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RESEARCH ARTICLE

Does ISO14001 raise firms' awareness of environmental protection? The case of Vietnam

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Abstract
Environmental protection is an issue that all developing countries must cope with when inviting foreign direct investment (FDI). However, the high correlation between FDI and pollution does not necessarily indicate that foreign firms are to blame. In this study, we apply firm-level panel data from Vietnam and unique information on waste discharge to demonstrate that foreign firms are actually more proactive in acquiring ISO14001 certification. ISO14001 is a voluntary environmental standard, the adoption of which improves 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 them as well.

Keywords: Environmental protection; FDI, ISO14001, Vietnam

JEL Classification: D22, F21, F64, Q56

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 the '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 the advanced waste-processing technology adopted by foreign firms and their awareness of corporate social responsibility (Lyon and Maxwell, 2008). Other motivation can 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 are to 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[1] for environmental management systems, and is likely to be adopted spontaneously by firms. 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 get involved more in waste management, which can ultimately benefit the firms themselves. This study differs from the 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 the 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 the instrumental variable method and propensity score matching (PSM)[2] to verify. The results are consistent and support our aforementioned hypothesis.

The remainder of this paper is organized as follows. In section 2, we briefly discuss the pollution situation in Vietnam, followed by a literature review in section 3. Section 4 describes the data and estimation strategy, and section 5 provides the robustness check and our findings. Lastly, section 6 concludes the paper.

2. Overview

2.1 About ISO14001

The International Organization for Standardization (ISO) was founded in 1946, and currently has 165 members, each representing a country. It is the most prominent developer of standards in the world. In the 1980s, ISO introduced the ISO9000 standards for quality manufacturing practices. Building upon this system, ISO set up ISO14001 for environmental standards in 1996.[3] According to ISO, ISO14001 sets out the criteria for an effective environmental management system, aimed at minimizing the negative

[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]Details on PSM, which include methodology and results, are presented in the online appendix.

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

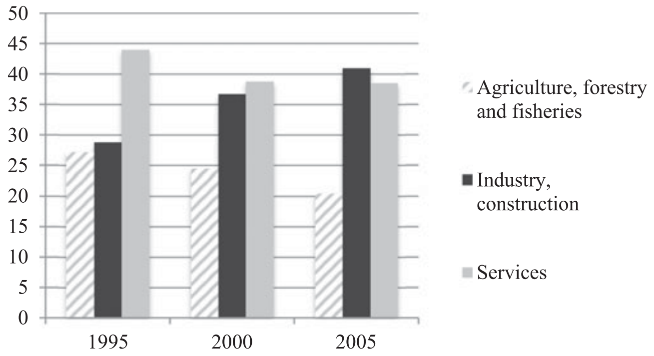

Figure 1. Structural change in Vietnam (percentage)
Source: Government of Vietnam (2001).

impacts that firms' operations might have on the environment. Examples of these criteria include whether firms are using environment-friendly materials for their production, whether waste discharge has been properly dealt with (e.g., chemical cleaning detergents), and whether disposed waste can be reused. By adopting ISO14001, firms are able not only to improve their corporate image among regulators, customers and the public, but also to reduce the cost of waste management and distribution, and increase savings in their consumption of energy and materials ISO (2015). The procedure is based on a plan–do–check–act cycle (for more detail, see Martin, 1998).

Other features of this standard are that adoption is voluntary, and the certification is performed by third-party organizations, rather than by direct application. However, the initial cost can be burdensome for small- and medium-sized firms (US$24,000–128,000), depending on the size of the firm (Jiang and Bansal, 2003). Firms also have to spend extra on training fees, auditing fees, and so on. Thus, firms are faced with a trade-off between the considerable cost of acquiring ISO14001 certification and the subsequent benefits, which leads to uncertainty with regard to the utility of adoption. In this study, we try to determine whether incentives exist for firms to adopt ISO14001, focusing on the case of Vietnam.

