The Role of ISO 14001 in China's Environmental Crisis

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Abstract

Adoption of the ISO 14001 environmental management standard is analyzed using data drawn from a survey of manufacturing firms in China. The analysis proceeds by first identifying predictors of ISO 14001 adoption and then estimating the relationship between ISO 14001 adoption and compliance with environmental regulations. Potential endogeneity between ISO 14001 and environmental performance is addressed by estimating ISO 14001 adoption and regulatory compliance models simultaneously using the SURBP estimator. Results indicate that ISO 14001 adoption increases compliance with environmental regulations, and this effect persists after implementing the appropriate controls for endogeneity.

Introduction

Worsening environmental conditions have earned China a reputation for putting economic growth ahead of sustainability. China is currently the largest emitter of greenhouse gasses in the world (New York Times, 2007), and home to 20 of the 30 most polluted cities in the world (World Bank, 2010). Given the strong potential cross-border effects of problems such as excessive air and water pollution, China's environmental crisis has become a subject of global as well as local concern. A central element of China's development strategy has been increased integration with world markets. China's accession to the WTO in 2001 sparked concerns that it would become a participant in the global "race to the bottom": the competitive lowering of environmental or other production standards to increase competitiveness on export markets and attract foreign direct investment (FDI) (Porter, 1999). However, careful analysis has shown that WTO accession had a significant positive effect on China's environmental quality. Vennemo et al. (2008) use a computable general equilibrium (CGE) model to decompose changes in key emissions categories in China along the lines of scale, composition and technique effects as described in Copeland and Taylor (2004). They find WTO accession had a net positive effect on environmental performance in China, driven in large part by the reallocation of resources away from pollution-intensive sectors. These results largely concur with the industry case studies presented in a report by the International Institute for Sustainable Development (IISD, 2004).

Venemo et al. (2008) also find evidence of reductions in certain emissions categories due to the adoption of cleaner production techniques. According to Copeland and Taylor (2004), increased openness to trade can lead to the use of "cleaner" technologies as the domestic policy environment responds to increased demand for environmental amenities driven by rising incomes. As incomes rise, domestic consumers demand greater environmental quality, and policy makers respond to those demands by tightening regulation of emissions. This type of endogenous policy response seems unlikely in a country known for poor enforcement of its regulatory standards like China (Beyer, 2006). McGuire and Sheldon (2012) show that similar technique effects can result from liberalization in the presence of a credible voluntary standard. At the same time that it was lowering trade barriers to comply with WTO rules, China experienced a dramatic increase in the adoption of the ISO 14001 environmental management standard. ISO 14001 adoption has increased exponentially, rising from only a few hundred firms in 1999 to nearly 70,000 firms in 2010. China is currently the largest adopter of the ISO 14001 standard in the world.

ISO 14001 is an internationally recognized standard certifying a firm has implemented a system to mitigate and continuously improve its environmental impact. Previous studies of ISO 14001 adoption outside of China have produced mixed evidence regarding its effectiveness (for example, see Potoski and Prakash, 2005 vs. Barla, 2007), but how ISO 14001 adoption has affected environmental performance in China remains an open question. What follows is an empirical analysis of ISO 14001 adoption in China using a unique firm-level data set on Corporate Social Responsibility (CSR) among Chinese manufacturers. The analysis identifies several predictors of ISO 14001 adoption in China and provides evidence that ISO 14001 adoption improved environmental performance among adopting firms. This may help explain why WTO accession was not followed by rapid environmental decline, despite China's weak domestic environmental regulations.

The paper proceeds as follows. Section one provides additional background on environmental regulation in China. Section two surveys the existing literature on the ISO 14001 standard. Section three discusses the data and empirical methodology. Estimation results are presented in Section 4. Section five discusses the results and concludes.

1: Environmental Regulation in China

China's first environmental regulations were written in the 1980s and 1990s, beginning with standards on water pollution in 1984, air pollution in 1987 and solid waste in 1995.[1] Complementary laws relating to soil and water conservation as well as biodiversity were passed in the 1990s and early 2000s (Beyer, 2006). Regulatory standards established by these laws were initially set at the federal level by the State Environmental Protection Agency (SEPA). SEPA was elevated to a ministerial-level agency in 2008, now called the Ministry of Environmental Protection (MEP), to signal the central government's new focus on sustainable development.

The MEP is tasked with administering environmental policies handed down by the National People's Congress (NPC) and coordinating with local Environmental Protection Bureaus (EPB). EPB's are vested with the power to monitor emissions, perform site inspections and levy fees according to national regulatory standards. Polluters are required to submit declarations of their total emissions to their local EPB, which then determines if they are consistent with applicable environmental laws. Firms are granted licenses for emissions that do not violate legal standards. Polluters are faced with fees to acquire these licenses as well as "discharge excess fees" for emissions above the licensed level. Firms that commit gross violations of the standard are faced with escalating penalties and egregious offenders could be

[1] China's first environmental regulation, the Environmental Protection Law, was passed provisionally in 1979. It established that enterprises would have to pay a fee for discharges exceeding prescribed emissions standards.

forced to shut down.

