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Abstract

Environmental protection is an inevitable issue that developing countries all have to deal with during the process of inviting foreign direct investment (FDI). However, high correlation between FDI and pollution doesn't necessarily indicate that foreign firms are to blame. In this paper, we apply firm-level panel data in Vietnam and unique information on waste discharge to show that foreign firms are actually more active to acquire ISO14001, a voluntary environmental standard. And the adoption will in turn improve firms' performance in waste control. It also increases firms' welfare as well as their productivity level. This paper provides strong evidence that firms' efforts towards corporate social responsibility will eventually benefit themselves as well.

JEL classification: D22, F21, F64, Q56
Keywords: FDI, ISO14001, Vietnam, environmental protection

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1 Introduction

It is known to all that foreign direct investment (hereafter FDI) has been a consider- able driving force to spur the economic growth in developing countries, especially in newly-emerging economies. But rapid growth usually comes with a price—pollution. Given the simultaneous rise in FDI and pollution level, it is natural to think that a positive correlation might exist between these two. Critics have accused foreign investors of shifting their heavily-polluting activities to countries with lax regulations in search of "pollution-haven", however, empirical evidence consistent with this hypothesis is surprisingly rare (Cole, 2004). Actually 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 awareness to achieve corporate social responsibilities (Lyon and Maxwell, 2008). Other stories include "protecting institutional reputation, appealing to 'green consumers', deterring lobbying and boycotts by environmental groups, avoiding regulatory scrutiny, and preempting future regulation"[1]. Under certain circumstances, we highly doubt the "pollution haven" hypothesis and propose the opposite idea that the more foreign firms invest in the host country, the more likely they become self-restrained in the sense of environmental protection.

In this paper we would like 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[2] for Environmental Management Systems, whose adoption is likely to be incurred by firms' spontaneous act[3]. Thus the possibility of acquiring ISO14001 is usually positively associated with firms' willingness to involve in the environmental protection. By quantifying firms' efforts before and after attending this program, we hope to answer the following questions: are foreign firms more active to be involved in ISO14001 than their domestic counterparts? How can ISO14001 improve firms' overall performance, especially their efforts in waste control?

By applying various methods to clear these doubts, this study differs from the previous literature in several ways: First, it will be the first paper to explore how firms' participation in voluntary program affects the pollution behavior in Vietnam, thus fill in the research gap in the developing countries (Arimura et al., 2014); Second, the

[1] Quoted from Bui and Kapon (2012).

[2] The environmental protection paradigm in developing countries is moving away gradually from compulsory approach to more flexible and voluntary ones (Tambunlertchai et al., 2013).

[3] Though some have argued that the adoption of ISO14001 is motivated primarily by domestic regulatory and market pressures (Khanna and Anton, 2002; Lyon and Maxwell, 2004). http://www.iso.org/iso/about/iso member.htm Accessed on 2014/11/25.

measurement will be based on multiple indexes, instead of single ones. After robustness check, we do achieve consistent results that support our hypothesis. The coherence, on the other hand, also leaves us the room for policy implications and future study.

This paper is organized as follows: in the next section we talk briefly about the pollution situation in Vietnam. Literature review then comes after. In section 4 we describe the data and estimation strategy, followed by robustness check and findings. Section 6 concludes.

2 Overview

2.1 About ISO14001

The International Organization for Standardization (ISO) was founded in 1946, which has 165 members by far, each representing a country. It is the most prominent developer of standards in the world. In 1980s, ISO introduced ISO9000 standards for quality manufacturing practices. Building on this system, ISO set up ISO14001 environmental standards in 1996[4]. According to the definition by ISO, ISO14001 sets out the criteria for an effective environmental management system so that firms can follow, aiming at minimizing the negative impact firms' operations might have on environment. The criteria includes, for example, whether firms are using environment-friendly materials for their production, whether the waste discharge has been properly dealt with (such as chemical cleaning detergent improvement), or whether some of the disposed wastes can be reused. By adopting ISO14001, firms can not only improve corporate image among regulators, customers and the public, but also reduce cost of waste management and distribution while increase savings in consumption of energy and materials; (ISO Homepage). The procedure is based on a Plan-Do-Check-Act cycle (for details see Martin, 1998).