2.2 Why Vietnam?

We focus on Vietnam because it is a typical example of a country that has witnessed rapid and simultaneous growth in foreign investment and industrial pollution. According to the Central Institute of Economic Management (CIEM, 2007, 2008) reports, in 2007 FDI as a share of Vietnam's GDP rose by more than 20 per cent, to as much as five times what it was in 2000. Between 2005 and 2006, about 60 per cent of total FDI occurred in industrial sectors, with 66.7 per cent of this capital being invested in heavy industries (Dore *et al.*, 2008). Figure 1 shows the structural change in the economic sectors in Vietnam, which is in line with Vietnam's national policy of rapid industrialization and its transition from a rural economy.

At the same time, pollution in Vietnam is anticipated to worsen if the current pattern of industrialization continues and no further controls are implemented. For example, nearly half of all nitrogen dioxide (NO_2) emissions are due to industrial development. In addition, industry is a major source of sulfur dioxide (SO_2) emissions (CAI-Asia,

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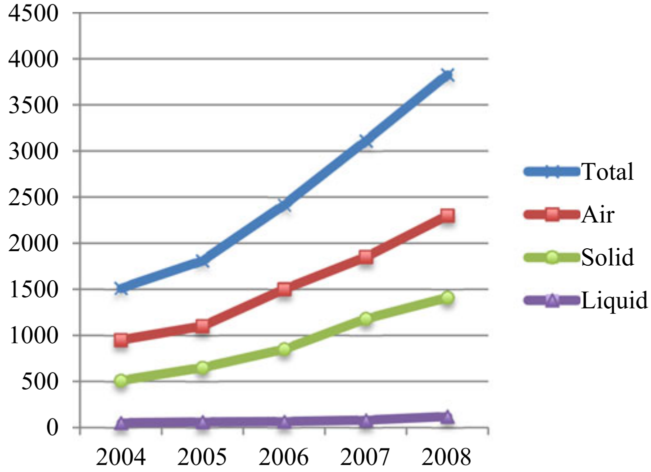

Figure 2. Pollution level in Vietnam (10,000 tons)
Source: Calculated by authors based on the statistics from Giovanna (2008).

2010). Both of these pollutants are detrimental to human health and to the environment. Both liquid (total suspended solids) and solid (chemical and metal) waste constitute a large portion of total industrial discharge. Although the Ministry of Natural Resources and Environment in Vietnam tries to maintain detailed records on pollution levels, precise data are not available. Therefore, we approximate Vietnam's pollution levels using the pollution intensity index constructed by the World Bank's Industrial Pollution Projections System. The same method has been applied by Mani and Jha (2006). Figure 2 indicates that total pollution rose by nearly 150 per cent over the five-year period 2004–2008. We find that most of the increase comes from airborne and solid waste, suggesting a possible shift in waste composition.[4]

Given that FDI continues to increase in Vietnam, it is important and interesting to investigate the role played by foreign firms in 'contributing' to pollution. Using ISO14001 as a benchmark, we measure foreign firms' awareness of environmental protection and post-adoption performance compared with those of domestic firms. If a positive relationship can be found between foreign ownership and the degree of awareness of acquiring ISO14001, at least we can provide the evidence that foreign firms are indeed more active in participating in environment-protection programs.

3. 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

[4] Dore *et al.* (2008) provide us with an extra index: the most seriously polluted areas (those with the highest overall ranking in the National Pollution Index) are those that experience the fastest economic growth, such as Ho Chi Minh City and Hanoi. With regard to sectors, heavy industry is undoubtedly responsible for the majority of the waste discharge.

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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 inputs 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 there, and are no longer bound by the same rules as those in their home country.[5] 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 (Prakash and Potoski, 2006; Potoski and Prakash, 2011). Given these contrasting theories, this study re-evaluates 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 the 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 (De Jaeger *et al.*, 2011; Kim and Lyon, 2011; Bui and Kapon, 2012).

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.

[5] Akbostanci *et al.* (2007) empirically verified that this phenomenon exists in Turkey. In addition, political economists such as Fredriksson *et al.* (2003) have argued that corruption affects the stringency of environmental policy in terms of attracting FDI.