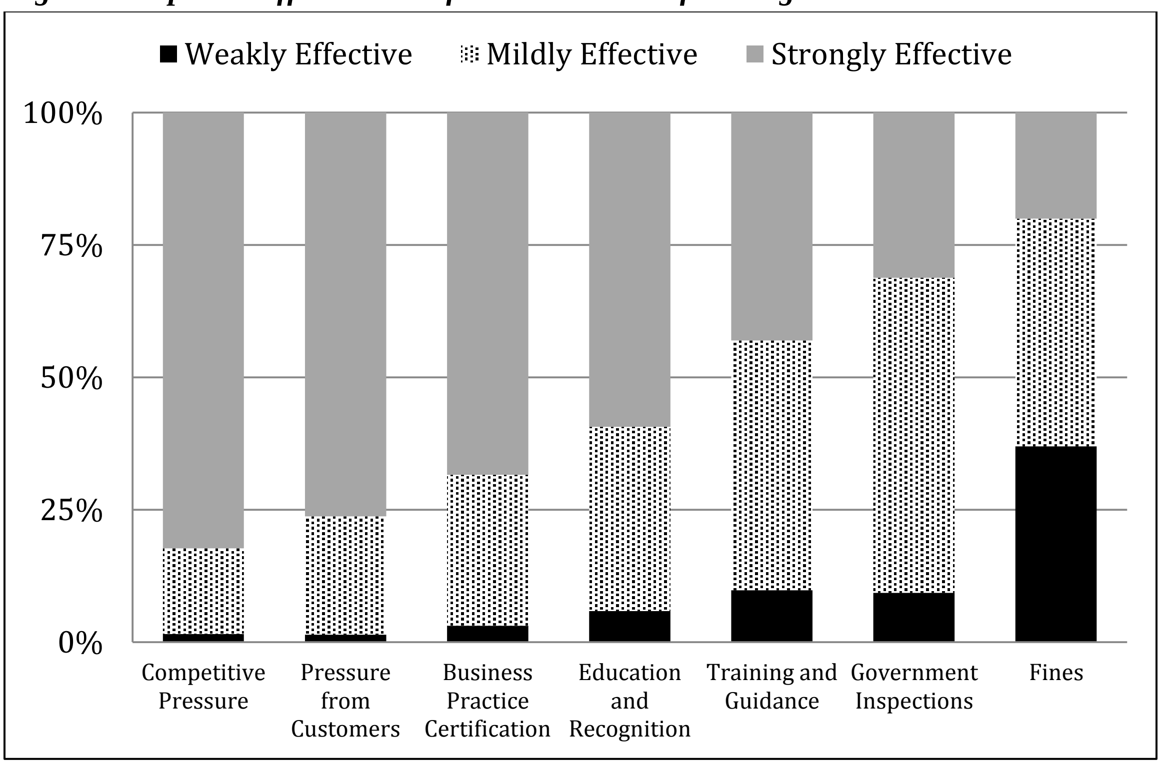
Official statements from the MEP tend to emphasize the progress that China has made in reducing emissions of key pollutants (see e.g. MEP, 2009), but these regulators are also keenly aware of “enforcement gaps” limiting the effectiveness of the current regulatory system (Stokoe and Gasne, 2008). The general consensus is that the system is undermined by weak local enforcement. Beyer (2006) argues that the fundamental problem with China's environmental regulation system is the fact that policy is set at the federal level while there is no mechanism for federal oversight in the enforcement process, which is done locally. Excess discharge fees are often subject to individual negotiation and local regulators may be more inclined to please local business interests than a distant federal authority. This problem is compounded by the fact that the biggest polluting enterprises also tend to be state-owned (Lo et al., 2006).

The result is widespread under-enforcement of environmental regulations. Winalski (2009) found that, while the number of discharge permits issued doubled between 1996 and 2000, it still lagged far behind the number of known polluting enterprises. In some areas, only 20% of polluting enterprises applied for discharge licenses at all. Beyer (2006) also reports collected fees are often made available to local polluters in the form of “grants” for investments in cleaner technology, but without adequate supervision of how the funds are used. Even when fines are levied appropriately, Stokoe and Gasne (2008) report maximum penalties are often set well below the cost of compliance.