Another feature of this standard is that the adoption takes a voluntary approach and the certification is performed by third-party organizations rather than direction application. The initial cost can be burdensome for small and medium-sized firms (it ranges from USD24,000~128,000, depending on the size of the firm. Jiang and Bansal, 2003). Firms also have to spend extra cost such as training and auditing fees. Thus firms are faced with a tradeoff between considerable cost to acquire ISO14001 and the benefits afterwards, which leads to the uncertainty of the adoption. In this paper, we try

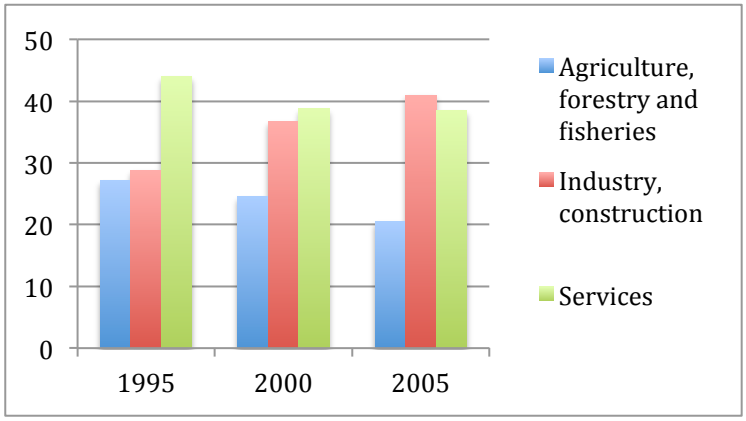
[4] In recent years, ISO22000 food safety standards, ISO26000 social responsibility standards, ISO36000 risk management standards, and ISO50001 energy management systems are also introduced.

to uncover the truth by focusing on the case of Vietnam.

2.2 Why Vietnam?

In this paper we would like to focus on Vietnam, a typical example that witnesses both fast growth in foreign investment and industrial pollution at the same time. According to Central Institute of Economic Management Report (CIEM) 2007 and CIEM 2008, FDI in 2007, as a share of Vietnam's GDP, has risen to more than 20%, to as much as five times that in 2000. In a single year between 2005 and 2006, about 60% of the total FDI were in the industrial sectors while 66.7% of the capital flew into heavy industries[5]. Figure 1 shows the structural change of the sectors in Vietnam. This is in line with Vietnam's national policy of rapid industrialization and transition from rural economy.

Figure 1: Structural Change in Vietnam (percentage)



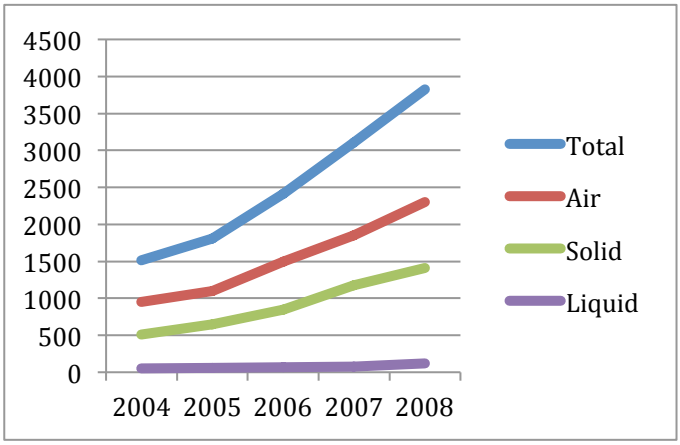
Source: Social-Economic Development Plan, 2006-2011

Meanwhile the pollution in Vietnam is considered to get even worse if the current pattern of industrialization continues and no further control is activated. Take air pollution, for instance, nearly half of Nitrogen dioxide (NO2) emission is due to industrial development, and when it comes to Sulfur dioxide (SO2) industry becomes the major criminal (Vietnam: Air Quality Profile 2010). These two kinds of pollutants are detrimental to both human health and the environment. Liquid (total suspended solids) and solid wastes (chemical and metal) also constitute a large portion of the total industrial discharge. Though Ministry and Departments of Natural Resources and

[5] Review and analysis of the pollution impacts from Vietnamese manufacturing sectors (2008), a report conducted by World Bank. Hereafter referred to as Review (2008).

Environment (MONRE) in Vietnam tries to record the pollution level in all aspects, the precise data is not available. Instead we approximate the amount of pollution in Vietnam by using the pollution intensity index constructed by World Bank's Industrial Pollution Projections System (IPPS). The same method has been applied in Mani and Jha (2006), and Ngo (2010). From Figure 2, we can see that the total pollution has risen by nearly 150 percent over five years. To decompose the contents, we find that most of the increase comes from air and solid waste, suggesting a possible shift in the waste composition[6].

