" model. The instrument needs to be correlated with the variables of interest, i.e. productivity and capital intensity, but does not affect the decision of ISO14001 adoption. In practice, we use two instrumental variables (IVs). The one for the productivity is "the number of workers whose education levels are equal to or above college." Since education is usually related to technology advancement, this measurement is quite likely to affect a firm's

Table 4-2 Baseline estimation results

Model	(1) Logit ISO14001	(2) Probit ISO14001	(3) Logit ISO14001	(4) Probit ISO14001	(5) Logit ISO14001	(6) Probit ISO14001
Dependent variable	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy
Lag (profit before tax)					0.317***	0.177***
					(0.0546)	(0.0307)
Lag (TFP)	7.450***	4.094***	6.102***	3.338***	3.060***	1.676***
	(0.892)	(0.493)	(0.875)	(0.485)	(1.146)	(0.638)
Lag (FDI share)			0.00793***	0.00438***	0.00773***	0.00436***
			(0.00201)	(0.00112)	(0.00243)	(0.00137)
Total no. of workers			0.000467***	0.000262***	0.000293***	0.000167***
			(6.96e-05)	(3.81e-05)	(7.16e-05)	(4.06e-05)
Lag (capital labor ratio)			0.000280***	0.000155***	0.000173*	9.75e-05*
			(9.25e-05)	(5.00e-05)	(9.09e-05)	(5.05e-05)
Manufacturing dummy	0.786***	0.430***	0.530**	0.286**	0.340	0.179
	(0.230)	(0.128)	(0.241)	(0.133)	(0.259)	(0.144)
Food industry dummy	0.243	0.134	0.299	0.162	0.365	0.199
	(0.283)	(0.157)	(0.287)	(0.158)	(0.308)	(0.172)
Waste dept. dummy	2.810***	1.534***	2.556***	1.388***	2.154***	1.190***
	(0.248)	(0.117)	(0.236)	(0.115)	(0.250)	(0.136)
Observations	8,283	8,283	8,283	8,283	6,312	6,312
Number of id	5,961	5,961	5,961	5,961	4,791	4,791

Notes: Random-effects Logit and Probit models are applied. Standard errors in parentheses. Year dummies are included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The results remain the same even if we take logs for *profit before tax*, *total number of workers* and *capital labor ratio*.

productivity in general, but less possible to determine the ISO14001 acquirement. Meanwhile, to follow common practice, we choose investment as the proxy for capital stock. Thus, we use "current assets and total investment" divided by the total number of workers, to instrument capital intensity. After we use the IV model, the main findings remain unchanged. Due to space constraint, we do not present all the estimation results but they are available upon request.

5.3.2 Difference across industries

Given the fact that most firms adopting ISO14001 are in the manufacturing industry, we have reason to believe that the incentive for the firms from other industries to adopt ISO14001 can be different. We are thus motivated to confirm how the impact of the determinants of ISO14001 adoption differs across industries. Accordingly, we further divide samples by industry and conduct the estimation as in equation (4.10). The upper panel of Table 4-3 shows the results when we use the samples in the food industry only and the lower panel is for the manufacturing industry.

Productivity is positive and significant for both industries. However, the magnitude of its influence in the manufacturing industry is larger than that in the food industry, showing that technology is crucial for manufacturing firms to care more about their engagement in environmental activities. Meanwhile, when we limit the samples to the food industry, *foreign capital share* lost its significance. This indicates that foreign firms in those industries other than manufacturing might not value corporate social responsibility as much as those in the manufacturing industry. It is also likely that foreign-owned firms from manufacturing-excluded industries in Vietnam do not respond actively to the shareholders' expectation of "green products". On the other hand, *capital labor ratio* is still significant, but its marginal effect is reduced to half of the manufacturing industry. The interpretation is that, since in manufacturing sectors firms produce products that heavily rely on usage of labor, machines and tools, the costs and benefits of applying more eco-friendly inputs will be weighed in a more serious way by each firm. Consequently, capital intensity plays a relatively more important role in firms'

Table 4-3 Industry comparison

Model	(1) Logit	(2) Probit	(3) Logit	(4) Probit
Dependent variable	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy	ISO14001 Dummy
Food industry				
Lag (TFP)	5.652*** (1.124)	3.041*** (0.617)	4.785*** (1.125)	2.557*** (0.612)
Lag (FDI share)			0.00200 (0.00381)	0.00114 (0.00208)
Total No. of workers			0.000319*** (0.000117)	0.000180*** (6.47e-05)
Lag (capital labor ratio)			0.000199** (9.95e-05)	0.000109** (5.28e-05)
Waste dept. dummy	2.267*** (0.299)	1.212*** (0.159)	2.102*** (0.300)	1.118*** (0.159)
Observations	3,166	3,166	3,166	3,166
Number of id	2,333	2,333	2,333	2,333
Manufacturing industry				
Lag (TFP)	8.918*** (1.336)	4.943*** (0.727)	7.382*** (1.295)	4.089*** (0.722)
Lag (FDI share)			0.00915*** (0.00252)	0.00508*** (0.00140)
Total no. of workers			0.000529*** (9.10e-05)	0.000297*** (4.97e-05)
Lag (capital labor ratio)			0.000381** (0.000157)	0.000215** (8.57e-05)
Waste dept. dummy	3.147*** (0.381)	1.745*** (0.163)	2.886*** (0.364)	1.594*** (0.166)
Observations	5,028	5,028	5,028	5,028
Number of id	3,582	3,582	3,582	3,582

Notes: Random-effects Logit and Probit models are applied. Standard errors in parentheses. Year dummies are included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The results remain the same even if we take logs for *profit before tax*, *total number of workers* and *capital labor ratio*.

decision of ISO14001 adoption. The post-estimation likelihood-ratio test ensures the appropriateness of the model (rejection of the null).

6. Conclusion

We use the firm-level survey data from 2007–2009 in Vietnam to investigate the determinants of the adoption of ISO14001, a voluntary environmental standard. We try to uncover the mechanism of how firms form the decision of adoption. Theoretically, by employing a general equilibrium model, we show that more productive and capital intensive firms will systematically have higher incentive to adopt because of the larger expected benefits, despite a higher fixed and variable cost. In the empirical verification, a random-effects Probit (Logit) model is applied to confirm our prediction. Some robustness checks are conducted and the qualitative results remain unchanged.

Furthermore, we try to verify the differential influence that the above determinants might have on ISO14001 adoption of firms in different industries. Both productivity and capital intensity have a higher decisive impact on the ISO14001 adoption of firms from non-food manufacturing industry compared to those from other industries. In addition, the result shows that foreign capital share has a significant impact as well, particularly on firms within the manufacturing industry, which to some extent offers evidence to refute the critics of "pollution haven hypothesis."

The above findings can lead to some policy implications that are especially critical to Vietnam because the country is faced with serious pollution problems. Due to the notion that ISO14001-adopting firms generally have higher awareness of environmental protection, it is urgent that the Vietnamese government explores more efficient ways to promote all firms' engagement in voluntary environmental programs, including, but not limited to, ISO14001. Technology progress, which reduces firms' abatement cost, could pose as a solution. However, it needs to be supplemented by policies such as subsidies and tax exemption provided to domestic firms that show capability to engage in environmental protection.

Last but not least, our research can be improved in many ways. For example, it would be more practical to take into account the influence of international trade, since a firm's efforts towards adoption of an environmental standard is also associated with its export destination and degree of trading. Also, further extension can take into account industrial and regional heterogeneity.

Notes

1 The hypothesis argues that when trade liberalizes, countries that are abundant in factors used in clean industries (such as pollution-free intermediate inputs) will grow cleaner.
2 Or the capital intensity can be modeled as exogenous, depending on the functional assumption.
3 http://www.iso.org/iso/about/iso_member.htm Accessed on 2015/10/19.
4 In recent years, ISO22000 food safety standards, ISO26000 social responsibility standards, ISO36000 risk management standards, and ISO50001 energy management systems are also introduced.
5 At this moment, we assume τ is exogenous. However, it can also be modeled as an endogeneous factor which depends on firms' characteristics. Since we are focusing on the endogeneity of productivity and capital intensity, such possibility is not discussed in this research.
6 See Appendix A-1 for detailed derivation.
7 See Appendix A-2 for details.
8 As for the case when s is endogeneously determined by each value of φ, it does not change our qualitative prediction. See Appendix A-1 for detailed discussion.
9 Though their practice is from the macro perspective by exploring FDI stock's impact on the number of ISO14001 adoption in developing countries.
10 When τ approaches 1 from above, $(\frac{\tau-1}{\rho})\tau - \sigma$ will be enlarged to get close to $\frac{1}{\rho\sigma}$. In the special case when $\tau = 1$, which indicates that $f_x = f_e$, equations (4.5) and (4.6) will converge.

Appendix

A-1 Derive a firm's average profit as a function of its equilibrium productivity level φ^*

The productivity distributions for non-ISO14001-adopted and adopted firms are: $\mu_e(\varphi) = \frac{g(\varphi)}{1 - G(\varphi_e^*)}$ if $\varphi \geq \varphi_e^*$ and $\mu_x(\varphi) = \frac{g(\varphi)}{1 - G(\varphi_x^*)}$ if $\varphi \geq \varphi_x^*$. And, the average profits of a firm before and after adopting ISO14001 can be expressed as follows:

$$\bar{\pi}_e = \int_{\varphi_e^*}^{\infty} \frac{\pi_e(\varphi)\, g(\varphi)}{1 - G(\varphi_e^*)}\, d\varphi \tag{4.11}$$

$$\bar{\pi}_x = \int_{\varphi_x^*}^{\infty} \frac{\pi_x(\varphi)\, g(\varphi)}{1 - G(\varphi_x^*)}\, d\varphi \tag{4.12}$$

where we can rewrite equation (4.11) as:

$$\int_{\varphi_e^*}^{\infty} \frac{[(\rho\varphi eP)^{\sigma-1}R - r^s f_e]\, g(\varphi)}{1 - G(\varphi_e^*)}\, d\varphi \tag{4.13}$$

Let ϕ be the firm's revenue, i.e. $p * q$. Following BRS (2010), we have

$$\begin{aligned} &\frac{\phi(\varphi'')}{\phi(\varphi')} = \left(\frac{\varphi''}{\varphi'}\right)^{\sigma-1} \\ &\Rightarrow \frac{\phi_e(\varphi_x^*)}{\phi_e(\varphi_e^*)} = \left(\frac{\varphi_x^*}{\varphi_e^*}\right)^{\sigma-1} \end{aligned} \tag{4.14}$$

Substituting equation (4.14) into (4.13), we get:

$$\bar{\pi}_e = \int_{\varphi_e^*}^{\infty} \frac{[(\frac{\varphi}{\varphi_e^*})^{\sigma-1} r^s f_e - r^s f_e]\, g(\varphi)}{1 - G(\varphi_e^*)}\, d\varphi \tag{4.15}$$

The zero-profit condition indicates that $r^s f_e$ is equal to $\phi(\varphi_e^*)$, thus $\bar{\pi}_e$ can also be represented by φ_e^*'s function. In the same way, $\bar{\pi}_x$ can be written as a function of φ_x^* as well.