The MEP has recently tried to address these “enforcement gaps” by developing new enforcement regimes that do not adhere so closely to the standard-and-penalty model. Zhang and Wen (2008) describe the government’s recent steps toward promoting the adoption of cleaner production technologies instead of focusing exclusively on end-of-the pipe treatment and control. The government has also introduced new regional standards for total concentrations of certain air and water pollutants, though it is not clear how these total control targets are allocated into individual permits (Winalski, 2009). Certain municipalities have also experimented with emissions permit trading schemes, though these have not yet been scaled up to the national level.

Despite these innovations, environmental regulation in China still relies heavily on the discharge permit system to control emissions. The conflicting incentives faced by local EPBs lead to systemic under-enforcement of environmental regulations and contribute to environmental degradation as China continues to grow.

Figure 1: Reported Effectiveness of Various Means of Raising Firm Standards in China



Note: Data taken from the Industrial Enterprise Survey conducted by China's NBS

The results of a recent survey on CSR in China highlight how ineffective these command

and control structures seem to be. Managers were asked to rate the effectiveness of several different ways they are encouraged to raise production standards. As shown in Figure 1, respondents rated traditional regulatory instruments, such as inspections and fines, as the least effective means of raising production standards. At the same time, they rated certifications, demand from customers and competitive pressure as the most effective. These findings suggest that institutions which provide market-based incentives for raising production standards might be the most effective means of addressing China's environmental crisis.

2: Previous Literature

2.1: The ISO 14001 Environmental Management Standard

Voluntary standards such as ISO 14001 were developed to overcome weaknesses in traditional regulatory instruments. The United States, for example, has experienced a great deal of success with its 33/50 program, a voluntary emissions reduction program introduced in 1991 to complement existing environmental regulations (Innes and Sam, 2009; Khanna and Damon, 1999). Such programs are seen as cost-effective alternatives to command-and-control regulation. Firms voluntarily over-comply with regulations in order to tap into "green" price premiums from environmentally conscious consumers (Eriksson, 2004) or to strategically preempt future tightening of environmental regulations (Lyon and Maxwell, 2003). In either case, voluntary standards provide incentives for firms to lower emissions while reducing the administrative and monitoring costs associated with traditional regulation.

ISO 14001 is one of the most popular voluntary environmental standards in the world. In 2010, there were over 250,000 ISO 14001 certified firms worldwide, with 69,784 in China alone (ISO, 2011). ISO 14001 was established in 1996 by the International Organization for

Standardization (ISO) to provide an internationally-recognized gold standard for environmental management systems (EMS), and to prevent the proliferation of mutually incompatible national standards. The existing literature often uses the terms ISO 14000 and ISO 14001 interchangeably.[2] To clarify, ISO 14000 refers to a *family* of standards, ranging from the ISO 14001 environmental management system standard to other standards on environmental communication (14063), life-cycle assessment (14040), and greenhouse gas accounting (14064). Unlike the U.S.'s 33/50 program, ISO 14001 does not commit firms to an emissions target. The ISO explains that ISO 14001 provides specific guidelines for the establishment of environmental management systems that are relevant for a wide range of industries and firms at various levels of "environmental maturity" (ISO, 2012). An ISO 14001 compliant EMS must enable firms to:

- Identify and control their environmental impact
- Continually improve their environmental performance
- Implement a systematic approach to achieving environmental goals

Certifying firms' EMS instead of environmental performance has helped establish ISO 14001 as a brand recognizable to a wide range of public and private sector entities (Potoski and Prakash, 2005). This has also helped to encourage ISO 14001 adoption in less developed countries (Clapp, 1998). As ISO 14001 was being developed, there was some concern the standard would act as a *de facto* trade barrier, giving firms in rich countries a competitive advantage if ISO 14001 compliance required meeting strict (and costly) emissions targets. Instead, ISO 14001 requires that firms commit to meeting their local legal obligations to environmental protection. Environmental regulations vary from place to place, so ISO 14001

[2]See, for example, Curkovic et al. (2005) vs. Welch et al. (2002).

certified firms in different countries could have very different emissions levels.

The flexibility inherent in ISO 14001 has led to considerable skepticism over its ability to deliver improved environmental outcomes (see e.g. Krut and Gleckman, 1998; Potoski and Prakash, 2005). While firms are expected to improve their environmental performance, firms seeking certification in the ISO 14001 system are not evaluated on their actual legal compliance. They need only develop an effective internal process for achieving legal compliance (ECA, 2010). Controversy over the effectiveness of ISO 14001 has led to a great deal of research aimed at understanding why firms choose to adopt ISO 14001 and identifying its effect on their actual environmental performance.