Figure 2: Pollution Level in Vietnam (10,000 tons)



Source: Calculated by authors based on the statistics from World Bank's "Review and analysis of the pollution impacts from Vietnamese manufacturing sectors P89-93."

Given the fact that FDI keeps flooding into Vietnam, it should be important and interesting to investigate what role foreign firms play in "contributing" to this wave of pollution. By using ISO14001 as the benchmark, we would like to measure the awareness of foreign firms' environmental protection and the post-adoption performance, compared with the case for domestic firms. If positive result is to be achieved for the foreign firms, then we can provide more evidence to refute the "pollution haven hypothesis", at least in the context of Vietnam.

3 Literature Review

By far several studies have investigated the direct relationship between FDI and pollution level: Jiang et al. (2014), He (2006) as well as Eskeland and Harrison (2003)

[6] Review (2008) provides us with extra index: the most seriously polluted areas are those that experience the fastest economic growth, such as Ho Chi Minh City and Hanoi. They have the highest overall ranking on the National Pollution Index. As for sectors, heavy industries are undoubtedly responsible for the major waste discharge.

all reach the unanimous conclusion that FDI has a negative impact on the pollution level in the host country. Based on this stylized fact but taking a step further, we would like to make explicit of the mechanism behind the phenomenon. We will divide the process into two steps: to find out how FDI (or firm's ownership in the micro level) affects ISO14001 adoption and the impact of ISO14001 adoption on firms' polluting behavior.

As for the first step, there are mainly two kinds of theories: convergence and divergence (Prakash and Potoski, 2007). Convergence advocates claim that foreign subsidiaries usually conform to global standard rather than adapting to host country characteristics. In other words, if the subsidiaries come from a country with a high coverage of ISO14001 adoption, it is quite likely that these firms will also acquire the certificate in the host country. And within the convergence debate, the main stream opinion is that foreign firms face greater scrutiny from local government, which gives them more incentive to adopt ISO14001, or even encourage their suppliers. Thus FDI will have a positive influence on firms' adoption of ISO14001 in the target country. While divergence supporters hold the opposite opinion: foreign investors choose to locate in developing countries because they face less stringent environmental control. And they no longer need to play by the rule as they do in the home country[7]. In the empirical verification, positive relationship is found between FDI and ISO14001 adoption in Thailand (Tambunlertchai et al., 2013) as well as Malaysia (Arimura et al., 2014). Both studies applied firm level data. In the macro level, similar result is achieved (Prakash and Potoski, 2006). This paper will be aimed at re-evaluating FDI's role in the ISO14001 adoption preference.

The second step focuses on the relationship between ISO14001 adoption and firms' performance. There is a large theoretical literature to study the connection between compulsory regulations and firms' polluting behavior, but few are found to investigate voluntary program's impact (e.g. Lyon and Maxwell, 2008). The conclusion has been mainly drawn on empirical evidence. Previous studies have used single pollution measure to assess the impact of ISO14001 (Potoski and Prakash, 2005; Turk, 2009) and they all find ISO14001 reduces pollution discharge. Meanwhile, Arimura et al. (2008) verify ISO14001's positive influence on reducing both solid and liquid waste in the case of Japan. Furthermore, Arimura et al. (2011) find ISO14001 also improves firms' supply chain management. Apart from ISO14001, other voluntary environmental programs promote firms to curb pollution as well (Bui and Kapon, 2012; Kim and Lyon, 2011).

[7] Political economists also argue that corruption plays its part in affecting environmental policy stringency to attract FDI, such as Fredriksson et al. (2003), Cole et al. (2004).

Our methodology is closest to that used in Blackman et al. (2010). We will describe the estimation strategy and data in the following section.

4 Estimation Strategy and Data

4.1 Estimation Strategy

For empirical verification we apply the firm level data in Vietnam. To account for the potential self-selection endogeneity problem, we incorporate it into a two-step sample selection framework.

$$ISO_{it}^{*} = \delta_{it} \cdot Z_{it} + U_{it} \quad (1)$$

$$Y_{it} = \alpha_{it} + \beta_{iso} \cdot ISO_{it} + \beta_{i} \cdot X_{it} + \varepsilon_{it} \quad (2)$$

where ISO=1 if ISO*>=0 and ISO=0 if ISO*<0.