A-2 Numerical example to show a firm's incentive to adopt ISO14001

We focus on the general profit conditions: equations (4.5) and (4.6). After rearranging, the first terms on the right hand side of both equations become the following:

$$\frac{1}{\rho\sigma} \bullet (\varphi_e^*)^{\sigma-1}(r^s)^{1-\sigma} RP^{\sigma-1} \tag{4.16}$$

$$(\frac{\tau}{\rho} - 1)\tau^{-\sigma} \bullet (\varphi_e^*)^{\sigma-1}(r^s)^{1-\sigma} RP^{\sigma-1} \tag{4.17}$$

For simplicity, we leave out the common factor and only have to compare $\frac{1}{\rho\sigma} \bullet (\varphi_e^*)^{\sigma-1}$ with $(\frac{\tau}{\rho} - 1)\tau^{-\sigma}$. Following Balistreri et al. (2011), we let $\sigma = 3.8$, then $\rho = .74$. We further assume that $\tau < 1.1$, since, in reality, it is hard to imagine that firms are willing to pay an extra 10 % (or larger) of its total operation cost to acquire the voluntary environmental standard. Though a larger τ over 1.1 will not change our prediction.

Substituting the values into the above expressions, we get $\frac{1}{\rho\sigma} \bullet (\varphi_e^*)^{\sigma-1} \approx .356$ and $(\frac{\tau}{\rho} - 1)\tau^{-\sigma} \approx .338$. Because the profit function is increasing in φ^*, to satisfy equations (4.5) and (4.6), a larger φ_x^* will be necessary so that the value of the term in equation (4.16) surpasses that of the term in equation (4.15).[10] This lends support to the notion that, without the growth of productivity, a firm will have little chance to start considering the adoption of ISO14001.

A-3 Discussion on the case when capital intensity s is also the function of the firm's productivity φ

As shown by Yeaple (2005), Harrigan and Reshef (2012), Verhoogen (2008), productive firms are usually more capital-intensive. Thus, it is natural to make the assumption that $\frac{\partial_s}{\partial_\varphi} > 0$. Since $r > 1$, r^s is therefore a monotonically increasing function of a firm's idiosyncratic productivity. Accordingly, equation (4.7) becomes:

$$\varphi_x^* = \frac{r^s(\varphi_e^*)}{r^s(\varphi_x^*)} \bullet \Lambda\varphi_e^*, \Lambda = \rho \bullet (\frac{f_x}{\sigma f_e(\frac{\tau}{\rho} - 1)(\frac{\tau}{\rho})^{-\sigma}})^{\frac{1}{\sigma-1}}$$

From equation (4.9), we know that $\bar{\pi}_x - \bar{\pi}_e = r^s[F(\varphi_x^*) - F(\varphi_e^*)] > 0$, and since $r^{s(\varphi_x^*)} > r^{s(\varphi_e^*)}$, we will have $r^{s(\varphi_x^*)}F(\varphi_x^*) > r^{s(\varphi_e^*)}F(\varphi_e^*)$ as long as $\varphi_x^* > \varphi_e^*$. Another way to confirm firms' decision-making is to calculate the probability of ISO14001 adoption. Similar to the probability of export in Melitz (2003), a firm's willingness to adopt ISO14001 P_{ISO} can be expressed as: $\frac{1-G(\varphi_x^*)}{1-G(\varphi_e^*)}$, where φ_x^* and φ_e^* are cutoff values for ISO14001 adoption and initiating production. Given the specific function form of G, we have the following expression:

$$P_{ISO} = (\frac{\varphi_e^*}{\varphi_x^*})^k = (\frac{r^s(\varphi_x^*) - s(\varphi_e^*)}{\Lambda}), k > 1$$

Because Λ is assumed to be constant, as s increases, P_{ISO} will be enlarged as well, indicating that the capital intensity level determines a firm' propensity to adopt ISO14001.

CHAPTER FIVE

Does ISO14001 raise firms' awareness of environmental protection?

Case of Vietnam

1. Introduction

Foreign direct investment (FDI) is a considerable driving force that spurs economic growth in developing countries, especially in newly emerging economies. At the same time, rapid growth usually comes with a price, namely, pollution. In "race to the bottom" literature, critics have raised the concern that multinational firms try to shift their heavily polluting activities to countries with lax regulations, as these countries are endeavoring to remove barriers to international trade and investment. By means of a voluntary environmental standard, this study, however, provides evidence to mitigate such concern. We show that firms with foreign ownership are more likely to be engaged in acquiring an environmental standard and this will in turn benefit them as a whole.

In fact, foreign firms have been found to be more energy efficient compared to state-owned firms (Eskeland and Harrison, 2003; He, 2006). This might be due to advanced waste-processing technology adopted by foreign firms and their awareness of corporate social responsibility (Lyon and Maxwell, 2008). Other motivation may include protecting institutional reputation, appealing to "green consumers," deterring lobbying and boycotts by environmental groups, and avoiding regulatory scrutiny by local governments (Bui and Kapon, 2012). Motivated by this line of literature, we propose the following hypothesis: the more foreign firms invest in the host country, the more likely they become

self-restrained in terms of environmental protection.

To be specific, this study seeks to verify this hypothesis by evaluating firms' participation in a voluntary environmental program—ISO14001—in the context of Vietnam. ISO14001 is considered one of the most widely recognized voluntary standards for environmental management systems,[1] and is likely to be adopted spontaneously by firms.[2] Thus, the possibility of acquiring ISO14001 certification is usually positively associated with firms' willingness to be involved in environmental protection. By quantifying firms' efforts before and after joining this program, we hope to answer the following questions: are foreign firms more likely to pursue ISO14001 than their domestic counterparts are? How does ISO14001 improve firms' overall performance, especially their efforts in terms of waste control?

To answer these questions, we take an empirical approach by applying a two-stage selection model for our baseline estimation. The findings show that the adoption of ISO14001 does improve firms' overall performance and help firms become more involved in waste management, which can finally benefit themselves. This study differs from previous literature in several ways. First, this is the first study to use panel data to explore how firms' participation in voluntary programs affects pollution behavior in Vietnam, thus filling the gap in literature on developing countries. Note that Arimura et al. (2014) also investigated the determinants of ISO14001 adoption, but they used cross-sectional data, and did not consider the relationship between ISO14001 adoption and waste management behavior. Second, the measurement employed in this study is based on multiple indices, instead of just one. To mitigate the endogeneity issue, we further use both an instrumental variable method and propensity score matching to verify.[3] The results are consistent and support our aforementioned hypothesis.

Since we have discussed the pollution situation in Vietnam and why it is important to improve this issue in the previous chapter, we will jump to a more detailed analysis. A literature review will be followed by data description and estimation strategy, and the following section provides the robustness check and findings. The last section concludes.

2. Literature review

Several studies have investigated the direct relationship between FDI and pollution levels. Bao et al. (2011), Jiang et al. (2014), He (2006), and Eskeland and Harrison (2003) all reach the unanimous conclusion that FDI impacts pollution levels negatively in the host country. Taking this stylized fact a step further, we examine and make explicit the mechanism behind the phenomenon. We divide the process into two steps: (1) How FDI (or firm ownership at the micro-level) affects ISO14001 adoption; and (2) The impact of ISO14001 adoption on firms' polluting behavior.

With regard to the first step, there are two main categories of theories: convergence and divergence (Prakash and Potoski, 2007). Convergence advocates that foreign subsidiaries usually conform to global standards, rather than adapting to host country characteristics. In other words, if the subsidiaries come from a country with a high ISO14001 adoption rate, it is quite likely that these firms will also acquire certification in the host country. According to the convergence theory, foreign firms face greater scrutiny from local governments, which gives them a greater incentive to adopt ISO14001, and even to encourage their input suppliers to do so. Thus, FDI has a positive influence on firms' adoption of ISO14001 in the target country. In contrast, divergence supporters claim that foreign investors choose to locate in developing countries because they will face less stringent environmental controls, and are no longer bound by the same rules as those in their home country.[4] Empirical studies have found a positive relationship between FDI and ISO14001 adoption in Thailand (Tambunlertchai et al., 2013) and in Malaysia (Arimura et al., 2014). In this case, both studies applied firm-level data. Macro-level studies have found similar results (Potoski and Prakash, 2006). Given these contrasting theories, this study takes into account the role of FDI in firms' ISO14001 adoption preferences.

The second step focuses on the relationship between the adoption of ISO14001 and firm performance. A large body of theoretical literature has studied the connection between compulsory regulations and firms' polluting behavior, complemented by empirical evidence (e.g., Kang and Lee, 2004). However, few studies have investigated the waste reducing

impact of voluntary programs. In existing literature, the mechanism is explained in terms of a signaling effect (Potoski and Prakash, 2005), whether firms have a greater awareness of corporate social responsibility (Lyon and Maxwell, 2008), and firms' maintenance of their ISO14001 status. Despite the conflicting arguments and results, most empirical studies point to a positive relationship between participation in a voluntary program and waste reduction. Previous studies have used a single pollution measure to assess the impact of ISO14001 (Potoski and Prakash, 2005; Turk, 2009), and found that ISO14001 reduces the levels of pollution discharge. In addition, Arimura et al. (2008) verified the positive influence of ISO14001 in terms of reducing both solid and liquid waste in Japan. Furthermore, Arimura et al. (2011) found that ISO14001 improves firms' supply-chain management. In addition to ISO14001, other voluntary environmental programs encourage firms to curb pollution (Bui and Kapon, 2012; Kim and Lyon, 2011; De Jaeger et al., 2011).

Our empirical methodology is closest to that of Blackman et al. (2010), who analyzed the incentives for firms to participate in voluntary environment programs, as well as their impact on firms' behavior. We describe our estimation strategy and data in the following section.

3. Estimation strategy and data

3.1 Estimation strategy

3.1.1 Baseline specification

For empirical verification, we start with a two-step estimation procedure:

$$ISO_{ijt} = \delta_{ijt} \bullet Z_{ijt} + \alpha_i + \alpha_j + \alpha_t + u_{ijt} \tag{5.1}$$

$$Y_{ijt} = \beta_{ISO} \bullet ISO_{ijt} + \beta_i \bullet X_{ijt} + \alpha_i + \alpha_j + \alpha_t + \varepsilon_{ijt} \tag{5.2}$$

In the first stage, we estimate the propensity of firms to adopt ISO standards using a series of potential determinants. Here, ISO is a dummy variable that takes value one if firm *i* in industry *j* adopts ISO14001

at time t, and zero otherwise. This is constructed using the observed data. Z_{ijt} is a vector of determinants that lead to the adoption decision, where it includes both objective and subjective firm characteristics. The former characteristics consist of firm size (number of workers), FDI (foreign capital/total capital) and the capital-labor ratio. The latter includes answers based on firms' self-evaluations, such as whether they follow environmental regulations. We include firm, industry and year fixed effects as well. u_{ijt} is an error term. In the second stage, as in equation (2), we will regress the adoption of ISO14001 on firms' performance, while controlling for the similar set of firm characteristics and fixed effects.

We consider two sets of indicators for the dependent variable Y_{ijt}: waste discharge and non-environmental performance (turnover, average salary, and total factor productivity (TFP)). Each variable of interest is estimated separately, and year dummies and industry dummies are included in both equations.

Determining TFP requires extra effort. Since the traditional Solow residue approach is unable to isolate the true productivity from statistical noise, we choose a stochastic frontier analysis (SFA) as the main method of calculation, as in Kumbhakar and Lovell (2000). The methodology is the same as in the previous two chapters, thus we omit detailed description.