2.2: Previous Studies of ISO 14001 Adoption

The literature on the diffusion of the ISO 14001 standard has focused primarily on identifying the determinants of ISO 14001 certification (see Nishitani, 2009 for a comprehensive review). Adoption of the standard is typically understood as a profit-maximizing strategy, whereby firms use the certification to earn higher revenues by credibly signaling the underlying quality of their production process. Several empirical findings are robust across different model specifications and country settings. Firms are more likely to adopt ISO 14001 if they deal with environmentally conscious consumers. Adoption is also correlated with firm size and profitability. Nishitani (2009) argues this is because larger and more profitable firms are better able to afford the costs of initial certification, which can range from $24,000 to $128,000. Potoski and Prakash (2005) report the total cost of compliance (including adoption of new technologies) often exceeds $1,000,000. It would likely be a mistake to treat these factors as exogenous to the certification decision. Certification can be used to attract customers who value environmentally-friendly products. Certification can also increase firm size and profitability if these "green" consumers are willing to pay more for goods produced with high environmental standards.

There has also been considerable research on the relationship between ISO 14001 certification and export participation. Several studies have highlighted the importance of ISO 14001 as a means for firms to access global value chains (Nishitani, 2010; Prakash and Potoski, 2007), but the empirical evidence is mixed. Nishitani (2009) finds a positive correlation between ISO 14001 adoption and exporting among a sample of Japanese manufacturers, but Dasgupta et al. (2000) find no such relationship in their sample of Mexican manufacturing firms. Using country-level data, Prakash and Potoski (2006) found that countries with high levels of ISO 14001 trade more with each other. Boys and Grant (2010) perform a similar analysis, but find importing countries do not generally show a preference for partners with similar certification levels. They still found certification was associated with larger export volumes, but they argue that the absence of preferential selection among importers implies certification is correlated with some unobserved firm characteristic that is important for exporting.

Very few scholars have studied ISO 14001 adoption in China, despite the standard's popularity among Chinese firms. Christmann and Taylor (2001) studied ISO 14001 adoption in a sample of 86 firms in China and found that ties to multinational corporations and exports to Japan were associated with adoption of ISO 14001. Fryxell et al. (2004) and Zeng et al. (2005) examine the motives for ISO 14001 certification samples of ISO 14001 certified firms. They found ISO 14001 adopters sought certification to boost their reputation, enhance regulatory compliance and gain access to lucrative international markets. Unfortunately, these results are difficult to interpret because their sampling strategy did not allow for comparisons between ISO 14001 adopters and non-adopters. To date, no study has examined ISO 14001 adoption in China with a large, representative sample of firms.

2.3: ISO 14001 and Environmental Performance

Proponents of ISO 14001 highlight the standard's potential to improve environmental outcomes even in countries where environmental regulations are weak, but the empirical evidence on ISO 14001 and environmental performance is mixed. Arimura et al. (2008), Potoski and Prakash (2005) and Dasgupta et al. (2000) find that adoption of ISO 14001 increased compliance with environmental regulations in samples of manufacturing firms. These findings are contradicted by Dahlstrom et al. (2003), who found no effect of ISO 14001 certification on compliance with the UK's Integrated Pollution Control regime. King et al. (2005) found ISO 14001 certified firms generally exhibited poorer environmental performance. Barla (2007) actually found that emissions levels rose following certification among a sample of firms in Canada's pulp and paper industry. Potoski and Prakash (2005) point out identifying the effect of ISO 14001 certification on environmental performance requires implementing the appropriate controls for endogeneity. Firms with superior environmental performance for other reasons might find it easier to meet the requirements for ISO 14001 certification. This makes it difficult to identify the direction of causality between ISO 14001 and environmental performance. Potoski and Prakash (2005) and Dasgupta et al. (2000) demonstrate how to derive a set of valid instruments for ISO 14001 certification by first identifying the predictors of certification adoption.

Potoski and Prakash (2005) also argue ISO 14001 may be more effective if customers actively monitor the certified firm's environmental performance. Since poor environmental performance is not technically grounds for decertification, firms may use ISO 14001 as a form of "green washing." It allows them to present an environmentally-friendly image without making any substantial changes in their performance. Christmann and Taylor (2006) address a similar question in a study of the ISO 9001 quality management system standard in China. They find more frequent customer inspections led to "higher quality" management standard implementation, using self-reported data in a sample of ISO 9001 certified firms. Incorporating information on this type of ex-post monitoring could also be important for understanding the relationship between ISO 14001 and environmental performance.

3: Data and Methodology

The following is an empirical analysis of ISO 14001 adoption and the effect of ISO 14001 adoption on environmental performance in a sample of Chinese manufacturing firms. Following Potoski and Prakash (2005) and Dasgupta et al. (2000), the analysis begins by identifying predictors of ISO 14001 adoption. These predictors are then used as instruments to identify the relationship between ISO 14001 certification and environmental performance.