Firstly we estimate the propensity of firms' decision to adopt ISO on a series of exogenous variables. ISO is a dummy variable which takes value of 1 if firm i adopts ISO14001 at time t, otherwise 0. It's taken from the observed data. Zit in Eq. (1) is a vector of derterminants which lead to the adoption. It includes both objective and subjective firm characteristics. The former consists of firm size (number of labor), FDI (foreign capital/total capital) and capital-labor ratio while the latter includes answers based on the firms' self-evaluation, such as whether they follow the environmental regulations. U_{it} is the error term.

X_{it} in Eq. (2) has similar elements as Zit. But when the Heckman-style model is applied, exclusion restriction has to be met. Thus we include some of the subjective variables in the selection equation (Eq. (1)), but exclude them in the outcome equation. Basically we choose the explanatory variables consistent with Tambunlertchai et al. (2013) and Arimura et al. (2014), but have to give up some (export status, ISO9000 certification, etc) because of data availability. Concerning dependent variable Y_{it}, it has two sets of indicators: waste discharge and non-environmental performance (turnover, average salary and total factor productivity). Each variable of interest will be estimated separately[8]. Year dummies and industry dummies are included in both equations. See Table 1 for detailed description of the variables.

As for TFP, it needs extra effort. Since traditional solow residue's approach is unable to isolate the true productivity from statistical noise, recent literature has

[8] We use "treatreg" as our baseline estimation command and try other alternatives for confirmation.

exclusively proxy methods (Olley and Pakes, 1996; Levinsohn and Petrin, 2003)[9]. Unfortunately, due to quality issue, neither is the ideal method to be used in our analysis, though we use them as robustness check tools. Another option is stochastic frontier analysis (SFA). According to Kumbhakar and Lovell (2000), given the Cobb-Douglas production function, the model for the SFA is specified as[10]:

$$\ln y_{it} = \sum \beta_n \cdot \ln x_{nit} + v_{it} - u_{it} \qquad (3)$$

where x_{it} is a vector of inputs. v_{it} is the noise component and u_{it} is the nonnegative technical inefficiency component. Our objective is to obtain estimate of the technical efficiency which is the proxy for TFP of a particular firm.

$$TE_{it} = \exp\{-\hat{u}_{it}\} \qquad (4)$$

where it is assumed that $u_i \sim iid\ N^+(0,\sigma_u^2)$. The other options might include Normal-Exponential Model, Normal-Gamma Model. We will use them alternatively.

4.2 Data

This paper uses a panel dataset, constructed from the Vietnam Enterprise Survey (hereafter VES) at firm level. The data was collected by the General Statistics Office of Vietnam (hereafter GSO) for all sectors and industries, as on March 1st annually. Company characteristics such as ownership, labor, capital stock, turnover, assets, FDI share, average wage rate, intermediate materials are available. Apart from the above, GSO has taken a census of all multinational enterprises (MNEs), which are defined 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 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 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 relatively objective criteria which 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, we have to limit our analysis to

[9] Though De Loecker (2011) has criticized their methodology for ignoring the omitted price variable bias. Since we don't have the product information, we will not consider his method in this paper.

[10] To distinguish from Eq.(1)-(2), we use lowercased letters.

this time period. Finally, the detailed data on waste discharge categorized by form (air, liquid, solid) is complete. It differentiates between treated and untreated amount of waste as well, which is important for us to conduct the second stage estimation.

Certainly we have to admit that the survey has its drawbacks. For example, 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 an unbalanced panel data here. We remove the missing observations necessary to calculate TFP, and delete outliers. After these arrangements, the total number of observations for estimation is 28274 over three years.

This paper focuses on the ISO14001 adoption by manufacturing firms, since In VSE dataset, 85% of the firms that adopt ISO14001 are manufacturing firms. The manufacturing sectors include manufacture of food products industry, manufacture of beverages industry, manufacture of tobacco products industry, manufacture of textiles, manufacture of wearing apparel, manufacture of leather and related products, 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 coke and refined petroleum products, manufacture of chemicals and chemical products, manufacture of pharmaceuticals, medicinal chemical and botanical products, manufacture of rubber and plastics products, manufacture of other non-metallic mineral products, manufacture of basic metals, manufacture of fabricated metal products, except machinery and equipment, manufacture of other fabricated metal products; metalworking service activities , 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, manufacture of other transport equipment, manufacture of furniture, other manufacturing, and, repair and installation of machinery and equipment.