3.1.2 Self-selection problem

However, if we want to estimate the equations (5.1) and (5.2) simultaneously, the difficulty lies in the fact that the adoption of ISO14001 might not be random. It can be argued that firms with certain characteristics have a higher propensity to adopt the standard, or might "self-select" in order to acquire the standard. In that case, unobserved characteristics (known to firm owners, but not known to econometricians) that affect a firm's decision to adopt ISO14001 might also influence its performance, which can contaminate the estimation of ISO14001's impact. In other words, when $Cov(u, \varepsilon) \neq 0$, the result of the second stage estimation will be biased. For example, firms with more personnel engaged in environment-friendly activities are likely to have a better chance of reducing the waste discharge, and the costs saved can lead to higher revenue/av-

erage salary, as a whole. However, the incentives for firms to participate in these activities are usually unobservable, and not controlling for such incentives will cause an upward estimation of the coefficient of the impact of ISO14001 on a firm's performance (if the incentive is positively correlated with the adoption of ISO14001). To mitigate this estimation bias, we employ the instrumental variable (IV) method as a robustness check. The basic idea is to find a proxy that affects a firm's decision to adopt ISO14001, but does not influence the firm's performance. To be more specific, the instruments will be valid if the following two requirements are satisfied: (1) Instrument relevance: valid instruments should be correlated with the endogenous variable of interest, in this case, the ISO14001 dummy, (2) Instrument exogeneity (exclusion restriction): instruments should be uncorrelated with the error term, or there should not be any direct effect of the instruments on the dependent variable.

Concerning the first condition, usually we can rely on a weak instrument test to verify the validity of the instrument, however, the second one is relatively difficult to clear. Since firm-level characteristics can usually be considered simultaneously determined with performance variables, we resort to industry-level variables. Specifically, we apply two kinds of IVs: the ratio of firms that carry out environmental management system while excluding itself (*Emsystem* = 1 if the system is adopted) in an industry, and the ratio of firms with a waste control department while excluding itself (*Wastedept* = 1 if a firm has such department) in an industry. As for the first ratio, we divide the number of firms that already adopt an environmental management system by the total number of firms in industry j at time t. We use the two-digit industry code as the categorization standard, yielding 24 industries in total. The second IV is constructed in a similar way—the number of firms with a waste department divided by the total number of firms in industry j at time t.[5]

Take the first instrument, which we define as *ratio_emsystem*, for example, since this is an industry-level measurement of how many firms have carried out an environmental management system and usually impossible to be observed by each firm, it is hard to imagine how an individual firm's performance can be affected by this ratio. Thus, when *ratio_emsystem* is used to proxy ISO14001, $Cov(u, \varepsilon) = 0$ and β_{ISO}

in equation (5.2) will capture the sole impact of adopting ISO14001 on a firm's behavior. The same argument applies to *ratio_wastedept* as well. In practice, we conduct the analysis by applying each individual IV, and their combinations.

3.2 Data

The same firm-level data from GSO Vietnam as used in Chapter 3 and 4 are applied. The most important variable of interest—whether the firm acquires ISO14001 certification is recorded. Since these are relatively objective criteria, free from measurement error, we use them to create our ISO adoption dummy. Apart from that, detailed data on waste discharge are categorized by form (air, liquid, and solid). Air waste is defined as that caused by burning fuel and materials to operate machinery. Liquid waste refers to waste water, oil, grease, liquid chemicals, and other forms of liquid that are common byproducts during the process of manufacturing production. Finally, solid waste refers to solid substances produced during the manufacturing process that cannot be utilized or recycled into useful products for future production. Firms report both treated and untreated amounts of waste discharge. Here, "treated" refers to a purification process that ensures that the discharged waste will not damage the environment. Here, we differentiate between the amounts of treated and untreated waste in order to conduct the second-stage estimation to evaluate the impact of ISO14001.

Table 5-1 lists the variables used in the estimation. In order to account for industrial heterogeneity, we include the categories of manufacturing sectors in Table 5-2. Statistical summaries are shown in Table 5-3. The pollution variables (*Air*, *Liquid*, and *Solid*) are defined as the share of treated waste in each case. We only include firms in the sample that emit all three types of waste. We use the capital–labor ratio and the number of employees (Labor) as proxies for firm size, and turnover, total salary level, and TFP as proxies for firms' economic performance. We also use ISO14001, *Emsystem*, *Envirstandard*, *Wastedept*, *Cleanemanuf acture*, and *Cost_environ*. All data are obtained from the VSE data set. The values of firms' turnover, total salaries, and total cost for environmental protection are normalized using the manufacturing gross

Table 5-1 Definitions of variables (abbreviation used in the manuscript)

Variables	Definition
Air	Share of treated air wastes, treated air waste divided by total air waste, (%)
Liquid	Share of treated water wastes, treated liquid waste divided by total liquid waste, (%)
Solid	Share of treated solid wastes, treated solid waste divided by total solid waste, (%)
Salary	Natural logarithm of real salary
Turnover	Natural logarithm of real turnover
TFP	Total factor productivity using stochastic frontier method.
ISO14001	Does the enterprise have ISO 14001 certification? Dummy variable.
Emsystem	Does the enterprise carry out environmental management system? Dummy variable.
Environstandard	Does the enterprise meet requirements of environmental standard? Dummy variable.
Cleanmanufacture	Does the enterprise meet requirements of environmental standard? Dummy variable.
Wastedept	Does the enterprise have an organization or department of environmental protection? Dummy variable.
Cost_environ	Natural logarithm of total costs of the enterprise for environmental protection in the year.
Cap_lab	Capital labor ratio
Labor	Total number of labor
FDI	Foreign direct investment ratio, (%)

Table 5-2 Categorization of manufacturing sectors

Variables	Definition
a_mnf	Dummy variable: 1 if firm is manufacture of food products industry, manufacture of beverages industry, or manufacture of tobacco products industry; 0 otherwise.
b_mnf	Dummy variable: 1 if firm is manufacture of textiles, manufacture of wearing apparel, or manufacture of leather and related products; 0 otherwise.
c_mnf	Dummy variable: 1 if firm is manufacture of coke and refined petroleum products, manufacture of chemicals and chemical products, manufacture of pharmaceuticals, medicinal chemical and botanical products, or manufacture of rubber and plastics products; 0 otherwise.
d_mnf	Dummy variable: 1 if firm is manufacture of other non-metallic mineral products, manufacture of basic metals, manufacture of fabricated metal products, except machinery and equipment, or manufacture of other fabricated metal products; metalworking service activities; 0 otherwise.
e_mnf	Dummy variable: 1 if firm is manufacture of computer, electronic and optical products, manufacture of electrical equipment, manufacture of machinery and equipment n.e.c, manufacture of motor vehicles; trailers and semitrailers, or manufacture of other transport equipment; 0 otherwise.
f_mnf	Dummy variable: 1 if firm is manufacture of wood and products of wood and cork except furniture, manufacture of paper and paper products, printing and reproduction of recorded media, manufacture of furniture, other manufacturing, or repair and installation of machinery and equipment; 0 otherwise.

Table 5-3 Summary statistics

Variables	Obs.	Mean	S.D.	Min.	Max.
Air	3043	34.925	22.605	0	50.000
Liquid	13043	46.514	12.105	0	50.000
Solid	17420	47.776	9.772	0	50.000
Salary	202068	5.820	1.531	0.270	10.640
Turnover	202126	8.220	1.866	0.732	13.394
TFP	202126	0.485	0.143	0.000	0.727
ISO14001	22672	0.742	0.262	0	1
Emsystem	22696	0.325	0.468	0	1
Environstandard	22708	0.315	0.464	0	1
Cleanmanufacture	22762	0.403	0.491	0	1
Wastedept	22728	0.328	0.328	0	1
Cost_environ	131584	0.361	1.244	0	14.440
Cap_lab	204168	101.598	1342.982	0	527071.750
Labor	204168	79.960	464.112	1	64751
FDI	55433	15.087	35.241	0	100

domestic product (GDP) deflator obtained from the World Bank. In order to avoid the potential influence of outliers in the data, we exclude the highest 1 % of the following variables: *Air*, *Liquid*, *Solid*, *Salary*, *Turnover*, *TFP*, and *Cost_environ*.[6]

Among the 28,274 cleaned observations over three years for the estimation, we focus on the adoption of ISO14001 by manufacturing firms because, in the VSE data set, such firms constitute 85 % of those that adopt ISO14001.

4. Results

4.1 Baseline results

We employ a treatment-effects model to analyze: (1) the determinants of ISO14001 adoption, (2) the effects of ISO14001 adoption on environmental problems, such as air, water, and land pollution, and (3) firms' economic performance, such as total salaries, turnover, and productivity. The estimation results of the baseline model are summarized in Tables 5-4 and 5-5. Table 5-4 presents the estimation results of the determinants of ISO14001 adoption. The shares of FDI in the five columns other than column (1) relating to air pollution are positive and statistically significant at the 1 % level in the first stage. The share of FDI in column (1) is not statistically significant, but is still positive. These results indicate that firms with foreign capital actively adopt ISO14001. The number of laborers is positive and statistically significant at the 1 % level in the first stage. That is, firm size (*Labor*) is also a determinant of ISO14001 adoption. If total labor is positive, this indicates that the larger the firm, the more likely it is to adopt ISO14001. Since the cost of adopting ISO14001 is high, larger firms have a greater capacity to participate in such voluntary programs. Then, the capital labor ratio is always positive and statistically significant in the specifications at the 1 % level in the first stage. The capital labor ratio also plays a positive role, implying that capital-intensive firms prefer ISO14001. Because capital-intensive firms have greater technological capacity than labor-intensive firms do, they can adopt ISO14001 more easily than labor-intensive firms can because of the relatively lower cost of ISO14001 adoption.

Table 5-4 First stage results of baseline estimation using the two-stage treatment model (Determinants of ISO 14001 Certification adoption)

1st stage	(1) ISO14001	(2) ISO14001	(3) ISO14001	(4) ISO14001	(5) ISO14001	(6) ISO14001
FDI (-1)	0.00152	0.00203***	0.00206***	0.00118***	0.00138***	0.00168***
	(0.00119)	(0.0005)	(0.00005)	(0.000413)	(0.00041)	(0.000385)
Labor	0.000293***	0.000174***	0.000166***	0.000276***	0.000184***	0.000111***
	(0.00006)	(0.00002)	(0.00002)	(0.00004)	(0.00003)	(0.00001)
Environment system						
Dummy	0.917***	0.693***	0.746***	0.574***	0.561***	0.625***
	(0.135)	(0.0619)	(0.0590)	(0.0448)	(0.0447)	(0.0434)
Environment						
Standard dummy	0.459***	0.664***	0.683***	0.662***	0.655***	0.671***
	(0.106)	(0.0543)	(0.0529)	(0.0415)	(0.0415)	(0.0396)
Waste department						
Dummy	0.259**	0.401***	0.384***	0.399***	0.409***	0.401***
	(0.1197)	(0.0567)	(0.0544)	(0.0416)	(0.0416)	(0.0401)
Clean manufacture						
Standard dummy	0.252**	0.0721	0.0677	0.147***	0.139***	0.116***
	(0.1190)	(0.0556)	(0.0521)	(0.0429)	(0.0427)	(0.0406)