4. Estimation strategy and data

4.1 Estimation strategy

4.1.1 Baseline specification

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

$$\text{ISO}_{ijt} = \delta_{ijt} \cdot Z_{ijt} + \alpha_i + \alpha_j + \alpha_t + U_{ijt}, \tag{1}$$

$$Y_{ijt} = \beta_{ISO} \cdot \text{ISO}_{ijt} + \beta_i \cdot X_{ijt} + \alpha_i + \alpha_j + \alpha_t + \varepsilon_{ijt}. \tag{2}$$

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 the value of 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, which includes both objective and subjective firm characteristics.[6] 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,[7] and year dummies and industry dummies are included in both equations. Table 1 provides a detailed description of the variables.

Determining TFP needs 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.[8] According to Kumbhakar and Lovell (2000), given the Cobb–Douglas production function, the model for SFA is specified as follows[9]:

$$\ln y_{it} = \sum (\beta \cdot \ln x_{it}) + v_{it} - u_{it}, \tag{3}$$

where x_{it} is a vector of inputs, v_{it} is the noise component, and u_{it} is the non-negative technical inefficiency component. Our objective is to obtain an estimate of technical efficiency, which we use as a proxy for the TFP of a particular firm, as follows:

$$TE_{it} = \exp\{-\hat{u}_{it}\} \tag{4}$$

where we assume that $u_i \sim iidN^{+}(0, \sigma_u^2)$. Since v_{it} is usually assumed to be normally distributed, this model is said to have a normal–half-normal error term. We also examine

[6] We choose explanatory variables that are consistent with those in Tambunlertchai *et al.* (2013) and Arimura *et al.* (2014), although we exclude some (e.g., export status, ISO9000 certification, etc.) owing to data unavailability.

[7] We use 'treatreg' as our baseline estimation command, and alternative commands for confirmation.

[8] Other options include the methods of Olley and Pakes (1996) and Levinsohn and Petrin (2000). Unfortunately, owing to insufficient information on investment or intermediate material, neither is ideal in our analysis, even though we use them for robustness checks.

[9] To distinguish the variables from those in equations (1) and (2), we use lowercase letters.

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Table 1. Definitions of variables (abbreviations used in the manuscript)

Variables	Definition
Air	Share of treated air waste, treated air waste divided by total air waste, (%)
Liquid	Share of treated water waste, treated liquid waste divided by total liquid waste, (%)
Solid	Share of treated solid waste, 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 adopt the clean environmental standard system? 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 employees
FDI	Foreign direct investment ratio, (%)

the robustness by using alternative distributions of the error terms, such as a combination of the normal and the exponential distributions, and a combination of the normal and the gamma distributions. And this does not change our predictions.

4.1.2 Self-selection problem

However, if we want to estimate the equations (1) and (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 $\mathrm{Cov}(U, \varepsilon) \neq 0$, 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/average salary, as a whole. But 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).

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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 that 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 our 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 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 an 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 a department) in an industry. As for the first ratio, we divide the number of firms that have already adopted 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.[10]

Take the first instrument, which we define as *ration_emsystem*, for example, since this is an industry-level measurement of how many firms have carried out environmental management system and usually is 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 *ration_emsystem* is used to proxy ISO14001, $\mathrm{Cov}(U, \varepsilon) = 0$ and β_{ISO} in equation (2) will capture the sole impact of adopting ISO14001 on a firm's behavior. The same argument applies to *ration_wastedept* as well. In practice, we conduct the analysis by applying each individual IV, and their combinations.

4.2 Data

We use a firm-level panel data set constructed from the Vietnam Enterprise Survey (VES). The data are collected annually by the General Statistics Office of Vietnam (GSO) for all sectors and industries on March 1. Company characteristics such as ownership, labor, capital stock, turnover, assets, FDI share, average wage rate, and intermediate materials are available. Furthermore, GSO takes a census of all multinational enterprises, which are defined as firms that have foreign capital, regardless of the share. The advantage of this data set is that the investment behavior of these foreign-capitalized firms can be captured over time. A census is also taken for firms with more than 10 employees. Each firm has an exclusive enterprise code, which we use together with the province code to identify firms.

[10] We also apply other industry-level IVs as well, such as ratio of firms with a certificate. The data 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, but the results are not presented due to space constraints.