Table 1 lists up all the variables used for estimation. In order to take into account industrial heterogeneity, we include the categories of manufacturing sectors, as in Table 2. Statistical summaries are shown in Table 3. We use capital labor ratio and the number of labor (*Labor*) as a proxy for firm size, turnover as the firms' economic performance, firms' total salary as the firms' economic performance, TFP as the firms' economic performance. We also use ISO14001, *Emsystem*, *Envirstandard*, *Wastedept, Cleanemanufacture,* and *Cost_environ.* All data are obtained from VSE dataset. Turnover, firms' total salary, and total cost for environmental protection are normalized by manufacturing gross domestic products (hereafter GDP) deflator. Manufacturing GDP deflator is obtained from the World Bank.

[Table 1 is inserted here]

[Table 2 is inserted here]

[Table 3 is inserted here]

5 Results

5.1 Baseline Results

We employ treatment-effects model to analyze the determinants of ISO 14001 adoption and the effects of ISO 14001 adoption on environmental problems such as air pollution, water pollution, and land pollution, and firm's economic performances such as salary, turnover and productivity. The estimation results of the estimation of baseline model are summarized in Table 4. The first panel presents the estimation result of the equation of the determinants of ISO 14001 adoption. Foreign direct investment ratio, number of labor, and capital labor ratio are positively statistically significant at the 1% level in the first stage. These results indicate that firms with foreign capital actively adopt ISO14001. Firm size (*Labor*) is also the determinant of the adoption of ISO 14001. The positive sign of total labor indicates that the larger a firm is, the more likely it is to adopt ISO14001. Since the cost of ISO 14001 adoptions is high, larger firms have more capacity to participate in such voluntary programs. Meanwhile capital-labor ratio also plays a positive role, implying that capital-intensive firms prefer ISO14001. Capital-intensive firms exceed labor-intensive firms in technological capacity. This causes that capital-intensive firms are easier to adopt ISO 14001 than labor-intensive ones because of low cost of ISO 14001 adoptions due to relative high technological capacity.

Environmental protection variables such as *Emsystem*, *Envirstandard*, *Wastedept,* and *Cleanemanufacture* are also statistically positively significant at the 1% level in the first stage. Firms which carry out environmental management system, firms which meet requirements of environmental standard, and the firms which apply or carry out the clean manufacturing process are more likely to adopt ISO 14001. That is, firms which take measures against environmental issues tend to adopt ISO 14001. However, *Cost_environ* is not statistically significant. *Cost_environ* differ in size between firms, and this might produce the results. VSE dataset has no data of *Total Cost* during 2006 to 2009, and then, we cannot use "the environmental protecting cost ratio" which is the

total costs of the enterprise for environmental protection divided by total costs. From the point of view of industry sector dummies, *a_mnf*, *c_mnf*, *d_mnf*, and *e_mnf* are positively statistically significant at the 1% level. Firms in these industry sectors are likely to adopt ISO14001.

The second panel of Table 4 presents the estimation results of the effects of ISO14001 adoptions on pollutions and on firm's economic performances. Columns (1), (2) and (3) present the effects of ISO14001 adoptions on pollutions. ISO 14001 adoptions are positively significantly at the 1% level in all three column. These results show that ISO 14001 adoptions increase the share of treated air or water or solid wastes, and therefore improve air pollution, water pollution and solid pollution. As long as waste discharge is concerned, ISO14001 adoptions increase the share of treated wastes in all three forms. The result provides evidence that once firms acquire this environmental certificate, they raise the awareness of environmental protection and try to control their polluting behavior.

When looking at the industry sector dummies, *c_mnf*, *d_mnf*, and *e_mnf* are statistically significant at the 1% level in column (1), *a_mnf*, *b_mnf*, *d_mnf*, and *e_mnf* are statistically significant at the 1% level in column (2), and *a_mnf*, *b_mnf*, and *c_mnf* are statistically significant at the 1% level in column (3). *c_mnf*, and *d_mnf* sectors make efforts to reduce air pollution, but *e_mnf* sector doesn't. *a_mnf* sector makes efforts to reduce water pollution, but *b_mnf, d_mnf,* and *e_mnf* sectors do not. Finally, *c_mnf*, and *d_mnf* sectors make efforts to reduce solid pollution, but *e_mnf* sector doesn't.