Cost in environmental						
Protection (log)	–0.0107 (0.0169)	0.0181** (0.00854)	0.0117 (0.00854)	–0.00511 (0.00779)	–0.00241 (0.00785)	0.0144** (0.00677)
2008 year dummy	0.104 (0.112)	0.0801 (0.0573)	0.0646 (0.0560)	0.0385 (0.0451)	0.0380 (0.0454)	0.0562 (0.0429)
2009 year dummy	–0.0158 (0.110)	0.0123 (0.0533)	0.0121 (0.0516)	–0.0405 (0.0416)	–0.00816 (0.0415)	–0.0142 (0.0395)
a_mnf	0.0945 (0.165)	0.375*** (0.0781)	0.310*** (0.0789)	0.187*** (0.0596)	0.200*** (0.0595)	0.255*** (0.0573)
b_mnf	–0.391 (0.240)	–0.106 (0.102)	–0.0691 (0.0910)	–0.0534 (0.0752)	–0.0834 (0.0728)	–0.0251 (0.0688)
c_mnf	0.183 (0.173)	0.508*** (0.0841)	0.473*** (0.0790)	0.426*** (0.0623)	0.412*** (0.0618)	0.439*** (0.0601)
d_mnf	0.265* (0.155)	0.368*** (0.0843)	0.310*** (0.0765)	0.257*** (0.0590)	0.235*** (0.0588)	0.259*** (0.0578)
e_mnf	0.463** (0.204)	0.797*** (0.0880)	0.774*** (0.0798)	0.607*** (0.0665)	0.581*** (0.0663)	0.653*** (0.0631)
Capital labor ratio	0.000180*** (0.00006)	0.000148*** (0.00004)	0.000173*** (0.00004)	0.000059 (0.000038)	0.000091** (0.000039)	0.000124*** (0.000030)
Constant	–2.790*** (0.189)	–3.051*** (0.0942)	–3.015*** (0.0836)	–2.781*** (0.0625)	–2.771*** (0.0621)	–2.842*** (0.0609)

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

Table 5-5 Second stage results of baseline estimation using the two-stage treatment model (Outcome equation)

2nd stage	(1) Share of treated air wastes	(2) Share of treated liquid wastes	(3) Share of treated solid wastes	(4) Natural logarithm of real salary	(5) Natural logarithm of real turnover	(6) TFP
FDI (-1)	0.0428**	0.00500*	0.00864***	0.00882***	0.00910**	0.000399***
	(0.0171)	(0.00302)	(0.00228)	(0.00025)	(0.00035)	(0.00002)
Labor	–0.00108	–0.000163	–2.47e-06	0.0025***	0.00137***	8.07e-06***
	(0.00101)	(0.000131)	(0.00010)	(0.00003)	(0.00003)	(1.03e-06)
2008 year						
Dummy	–5.421***	–1.481***	–0.601***	–0.0920***	0.0764**	0.00560**
	(1.333)	(0.316)	(0.223)	(0.0246)	(0.0338)	(0.00233)
2009 year						
Dummy	–2.793**	–0.280	–0.536**	–0.0106	0.147***	0.0128***
	(1.308)	(0.299)	(0.212)	(0.0230)	(0.0316)	(0.00217)
a_mnf	–4.093**	–0.759**	–0.104	–0.230***	0.215***	0.0207***
	(1.906)	(0.380)	(0.287)	(0.0297)	(0.0411)	(0.00284)
b_mnf	4.738*	–0.648	–0.264	0.124***	–0.234***	–0.0391***
	(2.802)	(0.488)	(0.323)	(0.0361)	(0.0488)	(0.00332)
c_mnf	–3.125	–0.432	–0.424	0.0414	0.425***	0.0466***
	(2.202)	(0.464)	(0.330)	(0.0359)	(0.0493)	(0.00341)
d_mnf	–13.436***	–1.626***	–2.709***	0.0363	0.0373	0.00733***
	(1.694)	(0.405)	(0.258)	(0.0284)	(0.0390)	(0.00271)
e_mnf	–8.966***	–2.465***	-0.265	0.111***	0.250***	0.0239***
	(2.817)	(0.538)	(0.357)	(0.0402)	(0.0555)	(0.00379)

Capital labor						
Ratio	0.00007 (0.00111)	0.000228 (0.000319)	–0.000157 (0.000239)	0.000177*** (0.000027)	0.000471*** (0.000042)	2.52e-05*** (2.55e-06)
ISO14001	48.335*** (4.698)	7.538*** (1.074)	0.732 (0.809)	1.981*** (0.103)	3.091*** (0.140)	0.143*** (0.00874)
Lambda	–24.927*** (2.615)	–3.891*** (0.625)	–0.355 (0.474)	–0.853*** (0.0555)	–1.369*** (0.0747)	–0.0660*** (0.00489)
Constant	38.831*** (1.674)	47.533*** (0.346)	48.960*** (0.230)	6.695*** (0.0254)	8.731*** (0.0347)	0.462*** (0.00239)
Observations	1,961	7,957	10,538	17,258	17,242	17,944

Notes: 'treatreg' model with 'two-step' option is applied. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Environmental protection variables are always positive and statistically significant in specifications at the 5 % level in the first stage. In other words, firms that: (1) utilize an environmental management system, (2) meet the requirements of environmental standards, or (3) apply or conduct a clean manufacturing process are more likely to adopt ISO14001. However, *Cost_environ* (cost spent on environmental protection) is not always statistically significant, although this might be attributable to the fact that it differs in size between firms. The VSE data set has no data on total cost during the period 2006–2009, which means we cannot use the environmental protection-cost ratio, which is the total cost to a firm for environmental protection divided by its total costs. With regard to the industry sector dummies, *a_mnf*, *c_mnf*, *d_mnf*, and *e_mnf* in five columns (except column (1)) are positive and statistically significant at the 1 % level. Here, *a_mnf* and *c_mnf* in column (1) are not statistically significant, but are still positive, while *d_mnf* and *e_mnf* in column (1) are positive and statistically significant at the 10 % and 5 % levels, respectively. These results indicate that firms in these industry sectors are likely to adopt ISO14001.

Table 5-5 presents the estimation results for the effects of ISO14001 adoption on pollution for various types of firms and economic performance. FDI (measured as the share of the foreign capital) is positive and statistically significant at the 10 % level in all specifications. This indicates that firms with foreign capital show an overall better performance. The first three columns are related to firms' waste control. ISO14001 adoption is positive and significant at the 1 % level in columns (1) and (2) with regard to pollution type. ISO14001 adoption in column (3), relating to share of treated solid waste, is not statistically significant, but is positive. These results show that, in general, ISO14001 adoption increases the share of treated air, water, and solid waste, thus mitigating the pollution in air, liquid, and solid waste. This provides evidence that once firms acquire this environmental certificate, they tend to control a wide range of their polluting behavior, possibly because their adoption of the environmental certificate induces their awareness of environmental protection.

Columns (4), (5), and (6) present the effects of ISO14001 adoption on a firm's economic performance. ISO14001 adoption is positive and

significant at the 1 % level in all three columns, showing that ISO14001 adoption improves a firm's economic performance. The positive economic impact of ISO14001 accreditation on a firm's total salaries (log), turnover (log), and TFP can improve its economic performance through several channels. For example, the cost of managing waste is reduced, which frees up more resources (capital and labor) to allocate to other productive uses. Thus, firms' commitment to social responsibility can lead to a win-win situation.

4.2 Robustness checks

4.2.1 Instrumental variable method

The results using the first IV—ratio of the firms that have environmental management system (*ratio_emsystem*) only are presented in Table 5-6. In the first stage, the excludable variable *ratio_emsystem* is strongly significant and positive, whereas the other control variables (*FDI*, *Capital labor ratio* and *Labor*) are all positively significant. In the second stage, the coefficient of ISO14001 is positive and significant when the dependent variable is salary, turnover, productivity or liquid waste, however, the coefficient changes sign when we focus on solid waste. The result of a Stock-Yogo weak instrument test shows that *ratio_emsystem* serves as a good instrument, except in the case of air and liquid waste. When we put the above findings together, it indicates that the adoption of ISO14001 in general has a strong and positive impact on a firm's overall performance. When it comes to waste control, ISO14001's impact on improvement is limited to the share of treated air and liquid waste. Similar conclusions can be drawn on the other control variables, such as *FDI*. The sign of *FDI* is also positive and significant in the cases of firm performance, which is in accordance with the results in the baseline estimation. This shows that firms with a higher foreign share are more likely to adopt the international environment standard. One explanation is that foreign-owned firms usually have greater awareness of corporate social responsibility. Thus, their affiliates in the host country will be encouraged by the headquarters in the home country to follow the environmental rules.

The results using both IVs are shown in Table 5-7. The prediction

Table 5-6 Using ratio of "Emsystem" only as IV

1st stage	(1) ISO14001	(2) ISO14001	(3) ISO14001	(4) ISO14001	(5) ISO14001	(6) ISO14001
Ratio of firms having environmental management system	0.131*** (0.0373)	0.138*** (0.0372)	0.199*** (0.0386)	0.141** (0.0660)	0.0736 (0.145)	0.177*** (0.0502)
FDI (-1)	0.000331*** (4.96e-05)	0.000366*** (4.93e-05)	0.000454*** (5.08e-05)	0.000379*** (8.18e-05)	0.000625*** (0.000216)	0.000616*** (6.74e-05)
Capital labor ratio	2.37e-05*** (5.48e-06)	2.46e-05*** (6.11e-06)	4.41e-05*** (5.33e-06)	6.82e-05*** (8.71e-06)	8.41e-05*** (1.36e-05)	6.68e-05*** (7.15e-06)
2008 year dummy	–0.00303 (0.00527)	–0.00180 (0.00525)	0.00360 (0.00549)	0.00718 (0.00930)	0.00601 (0.0185)	0.00461 (0.00725)
2009 year dummy	–0.00737 (0.00472)	–0.00320 (0.00471)	–0.00129 (0.00493)	0.00502 (0.00833)	–0.00366 (0.0173)	0.00228 (0.00659)
a_mnf	0.0118* (0.00681)	0.0127* (0.00684)	0.0175** (0.00715)	0.0414*** (0.0114)	0.0113 (0.0274)	0.0254** (0.00986)
b_mnf	–0.0255*** (0.00740)	–0.0276*** (0.00725)	–0.0263*** (0.00755)	–0.0312** (0.0134)	–0.101*** (0.0358)	–0.0337*** (0.0101)
c_mnf	0.0501*** (0.00850)	0.0467*** (0.00847)	0.0479*** (0.00891)	0.0778*** (0.0151)	0.0540 (0.0357)	0.0515*** (0.0118)
d_mnf	0.0226*** (0.00567)	0.0192*** (0.00567)	0.0270*** (0.00602)	0.0477*** (0.0112)	0.0207 (0.0217)	0.0281*** (0.00784)
e_mnf	0.0767*** (0.00881)	0.0716*** (0.00881)	0.0932*** (0.00912)	0.159*** (0.0155)	0.119*** (0.0385)	0.118*** (0.0117)
Labor	9.20e-05*** (6.23e-06)	5.81e-05*** (4.11e-06)	4.54e-05*** (2.00e-06)	6.10e-05*** (3.01e-06)	0.000104*** (1.10e-05)	5.86e-05*** (2.58e-06)