Another unique advantage of this data set is that it collects information on firms' engagement in environmental protection activities, including money spent on environmental protection; whether the firm employs an environmental management system; whether it follows a clean manufacturing process; and so on. Above all, the firm's status with regard to possession of the ISO14001 certification is recorded. Since these are relatively objective criteria, free from measurement error, we use them to create our ISO adoption dummy. Unfortunately, ISO status information is only available for the period 2007–2009, which means we have to limit our analysis to this time frame. Finally, detailed data on waste discharge is 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.

Certainly, the survey has drawbacks, including incomplete information about exports and imports, missing data on materials and other variables, and a lack of conformity in units across years. Consequently, we have unbalanced panel data. Here, we remove missing observations in order to calculate the TFP and delete outliers, yielding 28,274 observations over three years for the estimation.

We focus on the adoption of ISO14001 by manufacturing firms because, in the VES data set, such firms constitute 85 per cent of those that adopt ISO14001.[11]

Table 1 lists the variables used in the estimation. In order to account for industrial heterogeneity, we include the categories of manufacturing sectors in online appendix table A1. Statistical summaries are shown in online appendix table A2. 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*, *Cleanemanufacture*, and *Cost_environ*. All data are obtained from the VES data set. The values of firms' turnover, total salaries, and total cost for environmental protection are normalized using the manufacturing GDP deflator obtained from the World Bank. In order to avoid the potential influence of outliers in the data, we exclude the highest 1 per cent of the following variables: *Air*, *Liquid*, *Solid*, *Salary*, *Turnover*, *TFP*, and *Cost_environ*.[12]

5. Results

5.1 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,

[11] The manufacturing sectors are listed in the online appendix table A1.

[12] 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 per cent of these variables.

Table 2a. 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 (0.00119)	0.00203*** (0.0005)	0.00206*** (0.00005)	0.00118*** (0.000413)	0.00138*** (0.00041)	0.00168*** (0.000385)
Cap_lab	0.000180*** (0.00006)	0.000148*** (0.00004)	0.000173*** (0.00004)	0.000059 (0.000038)	0.000091** (0.000039)	0.000124*** (0.000030)
Labor	0.000293*** (0.00006)	0.000174*** (0.00002)	0.000166*** (0.00002)	0.000276*** (0.00004)	0.000184*** (0.00003)	0.000111*** (0.00001)
Emsystem	0.917*** (0.135)	0.693*** (0.0619)	0.746*** (0.0590)	0.574*** (0.0448)	0.561*** (0.0447)	0.625*** (0.0434)
Environ-standard	0.459*** (0.106)	0.664*** (0.0543)	0.683*** (0.0529)	0.662*** (0.0415)	0.655*** (0.0415)	0.671*** (0.0396)
Clean-manufacture	0.252** (0.1190)	0.0721 (0.0556)	0.0677 (0.0521)	0.147*** (0.0429)	0.139*** (0.0427)	0.116*** (0.0406)
Wastedept	0.259** (0.1197)	0.401*** (0.0567)	0.384*** (0.0544)	0.399*** (0.0416)	0.409*** (0.0416)	0.401*** (0.0401)
Cost_environ	−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)
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.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

turnover and productivity. The estimation results of the baseline model are summarized in tables 2a and 2b.

Table 2a 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 per cent level in the first stage. The share