Columns (4), (5) and (6) present the effects of ISO14001 adoptions on firm's economic performances. ISO 14001 adoptions are positively significantly at the 1% level in all three column. These results show that ISO 14001 adoptions also improve firm's economic performances. The positive economic impact of ISO14001 on firms' total salary, turnover and total factor productivity is telling us another story. After firms adopt ISO14001, the cost of managing the waste is reduced and allows firms to have more resources (capital and labor) to allocate. As a consequence, it benefits the firms by shifting up their economic performance. Firms' devotion to the social responsibility can lead to a win-win situation.

[Table 4 is inserted here]

5.2 Robustness Check

To ensure the robustness of our results, there are several issues that need further clarification. Since the term of validity for ISO14001 is 3 years, it is likely that firms

might "lose status" during anytime in between 2007-2009. If they fail to renew the certificate, then our estimation results would be biased when we count these firms as ISO14001-adopted. In order to alleviate the concern, we limit the samples to the firms that did not change the ISO14001 status or newly acquired ISO14001 during 2008-2009. The results are shown in Table 5. ISO14001 is still positively significant in all kinds of specifications, which supports our baseline estimation results. Furthermore, we use waste department, total_cost_environment, environment_system and environment_standard alternatively as exclusive variables in the first stage, and the results remain unchanged[11]. Concerning TFP calculation, Levinsohn and Petrin' method is also tried. We get similar and consistent results in all cases[12].

[Table 5 is inserted here]

Next, we use propensity score matching (PSM) to confirm our findings. The purpose of our estimation is to find out the average treatment effect on the treated (ATT), which in this paper is the difference of performance between ISO14001 adopters and non-adopters. The accurate measurement needs random experimental settings, however, the counterfactual phenomenon is usually unobserved. Rosenbaum and Rubin (1983) propose the propensity score which can be used in our analysis to match the adopters with non-adopters. We will use the first stage equation as introduced in Section 4.1 to predict the likelihood a firm adopts ISO14001.

The challenge is that firms didn't report in which year they acquired ISO14001. Thus we use the information in year 2007 (the first year of the observation) to calculate firms' propensity score of ISO adoption. Then we match them with the firms in 2009 (the last year) that have similar propensity and compare their difference. If the performance indicators in these two years are significantly different, then we can make the judgement that ISO14001 has potentially promoted firms to improve. To proceed, we further assume that by controlling the covariates, the error term will be uncorrelated with the decision of firms' adopting ISO14001[13].

Our treatment sample (ISO14001=1) varies from 825 in year 2007 to 1201 in year 2009. The average value of each control variable for the treated is higher than that for the control. For example, the average TFP for the treated group is 0.56 compared to 0.49 for the control group. The estimation results are consistent with the statistical

[11] We attempt different estimation models such as ivtreatreg. The results remain unchanged.
[12] To save space, we did not report all the results but they are available upon request.
[13] In reality this assumption can be violated. For example, a policy shock in some industry might promote firms to apply for ISO, and an opposite scenario can also be considered.

intuition. In Table 6, we report results for both nearest 1-to-1 matching and kernel matching in each model. ATT estimates are all significantly except for solid waste. This indicates that by adopting ISO14001, firms' overall performance will be greatly improved.

[Table 6 is inserted here]

We conduct the balance tests (for matched) as well. The results of t test for each covariate does not reject the null hypothesis that the mean between treated and control are equal, meaning the models balance the covariates quite well. Another evidence is that the standardized bias is 4.5% for kernel matching estimator while 1.4% for nearest 1-to-1 matching estimator. Based on the discussion in Caliendo and Kopeining (2008), standardized bias below 5% is enough to justify the balance.

Despite the strong evidence that ISO14001 improves firms' competitiveness, and raise their awareness of environmental protection, the estimation might still suffer from bias due to data limitation, as previously explained. More accurate result can be achieved if we have more detailed information on the background of ISO14001 adoption, e.g., why firms in some industries or areas have higher tendency to acquire ISO, especially in the context of Vietnam. It also leaves us room for future study on whether ISO's impact is temporary or not.

6 Conclusion

We use the firm level data from 2007-2009 in Vietnam to investigate the impact of the adoption of ISO14001, a voluntary environmental standard. In the empirical verification, two-stage selection model is applied to correct for the potential selection bias. The results show that foreign firms are more likely to adopt ISO14001, and the adoption does affect firms' overall performance, ranging from reduction on waste discharge to turnover and productivity. We use propensity score matching as the robustness check and obtain consistent results. This finding is in according with most of the existing literature[14]. It also provides evidence to refute the critics of "pollution haven" and makes acknowledgeable foreign firms' effort towards environmental protection. In the meantime we are aware of the limitation of this study. With more detailed information, we would like to extend our analysis to investigation into more specific industries and regions.