3.1: Data Description

The data are drawn from a unique firm-level dataset on CSR collected in 2006. The survey was funded by the International Finance Corporation and conducted by China's National Bureau of Statistics (NBS).[3] The full sample included 1,268 manufacturing firms. Approximately 100 firms were interviewed in each of 12 cities spread throughout China. After

[3]There exists no official English translation of the data set. The questionnaire used for this study was translated from Chinese by the author.

cleaning the data set and eliminating observations with missing information, 840 firms remain. Cities were not chosen randomly, but rather to represent the various stages of economic development observed within China.

Figure 2 shows the location of each city sampled in the survey.

Figure 2: Geographical Distribution of Sampled Cities

Within cities, firms were selected using a stratified sampling strategy. First, firms were stratified by ownership type and sampled in proportion with each ownership category's overall representation within the city. Firms were then stratified according to size and sampled according to each size category's representation within the city.

The survey was designed to study firms' attitudes and behavior related to CSR. Firms were asked to describe their production processes, the benefits they offer their workers and the measures they take to protect the local environment. This includes coordination with local regulators and community groups as well as adoption of ISO 14001. The survey also collected more general information about the firm (e.g. size, ownership, industry category), as well as firms' perceptions of their market and regulatory environments. Although the survey provides recall data on a few of the relevant characteristics, variables relating to environmental protection and ISO certification were only recorded in cross-section. This makes it difficult to control for unobservable firm-level heterogeneity, but the data set is otherwise uniquely well-suited to studying ISO 14001 and environmental performance among manufacturing firms in China.

The survey collected information on each firm's 4-digit industry code under China's industrial classification system. Industry classification was used to construct a set of fixed effects to control for any unobserved, industry-specific heterogeneity. Constructing a unique dummy for each four-digit code would maximize the explanatory power of the system, but including so many dummy variables often leads to convergence problems when estimating limited-dependent variable models. This is because some categories contain very few firms, even after aggregating up from four-digit to two-digit industry categories. In order to avoid convergence problems, certain categories were combined with other, related industry categories.

Table 1 describes the how the two-digit categories were aggregated to derive this new set of industry fixed effects. This aggregation scheme reduces the number of industry categories from 36 to 13. The smallest category (Wood Products) represents 1.36% of the sample, while the largest category (Manufacturing) represents 27.12% if the sample.

Table 1: Construction of Industry Categories

Aggregate Category	Two-Digit Category	% of Sample
Mining	Coal Mining and Dressing	0.26%
	Ferrous Metal Mining & Dressing	0.17%
	Non-ferrous Metal Ores Mining and Dressing	0.43%
	Non-Metal Ores Mining and Dressing	0.43%
Agricultural Processing	Agriculture and Sideline Foods Processing	5.27%
Food and Tobacco	Food Production	2.98%
	Beverage Production	2.04%
	Tobacco Products Processing	0.09%
Textiles	Textile Industry	6.97%
Other Textiles	Clothes, Shoes and Hat Manufacture	3.66%
	Leather, Furs, Down and Related Products	1.87%
Wood Products	Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	0.51%
	Furniture Manufacturing	0.85%
Paper Products	Papermaking and Paper Products	1.87%
	Printing and Record Medium Reproduction	1.70%
	Cultural, Educational and Sports Articles Production	0.26%
Fuels	Petroleum Processing, Coking and Nuclear Fuel Processing	0.94%
Chemicals	Raw Chemical Material and Chemical Products	9.10%
	Medical and Pharmaceutical Products	2.55%
	Chemical Fiber	0.85%
	Rubber Products	0.94%
	Plastic Products	3.15%
Mineral Products	Nonmetal Mineral Products	6.72%
	Smelting & Pressing of Ferrous Metals	3.15%
	Smelting & Pressing of Non-Ferrous Metals	2.21%
Manufacturing	Metal Products	3.91%
	Ordinary Machinery Manufacturing	6.29%
	Specialty Equipment Manufacturing	4.42%
	Transport Equipment and Manufacturing	12.50%
Electrical Equipment	Electric Machines and Apparatuses Manufacturing	5.53%
	Communications Equipment	3.57%
	Instruments, Meters, Cultural and Office Machinery Manufacture	1.28%
	Craftwork and Other Manufactures	0.77%
Utilities	Electricity and Heating Production and Supply	1.96%
	Fuel Gas Production and Supply	0.26%
	Water Production and Supply	0.60%

3.2: ISO 14001 Adoption Model Specification

Summary statistics and definitions for each variable used in the empirical analysis are presented in Table 2.