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Table 2b. 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*
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)
FDI (-1)	0.0428** (0.0171)	0.00500* (0.00302)	0.00864*** (0.00228)	0.00882*** (0.00025)	0.00910** (0.00035)	0.000399*** (0.00002)
Cap_lab	0.00007 (0.00111)	0.000228 (0.000319)	−0.000157 (0.000239)	0.000177*** (0.000027)	0.000471*** (0.000042)	2.52×10^{-5}*** (2.55×10^{-6})
Labor	−0.00108 (0.00101)	−0.000163 (0.000131)	-2.47×10^{-6} (0.00010)	0.0025*** (0.00003)	0.00137*** (0.00003)	8.07×10^{-6}*** (1.03×10^{-6})
2008 year dummy	−5.421*** (1.333)	−1.481*** (0.316)	−0.601*** (0.223)	−0.0920*** (0.0246)	0.0764** (0.0338)	0.00560** (0.00233)
2009 year dummy	−2.793** (1.308)	−0.280 (0.299)	−0.536** (0.212)	−0.0106 (0.0230)	0.147*** (0.0316)	0.0128*** (0.00217)
a_mnf	−4.093** (1.906)	−0.759** (0.380)	−0.104 (0.287)	−0.230*** (0.0297)	0.215*** (0.0411)	0.0207*** (0.00284)
b_mnf	4.738* (2.802)	−0.648 (0.488)	−0.264 (0.323)	0.124*** (0.0361)	−0.234*** (0.0488)	−0.0391*** (0.00332)
c_mnf	−3.125 (2.202)	−0.432 (0.464)	−0.424 (0.330)	0.0414 (0.0359)	0.425*** (0.0493)	0.0466*** (0.00341)
d_mnf	−13.436*** (1.694)	−1.626*** (0.405)	−2.709*** (0.258)	0.0363 (0.0284)	0.0373 (0.0390)	0.00733*** (0.00271)
e_mnf	−8.966*** (2.817)	−2.465*** (0.538)	−0.265 (0.357)	0.111*** (0.0402)	0.250*** (0.0555)	0.0239*** (0.00379)
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. The command treatreg of Stata version 14 is applied. Standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

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 per cent 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 per cent 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

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firms do, they can adopt ISO14001 more easily than labor-intensive firms can because of the relatively lower cost of ISO14001 adoption.

Environmental protection variables are always positive and statistically significant in specifications at the 5 per cent 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 VES 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 the five columns (except column (1)) are positive and statistically significant at the 1 per cent 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 per cent and 5 per cent levels, respectively. These results indicate that firms in these industry sectors are likely to adopt ISO14001.

Table 2b 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 foreign capital) is positive and statistically significant at the 10 per cent 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 per cent 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 per cent 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.

5.2 Robustness check

5.2.1 IV method

The results using the first IV–ratio of the firms that have an environmental management system (*ratio_emsystem*) only are presented in table 3. 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 the Stock-Yoko weak instrument test

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Table 3. 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_lab	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)
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)
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)

(*continued*)

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Table 3. Continued

2nd stage	(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*
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*** (6.40×10^{-5})	−0.00795 (0.0107)	−0.169 (0.468)	0.0238*** (0.00802)
Capital_lab	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)
Labor	0.00177*** (0.000262)	0.000551** (0.000269)	-1.10×10^{-5}* (5.66×10^{-6})	−0.00233 (0.00161)	−0.0355 (0.0773)	0.00144** (0.000716)
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)
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 used for the Sanderson-Windmeijer F statistic.

Table 4. 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 environmental 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_lab	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-06)	6.68e-05*** (7.15e-06)
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-06)	5.86e-05*** (2.58e-06)
2008 year dummy	−0.00169 (0.00640)	−0.00179 (0.00635)	0.00244 (0.00664)	0.00606 (0.0114)	-3.03×10^{-5} (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)

(*continued*)

Table 4. Continued

2nd stage	(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*
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*** (6.19×10^{-5})	−0.00806 (0.0107)	−0.000190 (0.124)	0.0304*** (0.00895)
Capital_lab	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)
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)
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)

(*continued*)

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Table 4. Continued

2nd stage	(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*
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)
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 used for the Sanderson-Windmeijer F statistic.

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 share of treated air and liquid waste. Similar conclusions can be drawn for 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 4. The prediction 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. In the meantime, 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. In keeping 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 the over-identification test C 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 serve to promote a firm's overall performance, but its influence on share of treated air and solid waste is not robust.

6. 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 PSM as robustness checks, and obtain consistent results. The findings presented here are in accordance with most of the existing literature.[13] We also find evidence to support foreign firms' efforts toward 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 paper can offer decision-makers some guidance in terms of implementing efficient policies to protect the environment. For example, such policies could further encourage ISO14001

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

adoption and call on more firms to participate in voluntary environment programs in order to realize the real benefits of doing so.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X18000396.

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