[14] Blackman et al. (2010) do not find significant impact of Clean Industry Program on average environmental performance.

Vietnam is undergoing fast economic transition, however, it is important for Vietnamese government to realize its current situation of industrial pollution. We hope this paper can offer decision-makers some clue to explore the real source of pollution and come up with more efficient ways to protect the environment.

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Table 1: Definitions of variables

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	Real salary
Turnover	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	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 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 3: Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Air	131584	0.809	6.281	0	90
Liquid	131584	5.302	16.430	0	100
Solid	131584	6.328	16.586	0	99.900
Salary	204168	2549.993	2549.993	0	2740906
Turnover	204168	4110.692	446357.1092	1.079	110604912
TFP	203168	0.487	0.145	0.000	0.850
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	139.399	8615.973	0	1867600
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

Table 4: Baseline estimation using two-stage treatment model

1st stage	iso14001
FDI	0.00164***
	(0.000382)
Labor	0.000115***
	(1.09e-05)
emsystem	0.631***
	(0.0427)
envirstandard	0.681***
	(0.0392)
wastedept	0.415***
	(0.0390)
cleanmanufacture	0.116***
	(0.0402)
totalcost4environ_	6.63e-07
	(5.13e-07)
y2	0.0601
	(0.0425)
y3	-0.00803
	(0.0391)
a_mnf	0.257***
	(0.0569)
b_mnf	-0.0225
	(0.0688)
c_mnf	0.440***
	(0.0599)
d_mnf	0.282***
	(0.0573)
e_mnf	0.665***
	(0.0626)
cap_lab	0.000116***
	(2.91e-05)
Constant	-2.836***
	(0.0606)

Standard errors in parentheses

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

Effects of ISO 14001 adoption on environmental and economic performance

	(1)	(2)	(3)	(4)	(5)	(6)
2nd stage	air	liquid	solid	ssalary	turnover	TFP
FDI	-0.0199***	0.0747***	0.0207***	9.150**	266.7**	0.000410***
	(0.00254)	(0.00530)	(0.00471)	(3.724)	(114.3)	(2.36e-05)
Labor	1.21e-05	0.000368	0.000648***	27.33***	230.1***	8.30e-06***
	(0.000111)	(0.000231)	(0.000207)	(0.163)	(5.004)	(1.03e-06)
y2	-0.218	1.075**	0.419	677.9*	14,464	0.00518**
	(0.251)	(0.525)	(0.467)	(368.5)	(11,310)	(0.00233)
y3	-0.622***	-0.431	-1.531***	685.6**	17,993*	0.0124***
	(0.235)	(0.491)	(0.436)	(344.3)	(10,567)	(0.00218)
a_mnf	0.357	8.694***	-5.917***	739.7*	128,380***	0.0261***
	(0.306)	(0.640)	(0.569)	(449.6)	(13,795)	(0.00284)
b_mnf	-0.347	-3.298***	-2.320***	-1,647***	-99,605***	-0.0395***
	(0.360)	(0.752)	(0.669)	(528.1)	(16,208)	(0.00334)
c_mnf	0.662*	-0.494	-2.274***	1,519***	12,788	0.0482***
	(0.368)	(0.769)	(0.685)	(540.8)	(16,592)	(0.00342)
d_mnf	1.919***	-2.195***	-0.442	941.4**	41,414***	0.00925***
	(0.294)	(0.614)	(0.546)	(431.2)	(13,232)	(0.00273)
e_mnf	-1.807***	-3.623***	0.253	1,370**	116,731***	0.0267***
	(0.409)	(0.855)	(0.762)	(601.6)	(18,454)	(0.00380)
cap_lab	0.00208***	0.00186***	0.000175	3.774***	255.3***	2.96e-05***
	(0.000263)	(0.000551)	(0.000490)	(0.387)	(11.87)	(2.45e-06)
iso14001	15.07***	39.10***	14.56***	15,834***	722,407***	0.138***
	(0.937)	(1.919)	(1.767)	(1,396)	(42,532)	(0.00873)
lambda	-7.258***	-21.03***	-7.789***	-6,037***	-266,855***	-0.0623***
	(0.524)	(1.053)	(1.001)	(790.7)	(23,935)	(0.00490)
Constant	2.683***	17.39***	28.41***	-1,209***	-57,790***	0.462***
	(0.259)	(0.541)	(0.481)	(380.1)	(11,664)	(0.00241)
Observations	18,140	18,140	18,140	18,140	18,140	18,140

Note: "treatreg" model with “twostep” option is applied.