2nd stage	Logarithm of real salary	Logarithm of real turnover	TFP	Share of treated liquid wastes	Share of treated air wastes	Share of treated solid wastes
ISO14001	8.813*** (2.754)	15.82*** (4.454)	0.483*** (0.120)	42.97* (26.07)	378.4 (741.4)	–23.61** (11.96)
FDI (-1)	0.00641*** (0.00104)	0.00426** (0.00185)	0.000176*** (6.40e-05)	–0.00795 (0.0107)	–0.169 (0.468)	0.0238*** (0.00802)
Capital labor ratio	1.28e-05 (8.64e-05)	0.000174 (0.000152)	5.85e-06 (6.39e-06)	–0.00227 (0.00187)	–0.0277 (0.0628)	0.00175** (0.000871)
2008 year dummy	–0.0328 (0.0547)	0.173* (0.0897)	0.00679** (0.00327)	–1.301*** (0.484)	–6.234 (6.754)	–0.737** (0.290)
2009 year dummy	0.0732 (0.0540)	0.241*** (0.0821)	0.0144*** (0.00309)	–0.216 (0.461)	–0.781 (7.490)	–0.520* (0.273)
a_mnf	–0.378*** (0.0871)	–0.108 (0.149)	0.00773 (0.00578)	–2.595* (1.476)	–9.309 (15.93)	0.882 (0.621)
b_mnf	0.273*** (0.0890)	0.0692 (0.153)	–0.0302*** (0.00506)	0.380 (1.009)	37.85 (74.17)	–0.919* (0.520)
c_mnf	–0.400** (0.196)	–0.354 (0.308)	0.0190* (0.00995)	–3.803 (2.608)	–23.50 (49.46)	1.391 (0.981)
d_mnf	–0.105 (0.0817)	–0.193 (0.125)	–0.000846 (0.00487)	–3.088** (1.325)	–19.81 (17.13)	–2.262*** (0.465)
e_mnf	–0.501* (0.262)	–0.869** (0.406)	–0.0211 (0.0147)	–8.675* (4.608)	–49.78 (94.49)	3.013* (1.701)
Labor	0.00177*** (0.000262)	0.000551** (0.000269)	–1.10e-05* (5.66e-06)	–0.00233 (0.00161)	–0.0355 (0.0773)	0.00144** (0.000716)
Stock-Yogo weak IV test	++	++	+++	/	/	++
Observations	15,595	15,575	16,456	7,400	1,832	9,655

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. +++ $p < 0.1$, ++ $p < 0.15$, + $p < 0.25$, / $p > 0.25$. Critical values are for Sanderson-Windmeijer F statistic.

Table 5-7 Using both ratio of "Wastedept" and ratio of "Emsystem" as IVs

1st stage	(1) ISO14001	(2) ISO14001	(3) ISO14001	(4) ISO14001	(5) ISO14001	(6) ISO14001
Ratio of firms having waste control department	0.0256 (0.0696)	7.06e-05 (0.0694)	–0.0223 (0.0720)	–0.0208 (0.122)	–0.0909 (0.261)	–0.0976 (0.0939)
Ratio of firms having enviro-mental management system	0.107 (0.0751)	0.138* (0.0750)	0.220*** (0.0772)	0.161 (0.131)	0.150 (0.264)	0.265*** (0.0991)
FDI (-1)	0.000330*** (4.96e-05)	0.000366*** (4.93e-05)	0.000454*** (5.09e-05)	0.000379*** (8.18e-05)	0.000624*** (0.000216)	0.000618*** (6.74e-05)
Capital labor ratio	2.37e-05*** (5.48e-06)	2.46e-05*** (6.11e-06)	4.41e-05*** (5.33e-06)	6.82e-05*** (8.71e-06)	8.43e-05*** (1.36e-05)	6.68e-05*** (7.15e-06)
2008 year dummy	–0.00169 (0.00640)	–0.00179 (0.00635)	0.00244 (0.00664)	0.00606 (0.0114)	–3.03e-05 (0.0254)	–0.000294 (0.00865)
2009 year dummy	–0.00709 (0.00478)	–0.00320 (0.00477)	–0.00156 (0.00500)	0.00474 (0.00849)	–0.00494 (0.0177)	0.000999 (0.00670)
a_mnf	0.0120* (0.00682)	0.0127* (0.00685)	0.0174** (0.00717)	0.0412*** (0.0115)	0.0109 (0.0274)	0.0251** (0.00986)
b_mnf	–0.0266*** (0.00801)	–0.0276*** (0.00788)	–0.0253*** (0.00821)	–0.0304** (0.0141)	–0.0975*** (0.0373)	–0.0289*** (0.0111)
c_mnf	0.0496*** (0.00859)	0.0467*** (0.00855)	0.0483*** (0.00901)	0.0782*** (0.0153)	0.0575 (0.0371)	0.0538*** (0.0120)
d_mnf	0.0222*** (0.00577)	0.0192*** (0.00577)	0.0274*** (0.00612)	0.0478*** (0.0112)	0.0208 (0.0217)	0.0299*** (0.00803)
e_mnf	0.0755*** (0.00945)	0.0716*** (0.00945)	0.0943*** (0.00983)	0.160*** (0.0164)	0.125*** (0.0418)	0.123*** (0.0129)
Labor	9.21e-05*** (6.23e-06)	5.81e-05*** (4.11e-06)	4.54e-05*** (2.00e-06)	6.10e-05*** (3.01e-06)	0.000104*** (1.10e-05)	5.86e-05*** (2.58e-06)

2nd stage	Logarithm of real salary	Logarithm of real turnover	TFP	Share of treated liquid wastes	Share of treated air wastes	Share of treated solid wastes
ISO14001	8.693*** (2.710)	15.83*** (4.455)	0.455*** (0.116)	43.27* (26.09)	106.1 (194.8)	–34.00** (13.28)
FDI (-1)	0.00645*** (0.00103)	0.00426** (0.00185)	0.000189*** (6.19e-05)	–0.00806 (0.0107)	–0.000190 (0.124)	0.0304*** (0.00895)
Capital labor ratio	1.58e-05 (8.52e-05)	0.000174 (0.000152)	7.12e-06 (6.17e-06)	–0.00229 (0.00187)	–0.00470 (0.0165)	0.00246** (0.000972)
2008 year dummy	–0.0340 (0.0540)	0.173* (0.0898)	0.00661** (0.00317)	–1.301*** (0.486)	–5.524*** (2.126)	–0.784** (0.335)
2009 year dummy	0.0718 (0.0534)	0.241*** (0.0821)	0.0142*** (0.00299)	–0.217 (0.462)	–2.233 (2.280)	–0.547* (0.316)
a_mnf	–0.376*** (0.0859)	–0.108 (0.149)	0.00873 (0.00559)	–2.611* (1.478)	–4.520 (4.503)	1.318* (0.699)
b_mnf	0.270*** (0.0879)	0.0692 (0.153)	–0.0307*** (0.00490)	0.388 (1.012)	11.04 (19.63)	–1.189** (0.593)
c_mnf	–0.392** (0.193)	–0.354 (0.308)	0.0210** (0.00961)	–3.832 (2.611)	–5.745 (13.13)	2.163** (1.098)
d_mnf	–0.102 (0.0806)	–0.193 (0.125)	–0.000121 (0.00471)	–3.102** (1.327)	–14.28*** (4.735)	–1.978*** (0.527)
e_mnf	–0.490* (0.258)	–0.869** (0.406)	–0.0179 (0.0142)	–8.727* (4.612)	–15.43 (24.95)	4.442** (1.894)
Labor	0.00178*** (0.000258)	0.000551** (0.000269)	–9.72e-06* (5.46e-06)	–0.00235 (0.00161)	–0.00713 (0.0203)	0.00206*** (0.000796)
Stock-Yogo weak IV test	/	/	++	/	/	/
Sargan test *P* value	0.6701	0.4103	0.0001	0.8841	0.0423	0.0081
Observations	15,595	15,575	16,456	7,400	1,832	9,655

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. +++ $p < 0.1$, ++ $p < 0.15$, + $p < 0.25$, / $p > 0.25$ Critical values are for Sanderson-Windmeijer *F* statistic.

on two IVs varies: in the first stage, the coefficient of *ratio_emsystem* remains positive and significant in most specifications. However, *ratio_wastedept* loses its significance in all cases. Meanwhile, the estimation of the coefficients on *FDI*, *Capital labor ratio* and *Labor* has similar results as in the previous method. In the second stage, the variable of interest—ISO14001 has the same sign and significance as when we use the single IV method. Consistent with the result above, the coefficient of ISO14001 changes sign when the dependent variable is solid waste. Since we use two IVs in this method, it is necessary to conduct an over-identification test—Sargan test. The results reject the validity of including both *ratio_emsystem* and *ratio_wastedept* as IVs, but only when we use TFP and share of treated solid waste as dependent variables. In other words, *ratio_emsystem* and *ratio_wastedept* serve as valid candidates in general when we conduct the IV analysis. Consequently this shows that the adoption of ISO14001 does have a promoting impact on a firm's overall performance, but its influence on the share of treated air and solid waste is not robust.

4.2.2 Propensity score matching

Next, we use propensity score matching (PSM) to confirm our findings. The purpose of our estimation is to determine the average treatment effect on the treated sample (ATT), which, in this study, is the performance difference between ISO14001 adopters and non-adopters. While accurate measurements need random experimental settings, the counterfactual phenomenon is usually unobserved. In this case, Rosenbaum and Rubin (1983) propose using a propensity score, which we can do here to match adopters with non-adopters. We use the first-stage equation introduced in the previous section to predict the likelihood of a firm adopting ISO14001.

The challenge is that firms do not report the year they acquired ISO14001. Thus, we use the information for 2006 (one year before our first year of observation) to calculate firms' propensity score for ISO14001 adoption in year 2007.[7] Then, we match them with firms in the same year that have similar propensity but do not adopt ISO14001. If the performance indicators in these two groups are significantly differ-

ent, then we can make the judgment that ISO14001 has potentially led firms to improve. To proceed, we further assume that by controlling the covariates, we can make the error term uncorrelated with firms' decisions with regard to ISO14001 adoption.[8]

Our treatment sample (ISO14001 = 1) varies in size from 825 in 2007 to 1201 in 2009. The average value of each control variable for the treated group is higher than that for the control group. For example, the average TFP for the treated group is 0.56, compared with 0.49 for the control group. The estimation results are consistent with the statistical intuition. Table 5-7 reports the results using nearest one-to-one matching. The ATT estimates are all significant, except for the share of treated solid waste. This indicates that firms' overall performance tends to improve significantly following the adoption of ISO14001.

We also conduct balance tests (for matched firms) to check for differences in average covariates between the treated and control groups to see if there remain any significant differences between the two groups after propensity score matching. The results of the *t*-test for the major covariates (*FDI*, *Capital labor ratio*, *Labor*) do not reject the null hypothesis that the mean of the treated group is equal to that of the control group for the matched pairs, meaning the models balance the covariates well. Also, as can be seen from Figures 5-1–5-3, the propensity score after matching is almost the same for the treated and control group, which verifies the validity of the covariates that we choose. Further evidence is found in that the standardized bias is substantially reduced after the matching. Based on the discussion of Caliendo and Kopeining (2008), a standardized bias below 5 % is enough to justify the balance.

Despite strong evidence that ISO14001 improves firms' competitiveness raises their awareness of the need for environmental protection, the estimation might still suffer from bias owing to data limitations, as previously explained. More accurate results could be achieved if more detailed information on the background of ISO14001 adoption was available: for example, why firms in some industries or areas have a greater tendency to acquire ISO accreditation, especially in the context of Vietnam. Thus, there is room for future research on whether the impact of ISO adoption is temporary.

To ensure the robustness of our results, several issues need further

clarification. Since ISO14001 accreditation is valid for three years, a firm might lose its accredited status during the study's 2007–2009 time frame. If they fail to renew their certificate, then our estimation results would be biased when we count these firms as ISO14001-adopters. In order to allay this concern, we limit the sample to those firms that did not change their ISO14001 status, or that acquired the ISO14001 certification during 2008–2009. Despite such changes, ISO14001 is still positive and significant in all specifications, which is consistent with our baseline estimation results. Besides, the TFP calculation using Levinsohn and Petrin's method is also used, which yields similar results in all cases. The results are excluded but are available upon request.