Table 2: ISO 14001 Adoption Model Summary Statistics and Variable Definitions

Variable	Definition	Mean	S.D.
ISO 14001	=1 if ISO 14001 certified	0.16	
EPD	=1 if firm has established an environmental protection department	0.54	
Revenue	Total revenue (100k yuan)	2.64	16.03
Customer	=1 if customers demand high environmental standards	0.63	
Inspection	=1 if customers inspect the firm	0.76	
CxI	Interaction term between Customer and Inspections	0.50	
FJV	=1 if foreign joint venture	0.21	
Exporter	=1 if firm sells some output abroad	0.44	
ISO 9001	=1 if ISO 9001 certified	0.63	

ISO 14001 certification is a binary decision, so it is possible to estimate the relationship between ISO 14001 and its predictors using a standard probit model. Certification status is measured with a dummy variable (*ISO 14001*) equal to one if the firm was ISO 14001 certified when the survey was administered, and zero otherwise. The existing empirical literature suggest ISO 14001 certification should be positively correlated with firm size as well as export status. Sinking the costs associated with ISO 14001 is only justified if certification delivers higher revenues. Firm size is measured using total revenues (*Revenue*), expressed in units of 100,000 yuan.[4] The model also predicts a positive correlation with export status, because both strategies require sinking substantial fixed costs and will only be adopted by the most productive firms. Export status is measured using a dummy variable (*Exporter*) equal to one if the firm reported any export revenue in the year the survey was administered, and zero otherwise. It may also be

[4] Each model specification was also estimated using total employment to measure firm size. Results were robust to either specification.

possible to predict certification status by observing the costs firms have sunk in environmental protection efforts. These sunk costs are captured using a dummy variable (*EPD)* equal to one if the firm had established an environmental protection department at the time of the survey.

The existing empirical literature suggests consumer preferences are also an important determinant of certification. The survey asked firms whether or not any of their customers had requested they take some steps to manage the firm's environmental impact. The response to this question was used to construct a dummy variable (*Customer*) equal to one if the firm's customers had requested some environmental protection, and zero otherwise. This reflects the firm's access to potentially high-premium markets for "green" goods. As Potoski and Prakash (2005) point out, certification might not improve environmental performance unless firms are subject to some form of ex-post monitoring. The survey asked firms whether or not their customers inspected their facilities for "quality management" purposes. These inspections may also provide customers with information on firms' true environmental performance. This ex-post monitoring is measured using a dummy variable (*Inspection*) equal to one if the firm allows customers to inspect their facilities, and zero otherwise. Since these inspections would be more relevant for "green" customers, the model also includes an interaction term between these two variables (*CxI*). [5]

Following Christmann and Taylor (2001), each model includes a dummy variable (*FJV*) equal to one if the firm was a foreign joint venture, and zero otherwise. Christmann and Taylor (2001) argue foreign ownership may lead to increased scrutiny and therefore more self-

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[5] *Customer* and *Inspection* were de-meaned before being included in the regression models in order to address the high degree of collinearity between these two variables and their interaction term.

regulation. Helpman, Melitz and Yeaple (2005) showed only the most productive firms engage in FDI. Since certification is also a strategy adopted by high-productivity firms, the positive correlation between ISO 14001 and foreign ownership share could also reflect differences in productivity between certified and uncertified firms. In either case, foreign joint ventures would be more likely to adopt ISO 14001.

Finally, each model includes a dummy variable (*ISO 9001*) equal to one if the firm had ISO 9001 certification when the survey was administered. The literature on ISO 14001 generally finds a positive relationship between ISO 9001 and ISO 14001 certification, for example Christmann and Taylor (2001). Researchers argue firms with ISO 9001 certification may be more likely to adopt ISO 14001 because they face lower effective costs. These firms would already know the general structure of an ISO management standard, they would be familiar with the necessary paperwork involved in certification and they may already have established relationships with local ISO auditors.

Estimating a single-stage probit model ignores any potential endogeneity between ISO 14001 certification and the determinants identified above. The estimated relationships should therefore not be interpreted causally. However, the goal of this estimation exercise is to identify a set of variables that predict certification status. This will provide a set of potential instruments for ISO 14001 certification and can provide some sense of how well ISO 14001 adoption in China conforms with findings in the previous literature.

3.3: Environmental Performance Model Specification

Estimating a standard ordinary least squares (OLS) or single-stage limited dependent variable model would ignore potential endogeneity between ISO 14001 and environmental performance. Firms with high environmental performance for reasons unrelated to ISO 14001 may self-select into the standard because they find it easier to meet the requirements. In order to identify the causal relationship between ISO 14001 certification and environmental performance, it is necessary to implement the appropriate controls for endogeneity.

This relationship is estimated using two separate binary indicators of environmental performance. One is a dummy variable (*Compliance*) equal to one if the firm reported it was in compliance with all relevant environmental regulations in the year the survey was administered. The second is a dummy variable (*Violation*) equal to one if the firm was cited for violating an environmental regulation in the year the survey was administered.