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

Table 5 After removing observations that have changed ISO status

	(1)	(2)	(3)	(4)	(5)	(6)
1st Stage	ISO14001	ISO14001	ISO14001	ISO14001	ISO14001	ISO14001
fdi_capital	0.00180***	0.00180***	0.00180***	0.00180***	0.00180***	0.00180***
	(0.000396)	(0.000396)	(0.000396)	(0.000396)	(0.000396)	(0.000396)
total_labor	0.000114***	0.000114***	0.000114***	0.000114***	0.000114***	0.000114***
	(1.12e-05)	(1.12e-05)	(1.12e-05)	(1.12e-05)	(1.12e-05)	(1.12e-05)
capital_labor ratio	0.000120***	0.000120***	0.000120***	0.000120***	0.000120***	0.000120***
	(2.95e-05)	(2.95e-05)	(2.95e-05)	(2.95e-05)	(2.95e-05)	(2.95e-05)
environment_system	0.637***	0.637***	0.637***	0.637***	0.637***	0.637***
	(0.0448)	(0.0448)	(0.0448)	(0.0448)	(0.0448)	(0.0448)
enviroment_standard	0.707***	0.707***	0.707***	0.707***	0.707***	0.707***
	(0.0412)	(0.0412)	(0.0412)	(0.0412)	(0.0412)	(0.0412)
waste_department	0.413***	0.413***	0.413***	0.413***	0.413***	0.413***
	(0.0406)	(0.0406)	(0.0406)	(0.0406)	(0.0406)	(0.0406)
clean_manufacturing	0.0855**	0.0855**	0.0855**	0.0855**	0.0855**	0.0855**
	(0.0418)	(0.0418)	(0.0418)	(0.0418)	(0.0418)	(0.0418)
totalcost_environment	7.36e-07	7.36e-07	7.36e-07	7.36e-07	7.36e-07	7.36e-07
	(6.20e-07)	(6.20e-07)	(6.20e-07)	(6.20e-07)	(6.20e-07)	(6.20e-07)
2nd Stage	air	liquid	solid	total_salary	turnover	TFP
iso14001	14.84***	39.57***	15.90***	13,836***	647,846***	0.136***
	(0.979)	(2.016)	(1.865)	(1,190)	(38,822)	(0.00921)
fdi_capital	-0.0197***	0.0766***	0.0197***	10.31***	266.7***	0.000418***
	(0.00254)	(0.00535)	(0.00477)	(3.038)	(99.85)	(2.38e-05)
total_labor	2.75e-05	0.000400*	0.000615***	23.29***	194.0***	8.43e-06***
	(0.000112)	(0.000235)	(0.000211)	(0.134)	(4.413)	(1.05e-06)
capital_labor ratio	0.00204***	0.00173***	8.09e-05	3.144***	214.7***	2.91e-05***
	(0.000263)	(0.000554)	(0.000494)	(0.315)	(10.35)	(2.46e-06)
lambda	-7.218***	-21.30***	-8.403***	-5,010***	-232,699***	-0.0600***
	(0.543)	(1.098)	(1.048)	(669.1)	(21,697)	(0.00514)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,785	17,785	17,785	17,785	17,785	17,785

Note: "treatreg" model with “twostep” option is applied.

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

Table 6 Results using propensity score matching

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	air	air	liquid	liquid	solid	solid
Method	Nearest	Kernel	Nearest	Kernel	Nearest	Kernel
ATT	2.398*	2.437**	3.572*	1.574	1.673	-0.326
	(1.629)	(1.364)	(2.307)	(1.881)	(2.129)	(1.731)
Observations	1,935	1,935	1,935	1,935	1,935	1,935
	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	total_salary	total_salary	turnover	turnover	TFP	TFP
Method	Nearest	Kernel	Nearest	Kernel	Nearest	Kernel
ATT	12890.702**	4632.676**	197537.429**	164014.116**	0.018**	0.032***
	(6013.768)	(2793.106)	(97780.390)	(81050.043)	(0.009)	(0.008)
Observations	1,935	1,935	1,935	1,935	1,935	1,935

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (One-tail significance test is conducted.)