5. Conclusion

We use firm-level data from Vietnam for the period 2007–2009 to investigate the impact of adopting ISO14001, a voluntary environmental standard. In the empirical verification, a two-stage selection model is applied to correct for potential selection bias. The results show that foreign firms are more likely to adopt ISO14001. Furthermore, such adoption affects firms' overall performance in terms of reducing their waste discharge and improving their turnover and productivity. We use IV estimation and propensity score matching as robustness checks, and obtain consistent results. The findings presented here are in accordance with most existing literature.[9] We also find evidence to support foreign firms' efforts towards environmental protection. At the same time, our study has certain limitations. By employing more detailed information, we would like to extend our analysis to additional industries and regions.

Vietnam is undergoing a rapid economic transition. However, this growth comes with a price, namely, environmental pollution, which is an important issue that the Vietnamese government has to deal with. We hope the findings presented in this book can offer decision-makers some guidance in terms of implementing efficient policies to protect the environment. For example, such policies could further encourage ISO14001 adoption and call on more firms to participate in voluntary environment

programs in order to realize the real benefits of doing so.

Notes

1 The environmental protection paradigm in developing countries is gradually moving away from a compulsory approach to a more flexible and voluntary approach (Tambunlertchai et al., 2013).
2 However, some have argued that the adoption of ISO14001 is motivated primarily by domestic regulatory and market pressures (Khanna and Anton, 2002; Lyon and Maxwell, 2008). http://www.iso.org/iso/about/iso member.htm. Accessed on November 25, 2014.
3 Details on PSM, which include methodology and results, are presented in the appendix.
4 Akbostanci et al. (2007) empirically verified that this phenomenon exists in Turkey. In addition, political economists such as Fredriksson et al. (2003) and Cole et al. (2004) have argued that corruption affects the stringency of environmental policy in terms of attracting FDI.
5 We also apply other industry-level IVs as well, such as ratio of firms with certificate. The information is taken from JETRO, whereas the ratio is defined as the number of firms with the certificate indicating that they meet the chemical regulation standard divided by the total number of firms in industry j at time t. The combinations of different IVs are tested, and the results are not presented due to space constraint.
6 Since there are many firms that do not treat waste and/or have a low turnover or TFP, we do not exclude the lowest 1 % of these variables.
7 We repeat the same practice for the other years as well.
8 In reality, this assumption can be violated. For example, a policy shock in an industry might encourage firms to apply for ISO accreditation; an opposite scenario can also be considered.
9 Blackman et al. (2010) do not find a significant impact of the Clean Industry Program on average environmental performance.

Appendix

Table 5-8 Results using propensity score matching

Variables	(1) Logarithm of real salary	(2) Logarithm of real turnover	(3) TFP	(4) Share of treated liquid wastes	(5) Share of treated air wastes	(6) Share of treated solid wastes
Method	Nearest	Nearest	Nearest	Nearest	Nearest	Nearest
ATT	1.127***	1.319***	0.0559***	1.812**	13.24***	0.470
	(0.101)	(0.121)	(0.00635)	(0.848)	(3.024)	(0.699)
Observations	4,007	3,987	4,253	2,021	536	2,591

Notes: Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ (One-tail significance test is conducted). One-to-one matching is applied.

Table 5-9 Results of balancing test (PS test)

Variable	Unmatched Matched	Mean Treated	Control	%bias	%reduct bias	*t*-test *t*	$p > t$	$V(T) / V(C)$
FDI2006	U	47.049	22.921	53.8		10.57	0.000	1.37*
	M	54.517	57.961	–7.7	85.7	–0.75	0.455	1
Capital								
Labor ratio 2006	U	314.82	142.45	25.4		6.51	0.000	3.77*
	M	364.18	389.48	–3.7	85.3	–0.34	0.737	0.88
a_mnf	U	0.18421	0.2027	–4.7		–0.86	0.387	.
	M	0.16744	0.13023	9.4	–101.2	1.08	0.279	.
b_mnf	U	0.11842	0.12471	–1.9		–0.36	0.721	.
	M	0.11163	0.17209	–18.5	–862.2	–1.8	0.073	.
c_mnf	U	0.20263	0.11249	24.9		5.23	0.000	.
	M	0.2	0.24186	–11.6	53.6	–1.05	0.297	.
d_mnf	U	0.18684	0.24941	–15.2		–2.73	0.006	.
	M	0.18605	0.12093	15.8	–4.1	1.88	0.061	.
e_mnf	U	0.22105	0.08507	38.4		8.75	0.000	.
	M	0.26512	0.25581	2.6	93.2	0.22	0.827	.
f_mnf	U	0.08684	0.22563	–38.9		–6.35	0.000	.
	M	0.06977	0.07907	–2.6	93.3	–0.37	0.714	.
Labor2006	U	919.89	251.06	44.5		14.17	0.000	8.53*
	M	855.97	898.15	–2.8	93.7	–0.23	0.822	0.64*
Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.105	248.73	0	27.5	25.4	82.0*	2.82*	100
Matched	0.014	8.52	0.384	8.3	7.7	28.3*	0.98	33

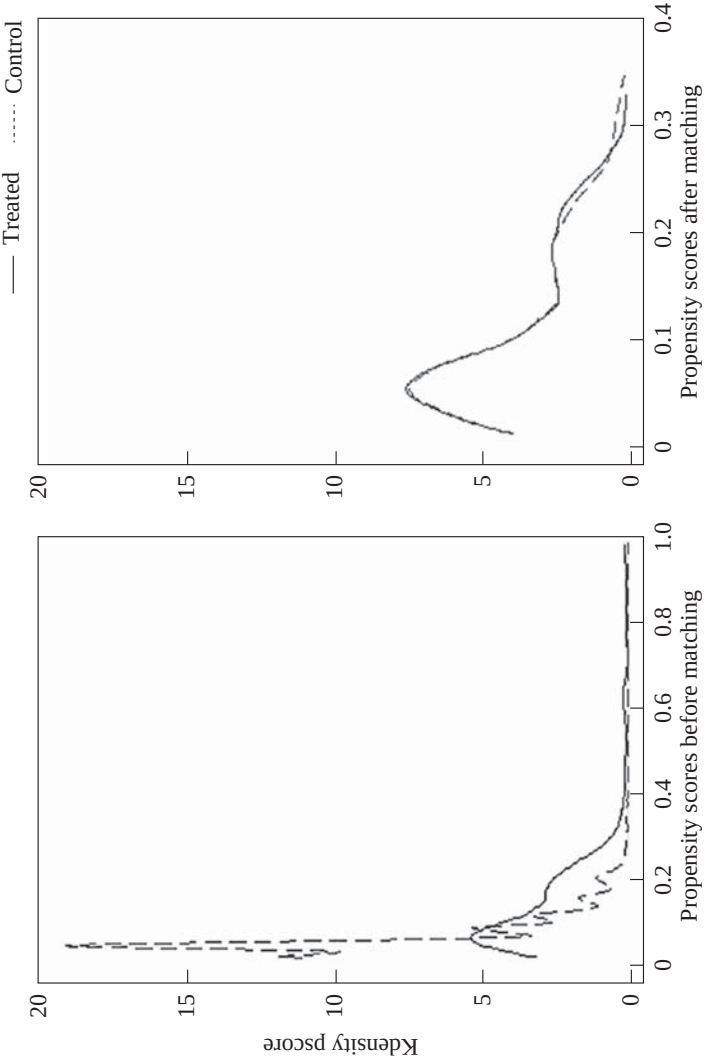


Figure 5-1 Propensity score before and after matching (salary)

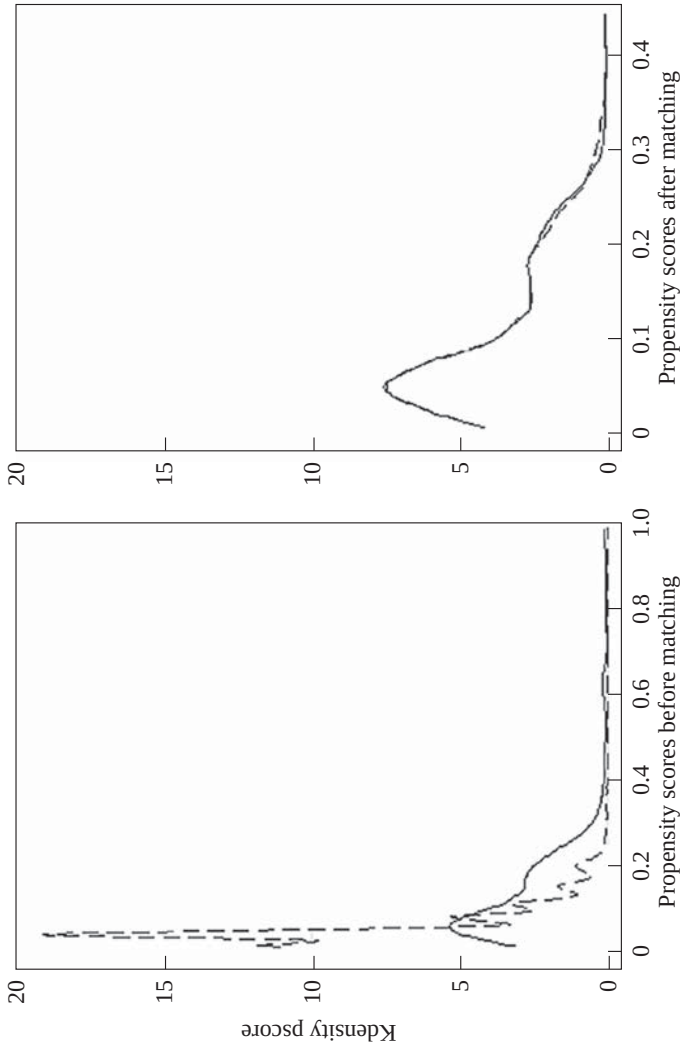


Figure 5-2 Propensity score before and after matching (turnover)

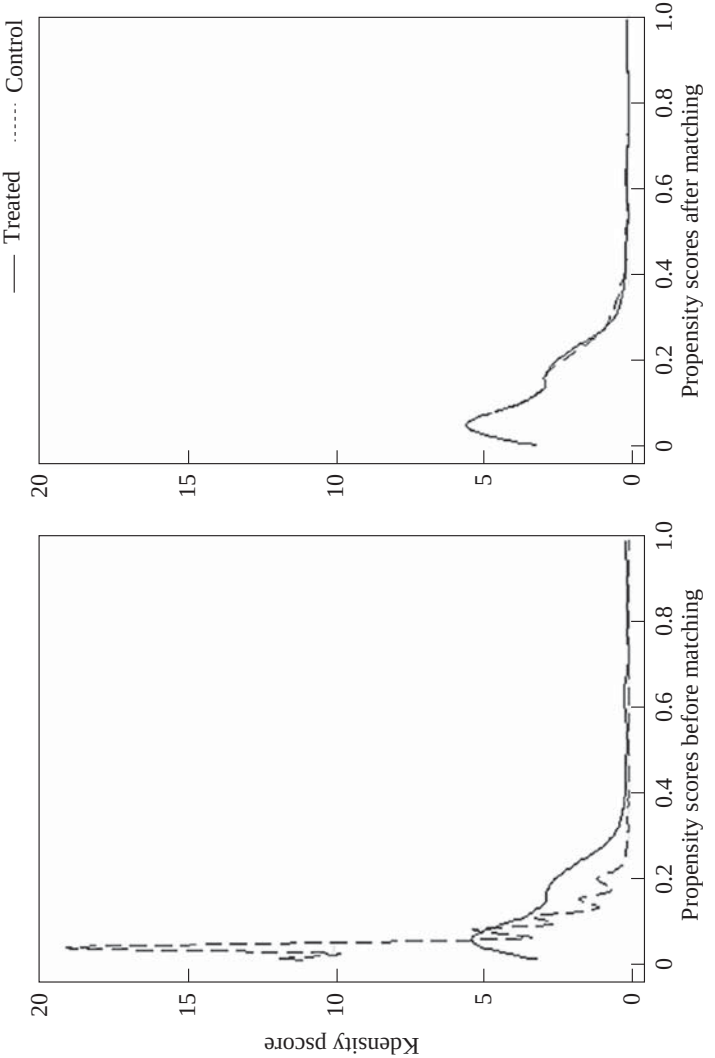


Figure 5-3 Propensity score before and after matching (productivity)