The environmental performance models are estimated including two additional control variables not previously included in the ISO 14001 models. One is a measure of the number of environmental standards that apply to the firm and its products (*Standards*). This controls for differences in the strictness of the regulatory environment not captured by city or industry fixed effects. Each model also includes a variable measuring the number of times the firm was inspected by their local EPB in the year the survey was administered (*GInspections*). This controls for differences in environmental performance driven by direct pressure from regulators. Summary statistics for these variables can be found in Table 3.

Table 3: Environmental Performance Model Summary Statistics and Variable Definitions

Variable	Definition	Mean	S.D.
Compliance	=1 if reports compliance with environmental regulations	0.87	
Violation	=1 if cited for violating environmental regulations	0.08	
GInspections	# of inspections by local EPB	4.23	14.25
Standards	# of applicable environmental standards	3.21	1.84

Four models are estimated for each measure of environmental performance. The sample size for the environmental performance models is smaller than the sample used in the ISO 14001 adoption model. This is because fewer firms provided information on environmental performance than on ISO certification. The sample size falls from 840 to 558. First, a naïve probit model is estimated including firms' observed ISO 14001 certification status (*ISO 14001*) as an independent variable in both regressions. Subsequent models are estimated using the appropriate estimation technique to control for potential endogeneity between *ISO 14001* and environmental performance. Both measurements of environmental performance and *ISO 14001* are binary, so traditional two stage least squares and IV probit are not appropriate. Greene (2000) shows the seemingly unrelated bivariate probit estimator (SURBP) is appropriate for this case.[6]

SUR estimators are generally used to estimate systems of equations where potential correlation of the residuals across equations leads to a loss of efficiency. This framework naturally extends to the estimation of a limited dependent variable model with a potentially endogenous binary regressor. Assume a simple example where the full model is specified as:

$$Y = \alpha_1 + \beta_1 X + \varepsilon_1 \qquad Y^* = \begin{cases} 1\ if\ Y > 0, \\ 0\ otherwise \end{cases}$$

$$X = \alpha_2 + \beta_2 Z + \varepsilon_2 \qquad X^* = \begin{cases} 1\ if\ X > 0, \\ 0\ otherwise \end{cases}$$

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} | Z \sim N\left(0, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}\right)$$

[6] The same models were also estimated using traditional two-stage least squares and instrumental variables probit. The results were qualitatively similar and, in each case, supported the instrumentation strategy adopted in the SURBP models.

Correlation between the error terms leads to endogeneity because it induces correlation between X and ε_1 in the Y model. This endogeneity will bias parameter estimates as long as $\rho \neq 0$. Estimating this system using the bivariate probit estimator corrects for potential bias in the calculation of treatment effects of X on Y.

As in a standard IV strategy, identifying the model requires finding a set of regressors (Z) that are correlated with the binary endogenous regressor (X) but not the dependent variable of interest (Y), except through their relationship with X. Testing the restriction $\rho = 0$ is typically used as a test of exogeneity in a well-specified SURBP model with an endogenous binary regressor. The normal tests for weak instruments and the exclusion restriction do not apply. Standard procedure to test instrument quality is a joint chi-squared test of significance for the excluded instruments (Z) in the first stage (X) regression. In the case of an over-identified model, where there are two or more elements in Z, the exclusion restriction can be tested in two steps. The first step is to estimate a just-identified specification of the model, including all but one element of Z in the second stage (Y) model. The second step is to perform a chi-squared test of joint significance of the elements of Z in the second stage (Y) model. Valid instruments should fail to reject the null of joint insignificance in the second stage model (Y) (Rashad and Kaestner, 2003).

The SURBP model is first estimated using the full set of independent variables from the ISO 14001 adoption model described in the previous section. The model is then re-estimated using a restricted subset of the determinants of *ISO 14001* to ensure the exclusion restriction is satisfied. The final specification excludes any other potentially endogenous variables from the environmental performance equation to avoid inducing bias through so-called “bad control”

(Angrist and Pischke, 2008). All specifications include city and industry fixed effects. Estimation results for *Violation* are presented in Table 5. Estimation results for *Compliance* are presented in Table 6.

4: Results

3.4: ISO 14001 Adoption Model Results

Table 4 presents results for three specifications of the ISO 14001 certification model.

Table 4: Predictors of ISO 14001 Certification

Dependent Variable: *ISO 14001*	(1)	(2)	(3)
ISO 9001	1.40 [A]	1.38 [A]	1.36 [A]
	(0.00)	(0.00)	(0.00)
Exporter	0.31 [B]	0.23	0.24
	(0.03)	(0.17)	(0.16)
Revenue	0.02 [B]	0.02 [B]	0.02 [B]
	(0.05)	(0.04)	(0.04)
FJV	0.16	0.19	0.17
	(0.37)	(0.29)	(0.33)
EPD	1.11 [A]	1.07 [A]	1.08 [A]
	(0.00)	(0.00)	(0.00)
Customer		0.43 [B]	0.42 [C]
		(0.01)	(0.05)
Inspection			-0.001
			(0.99)
CxI			0.73[B]
			(0.04)
Constant	-3.23 [A]	-3.15 [A]	-3.21 [A]
	(0.00)	(0.00)	(0.00)
Observations	840	840	840
Pseudo R2	0.32	0.33	0.33
LR Test P-Value	0.00	0.00	0.00