CHAPTER SIX

Concluding remarks

In this book, I try to investigate the strategic determinants of foreign direct investment as well as the potential impacts that such investment might have on the targeting countries, from various perspectives. In Chapter 2, I first apply Chinese firm- and city-level data to evaluate the effectiveness of investment promotion agency—a public policy made by the Chinese government to attract FDI apart from the existing policy tools, such as special economic zones. Unfortunately, no obvious causality between the implementation of IPAs at the city-level and FDI growth has been found. This indicates that IPAs established in China might not be able to meet the expectation of their founders, in terms of inviting FDI. Thus, it leaves room for us to find proper ways to improve the performance of IPAs and exploit new directions of attracting high-quality FDI in the future. The latter is even more important for developing countries like China, which is undergoing the transition from the world's factory to a technology-oriented economy.

Meanwhile, the substantial influence brought about by foreign investors is also confirmed. The verification has been done throughout Chapters 3–5. On one hand, foreign firms induce technology spillover to local firms through the channels of labor movement and inputs purchasing. Local suppliers can usually benefit through the process of learning by doing, and end up increasing their technological levels. In Chapter 3, I confirm such phenomenon and further examine the heterogeneous impact of foreign firms by their country origin. As a result, I show that

technology spillover is most likely to occur when the investors are from East Asian countries, because these investors tend to keep the closest interactaction with domestic suppliers, thus causing backward vertical technology spillover.

On the other hand, environmental pollution is an inevitable issue in developing economies during industrialization. However, to what extent should foreign investors be to blame for the undesirable consequences? Do foreign investors act differently from domestic counter-parts in terms of environmental protection? To answer these questions, in Chapter 4, I focus on firms' decision-making of participation in ISO14001, a voluntary environmental standard which measures the level of environmental awareness. I show both theoretically and empirically that more productive and capital intensive firms have greater incentive to adopt ISO14001, especially when the firms are foreign-invested. This in turn provides solid counter-evidence for the "pollution haven hypothesis" (the famous criticism on FDI). Finally, Chapter 5 shows that when firms actively participate in acquiring such voluntary standard, it can improve the firm's performance in terms of not only the cost of waste control, but its welfare and productivity as well. This study thus complements existing literature by indicating the positive linkage between firms' awareness of corporate social responsibility and their future benefits.

This book is only a glimpse into the sea of FDI-related literature in the context of developing nations. There are many more topics that still need to be ventured. For example, how does inward FDI affect the local labor market? How does outward FDI, such as Japanese firms' overseas expansion, influence the labor reallocation at home? Do firms always experience product upgrading or product differentiation, if they decide to go abroad? Some of the studies towards these questions are already under way and I will leave the remaining issues for my future study.

References

Aigner, D., Lovell, C., and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, Vol. 6, 21–37.

Aitken, B. J. and Harrison, A. E. (1999). Do domestic firms benefit from direct foreign investment?: Evidence from Venezuela. *American Economic Review*, Vol. 89, No. 3, 605–618.

Akbostanci, E., Tunc, G. I., and Asik, S. T. (2007). Pollution haven hypothesis and the role of dirty industries in Turkey's exports. *Environment and Development Economics*, Vol. 12, 297–322.

Amiti, M. and Javorcik, B. S. (2008). Trade costs and the location of foreign firms in China. *Journal of Development Economics*, Vol. 85, Nos. 1–2, 129–149.

Anwar, S. and Nguyen, L. P. (2014). Is foreign direct investment productive?: A case study of the regions of Vietnam. *Journal of Business Research*, Vol. 67, No. 7, 1376–1387.

Arimura, T., Iguchi, H., and Michida, E. (2014). *Product-related environmental regulation and voluntary environmental actions: Impacts of RoHS and REACH in Malaysia*. IDE discussion paper, No. 454.

Arimura, T., Darnall, N., and Katayama, H. (2011). Is ISO 14001 a gateway to more advanced voluntary action?: The case of green supply chain management. *Journal of Environmental Economics and Management*, Vol. 61, No. 2, 170–182.

Arimura, T., Hibiki, A., and Katayama, H. (2008). Is a voluntary approach an effective environmental policy instrument?: A case for environmental management systems. *Journal of Environmental Economics and Management*, Vol. 55, No. 3, 281–295.

ASEAN Secretariat (2006). *Statistics of foreign direct investment in ASEAN*. Eighth Edition.

Ayyagari, M. and Kosova, R. (2010). Does FDI facilitate domestic entry?: Evidence from the Czech Republic. *Review of International Economics*, Vol. 18, No. 1, 14–29.

Backer, K. D. and Sleuwaegen, L. (2003). Does foreign direct investment crowd out domestic entrepreneurship? *Review of Industrial Organization*, Vol. 22, 67–84.

Bao, Q., Chen, Y. Y., and Song, L. G. (2011). Foreign direct investment and environmental pollution in China: A simultaneous equations estimation. E*nvironment and Development Economics*, Vol. 16, 71–92.

Balistreri, E. J., Hillbery, R. H., and Rutherford, T. F. (2011). Structural estimation and solution of international trade models with heterogeneous firms. *Journal of International Economics*, Vol. 83, 95–108.

Bernard, A., Jensen, B., Redding, S., and Schott, P. (2007). Firms in international trade. *Journal of Economic Perspectives*, Vol. 21, 105–130.

Bernard, A., Redding, S. and Schott, P. (2011). Multi-product firms and trade liberalization. *Quarterly Journal of Economics*, Vol. 126, 1271–1318.

Bernard, A., Redding, S., and Schott, P. (2010). Multiple-product firms and product switching. *American Economic Review*, Vol. 100, 70–97.

Blackman, A., Lahiri, B., Pizer, W., Rivera, P., and Marisol, M. P. C. (2010). Voluntary regulation in developing countries: Mexico's clean industry program. *Journal of Environmental Economics and Management*, Vol. 60, No. 3, 182–192.

Blomstrom, M. and Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic Surveys*, Vol. 12, No. 3, 247–277.

Blomstrom, M. and Wang, J. (1992). Foreign investment and technology transfer: A simple model. NBER Working Paper. No. 2958.

Blomstrom, M., Kokko, A., and Mario, Z. (2000). F*oreign direct investment: Firm and host country strategies*. Macmillan Press.

Bui, T. M. L. and Kapon, S. (2012). The impact of voluntary programs on polluting behavior: Evidence from pollution prevention programs and toxic releases. *Journal of Environmental Economics and Management*, Vol. 64, 31–44.

Caliendo, M. and Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, Vol. 22, No. 1, 31–72.

Caves, R. E. (1996). *Multinational enterprise and economic analysis, 2nd ed.* New York, NY: Cambridge University Press.

Charlton, A. and Davis, N. (2007). Does investment promotion work?". *The B.E. Journal of Economic Analysis & Policy*, Vol. 7, No. 1, 1935–1682.

Chen, W. (2011). The effect of investor origin on firm performance: Domestic and foreign direct investment in the United States. *Journal of International Economics*, Vol. 83, No. 2, 219–228.

Cho, S. and Tung, S. (1998). Special tax incentive zones and regional tax incentive policy in the peoples republic of China. *The International Tax Journal*, Vol. 14, No. 3, 453–480.

Christmann, P. and Taylor, G. (2001). Globalization and the environment: Determinants of firm self-regulation in China. *Journal of International Business Studies*, Vol. 32, No. 3, 439–458.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, Vol. 48, 71–81.

Copeland, B. R. and Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature*, Vol. 42, No. 1, 7–71.

Copeland, B. R. and Taylor, M. S. (2003). *Trade and the environment: Theory and evidence*. Princeton, NJ: Princeton University Press.

De Jaeger, S., Eyckmans, J., Rogge, N., and Puyenbroeck, T. V. (2011). Wasteful waste-reducing policies?: The impact of waste reduction policy instruments on collection and processing costs of municipal solid waste. *Waste Management*, Vol. 31, 1429–1440.

Dean, J., Lovely, M., and Wang, H. (2009). Are foreign investors attracted to weak environmental regulations?: Evaluating the evidence

from China. *Journal of Development Economics*, Vol. 90, No. 1, 1–13.

Egger, P. and Pfaffermayr, M. (2004). The impact of bilateral investment treaties on foreign direct investment. *Journal of Comparative Economics*, Vol. 32, No. 4, 788–804.

Ehrlich, I., Gallais-Hamonno, G., Liu, Z., and Lutter, R. (1994). Productivity growth and firm ownership: An analytical and empirical investigation. *Journal of Political Economy*, Vol. 102, 1006–1038.

Eskeland, S. G. and Harrison, E. A. (2003). Moving to greener pastures?: Multinationals and the pollution haven hypothesis. *Journal of Development Economics*, Vol. 70, 1–23.

Fredriksson, P. G., List, J. A., and Millimet, D. L. (2003). Bureaucratic corruption, environmental policy and inbound US FDI: Theory and evidence. *Journal of Public Economics*, Vol. 87, 1407–1430.

Gallagher, K. (1999). Pollution intensive industry in Mexico under NAFTA: Model and empirical evidence. *The Fletcher Journal of Development Studies*, Vol. XV.

Glass, A. J. and Saggi, K. (2002). Multinational firms and technology transfer. *Scandinavian Journal of Economics*, Vol. 104, 495–513.

Gorg, H. and Greenaway, D. (2004). Much ado about nothing?: Do domestic firms really benefit from foreign investment? *World Bank Research Observer*, Vol. 19, No. 2, 171–197.

Guimaraes, P., Figueiredo, O., and Woodward, D. (2000). Agglomeration and the location of foreign direct investment in Portugal. *Journal of Urban Economics*, Vol. 47, No. 1, 115–135.

Harding, T. and Javorcik, B. S. (2007). *Developing economies and international investors: Do investment promotion agencies bring them together*. Working Paper 4339, The World Bank Policy Research.

Harding, T. and Javorcik, B. S. (2011). Roll out the red carpet and they will come: investment promotion and FDI inflows. *Economic Journal*, Vol. 121, No. 557, 1445–1476.

Harding, T. and Javorcik, B. S. (2012). *Investment promotion and FDI inflows: Quality matters*. Working Paper 612, Department of Economics, University of Oxford.

Harrigan, J. and Reshef, A. (2012). *Skill biased heterogeneous firms,*

trade liberalization and the skill premium. Working paper. University of Virginia.

Haskel, J. E., Pereira, S. C., and Slaughter, M. J. (2007). Does inward foreign direct investment boost the productivity of domestic firms? *Review of Economics and Statistics*, Vol. 89, No. 3, 482–496.

He, J. (2006). Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO2) in Chinese Provinces. *Ecological Economics*, Vol. 60, 228–245.

Head, K. and Ries, J. (1996). Inter-city competition for foreign investment: Static and dynamic effects of Chinas incentive areas. *Journal of Urban Economics*, Vol. 40, No. 1, 38–60.

Head, K., Ries, J., and Swenson, D. (1995). Agglomeration benefits and location choice: Evidence from Japanese manufacturing investment in the United States. *Journal of International Economics*, Vol. 38, Nos. 3–4, 223–247.

Inada, M. (2013). *The effects of foreign direct investment on industrial growth: Evidence from a regulation change in China*. KIER Discussion Paper, No. 856.

ISO, 2015. ISO14001 Key Benefits. [Available at] http://www.iso.org/iso/iso_14001_-_key_benefits.pdf. Last access on June 1st, 2016.

Ito, B., Yashiro, N., Xu, Z., Chen, X., and Wakasugi, R. (2012). How do Chinese industries benefit from FDI spillovers? *China Economic Review*, Vol. 23, No. 2, 342–356.

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic Firms? In search of spillovers through backward linkages. *American Economic Review*, Vol. 94, No. 3, 605–631.

Javorcik, B. S. and Spatareanu. M. (2011). Does it matter where you come from?: Vertical spillovers from foreign direct investment and the origin of investors. *Journal of Development Economics*, Vol. 96, 126–138.

JETRO Survey (2005). *Supporting industries in Vietnam from the perspective of Japanese manufacturing firm*s. Vietnam Development Forum 2005, Chapter 1.

Jiang, R. J. and Bansal, P. (2003). Seeing the need for ISO 14001. *Jour-*

nal of Management Studies, Vol. 40, No. 4, 1047–1067.

Jiang, L. L., Lin, C., and Lin, P. (2014). The determinants of pollution levels: Firm-level evidence from Chinese manufacturing. *Journal of Comparative Economics*, Vol. 42, 118–142.

Kamal, F. (2014). Origin of foreign direct investment and firm performance: Evidence from foreign acquisitions of Chinese domestic firms. *World Economy*, doi: 10.1111/twec.12147.

Kang, S. M. and Lee, M. (2004). An empirical study on effective pollution enforcement in Korea. *Environment and Development Economics*, Vol. 9, 353–365.

Khanna, M. and Anton, W. R. Q. (2002). Corporate environmental management: Regulatory and market-based incentives. *Land Economics*, Vol. 78, 539–558.

Kim, E. H. and Lyon, T. P. (2011). Strategic environmental disclosure: evidence from the DOEs voluntary greenhouse gas registry. *Journal of Environmental Economics and Management*, Vol. 61, 311–326.

Kumbhakar, S. C. and Lovell, C. A. K. (2000). Stochastic frontier analysis, Published by the Press Syndicate of the University of Cambridge.

Lee, J. and Folkmanis, J. (2013). Samsung shifts plants from China to protect margins. Bloomberg/Tech, 12 Dec. 2013. http://www.bloomberg.com/news/2013-12-11/samsung-shifts-plants-from-china-to-protect-margins.html.

Levinson, A. (2009). Technology, international trade, and pollution from US manufacturing. *American Economic Review*, Vol. 99, No. 5, 2177–2192.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economics Studies*, Vol. 70, 317–341.

Liu, X. P., Lovely, M., and Ondrich, J. (2010). The location decisions of foreign investors in China: Untangling the effect of wages using a control function approach. *The Review of Economics and Statistics*, Vol. 92, No. 1, 160–166.

Liu, Z. (2008). Foreign direct investment and technology spillovers: Theory and evidence. *Journal of Development Economics*, Vol. 85, 176–193.

Lovell, C. and Kumbhakar, S. (2000). *Stochastic frontier analysis.* NY,

USA, Cambridge University Press.

Lu, Y., Tao, Z. G., and Zhu, L. M. (2017). Identifying FDI spillovers. *Journal of International Economics*, Vol. 107, 75–90.

Lu, Y., Wang, J., and Zhu, L. M. (2015). Do place-based policies work?: Micro-level evidence from China's economic zone program. Working Paper.

Lyon P. T. and Maxwell, W. J. (2008). Corporate social responsibility and the environment: A theoretical perspective. *Review of Environmental Economics and Policy*, Vol. 1, No. 0, 1–22.

Ma, Y., Tang H., and Zhang, Y. F. (2014). Factor intensity, product switching, and productivity: Evidence from Chinese exporters. *Journal of International Economics*, Vol. 92, No. 349–362.

Mani, M. and Wheeler, D. (1997). In search of pollution havens?: Dirty industry migration in the world economy. World Bank Working Paper, No. 16.

Markusen, J. R. and Venables, A. J. (1999). Foreign direct investment as a catalyst for industrial development. *European Economic Review*, Vol. 43, 335–356.

Melitz, M. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, Vol. 71, 1695–1725.

Monastiriotis, V. and Alegria, R. (2011). Origin of FDI and intra-Industry domestic spillovers: The case of Greek and European FDI in Bulgaria. *Review of Development Economics*, Vol. 15, No. 2, 326–339.

Mori, J. (2006). *Designing and managing supporting industry databases*. Vietnam Development Forum, Chapter 4.

Morisset, J. and Andrews-Johnson, K. (2004). The effectiveness of promotion agencies at attracting foreign direct investment. Occasional Paper 16, FIAS.

Morisset, J. (2003). Does a country need a promotion agency to attract foreign direct investment?: A small analytical model applied to 58 countries. Working Paper 3028, The World Bank Policy Research.

Ministry of Planning and Investment of Vietnam (MPI) (2011). Tinh hinh thu hut dau tu nuoc ngoai 12 thang dau nam 2010 [Foreign direct invest- ment into Vietnam in 12 months of 2010]. Retrieved July 14, 2011 from http://fia.mpi.gov.vn/News.aspx?ctl=newsdetailandp=a

ndaID=1043.

Nakamura, M., Takahashi, T., and Vertinsky, I. (2001). Why Japanese firms choose to certify: A study of managerial responses to environmental issues. *Journal of Environmental Economics and Management*, Vol. 42, No. 1, 23–52.

Nguyen, L. P. (2008). *Productivity spillovers from foreign direct investment: Evidence from Vietnamese firm data*. Working paper, National Economics University in Vietnam.

Nishitani, K. (2010). Demand for ISO 14001 adoption in the global supply chain: An empirical analysis focusing on environmentally conscious markets. *Resource and Energy Economics*, Vol. 32, 395–407.

Nishitani, K. (2009). An empirical study of the initial adoption of ISO 14001 in Japanese manufacturing firms. *Ecological Economics*, Vol. 68, No. 3, 669–679.

Olley, S. G. and Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, Vol. 64, No. 6, 1263–97.

Potoski, M. and Prakash, A. (2011). ISO 14001 and pollution reduction: A cross-country panel study. SSRN working paper: id1900139.

Potoski, M. and Prakash, A. (2006). Investing up: FDI and the cross-country diffusion of ISO 14001 management systems. *International Studies Quarterly*, Vol. 51, 723–744.

Potoski, M. and Prakash, A. (2005). Covenants with weak swords: ISO 14001 and firms?: Environmental performance. *Journal of Policy Analysis and Management*, Vol. 24, No. 4, 745–769.

Prakash, A. and Potoski, M. (2007). Investing up: FDI and the cross country diffusion of ISO 14001 management systems. *International Studies Quarterly*, Vol. 51, 723–744.

Rodriguez-Clare, A. (1996). Multinationals, linkages, and economic development. *American Economic Review*, Vol. 85, 852–873.

Roodman, D. (2009). How to do xtabond2: an introduction to difference and system GMM in Stata. *The Stata Journal*, Vol. 9, No. 1, 86–136.

Rosenbaum, P. R. and Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*,

Vol. 70, No. 1, 41–55.

Rosendorff, B. P. and Shin, K. (2012). Importing transparency: The political economy of BITs and FDI flows. New York University Working Paper.

Saggi, K. (2002). Trade, foreign direct investment, and international technology transfer: A survey. *World Bank Research Observer*, Vol. 17, No. 2, 191–236.

Shapiro, J. S. and Walker, R. (2015). Why is pollution from US manufacturing declining?: The roles of trade, regulation, productivity, and preferences. NBER Working Paper 20879.

Schoors, K. and van der Tol, B. (2001). The productivity effect of foreign ownership on domestic firms in Hungary. Paper presented at the International Atlantic Economic Conference in Philadelphia, PA, October 11–14, 2001.

Tambunlertchai, K., Kontoleon, A., and Khanna, M. (2013). Assessing participation in voluntary environmental programmes in the developing world: The role of FDI and export orientation on ISO14001 adoption in Thailand. *Applied Economics*, Vol. 45, No. 15, 2039–2048.

Thuy, L. T. (2007). Does foreign direct investment have an impact on the growth in labor productivity of Vietnamese domestic firms? RIETI Discussion Paper Series 07-E-021.

Turk, A. M. (2009). The benefits associated with ISO 14001 certification for construction firms: Turkish case. *Journal of Cleaner Production*, Vol. 17, No. 5, 559–569.

UNCTAD (2001). The world of investment promotion at a glance: A survey of investment promotion practices. *ASIT Advisory Studies*, No. 17.

Vega, M. G., Hofmann, P., and Kneller, R. (2011). International technology transfer from above and below. Working paper.

Verhoogen, E. (2008). Trade, quality upgrading and wage inequality in the Mexican manufacturing sector. *Quarterly Journal of Economics*, Vol. 123, 489–530.

Wang, H. and Jin, Y. H. (2007). Industrial ownership and environmental performance: Evidence from China. *Environmental and Resource Economics*, Vol. 36, No. 3, 255–273.

Wang, J. (2013). The economic impact of special economic zones: Evidence from Chinese municipalities. *Journal of Development Economics*, Vol. 101, No. C, 133–147.

Welch, E. W., Mori, Y., and Aoyagi-Usui, M. (2002). Voluntary adoption of ISO 14001 in Japan: Mechanisms, stages and effects. *Business Strategy and the Environment*, Vol. 11, No. 1, 43–62.

Wint, A. G. (1993). Promoting transnational investment: Organizing to service approved investors. *Transnational Corporations*, Vol. 2, No. 1, 71–90.

Wu, S. Y., Chu, P. Y., and Liu, T. Y. (2007). Determinants of a firm? ISO 14001 certification: An empirical study of Taiwan. *Pacific Economic Review*, Vol. 12, No. 4, 467–487.

Xuan, N. T. and Xing, Y. (2008). Foreign direct investment and exports: The experiences of Vietnam. *Economics of Transition*, Vol. 16, No. 2, 183–197.

Yeaple, S. (2005). A simple model of firm heterogeneity, international trade, and wages. *Journal of International Economics*, Vol. 65, 1–20.

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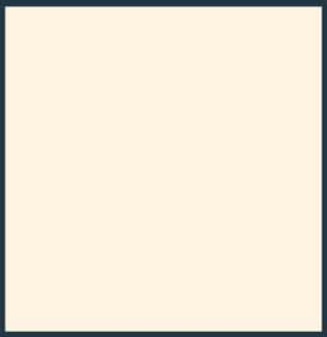

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