Notes:
1. Robust P-Values in parentheses. A: p<0.01, B: p<0.05, C: p<0.1
2. All specifications include city and industry fixed effects

Each model was run on 840 observations and included city and industry fixed effects, in addition to the variables listed in the table. Reported p-values for each parameter were calculated using robust standard errors clustered at the city level. The results of the likelihood ratio tests reported at the bottom of Table 4 indicate each specification of the model had significant predictive power for ISO 14001 certification.

The results generally conform to expectations Several relationships were robust across every model specification. *Revenue* was positively related to ISO 14001 certification in every specification. There was also a consistent positive and significant relationship between *ISO 9001* and ISO 14001 certification. Firms with an established *EPD* were also significantly more likely to be ISO 14001 certified in every specification. The relationship between *Exporter* and certification was positive in every specification, but only significant in column (1). The p-value on the estimated coefficient falls after introducing controls for customer type (*Customer*). The coefficient on *Customer* is positive and significant in models (2) and (3). *Inspection* was not a significant predictor of ISO 14001 certification, but the estimated coefficient on the interaction term (*CxI*) was positive and significant in model (3). Foreign joint ownership (*FJV*) was not a significant predictor of ISO 14001 certification in any specification of the model.

3.4.3: Environmental Performance Model Results

Estimation results are presented in Table 5 and Table 6. Not all firms provided information on their regulatory compliance, so both models are run on a sub-sample of 558 observations. Sample sizes are slightly smaller in each column (1) because certain observations are excluded due to perfect predictability. Chi-squared tests indicate all specifications have significant predictive power. Results of the Wald test of $\rho = 0$ indicate the null of zero correlation across error terms can only be rejected in column (2) of Table 6. Despite this generally negative result, King et al. (2005) advise proceeding with the SURBP specification when there is good theoretical justification to suspect endogeneity.

Table 5: Estimation Results for Violation

Dep. Variable: *Violation*	(1) Probit	(2) Violation	(2) ISO14001	(3) Violation	(3) ISO14001	(4) Violation	(4) ISO14001
ISO 14001	-0.44^{B}	-0.81^{C}		-1.37^{A}		-1.09^{A}	
	(0.03)	(0.05)		(0.00)		(0.01)	
Standards	0.01	0.02		0.01		-0.004	
	(0.90)	(0.84)		(0.83)		(0.96)	
GInspections	0.002	0.002		-0.00			
	(0.68)	(0.48)		(0.98)			
ISO 9001			1.28^{A}		1.24^{A}		1.31^{A}
			(0.00)		(0.00)		(0.00)
Exporter			0.15		0.15		0.18
			(0.27)		(0.26)		(0.24)
Revenue			0.02^{C}		0.02^{B}		0.02^{B}
			(0.06)		(0.05)		(0.04)
FJV			0.23	-0.71^{A}	0.20	-0.76^{A}	0.21
			(0.15)	(0.02)	(0.27)	(0.00)	(0.22)
EPD			0.95^{A}	0.62^{A}	0.95^{A}	0.56^{A}	1.03^{A}
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Customer			0.59^{B}	0.10	0.54^{B}		
			(0.02)	(0.72)	(0.03)		
Inspection			-0.21	-0.003	-0.23		
			(0.22)	(0.99)	(0.30)		
C x I			1.05^{A}	-0.51	1.07^{A}		
			(0.01)	(0.15)	(0.01)		
Constant	-2.07^{A}	-1.36^{A}	-3.26^{A}	-1.47^{A}	-2.68^{A}	-1.53^{A}	-3.07^{A}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	537	558		558		558	
Chi^2 (Fit) P-Val	0.04	0.00		0.00		0.00	
Anderson Stat. P-Value		0.00		0.00		0.00	
Hansen Stat. P-Value		0.03		0.72		0.53	
Wald P-Value (ρ =0)		0.36		0.22		0.21	

Notes:

1. Robust P-Values in parentheses. A: p<0.01, B: p<0.05, C: p<0.1
2. All specifications include city and industry fixed effects

Table 6: Estimation Results for Compliance

Dep. Variable:	(1)	(2)		(3)		(4)	
Compliance	Probit	Compliance	ISO14001	Compliance	ISO14001	Compliance	ISO14001
ISO 14001	0.52 ^{A}	1.30 ^{A}		1.07 ^{C}		0.96^{C}	
	(0.01)	(0.00)		(0.06)		(0.06)	
Standards	-0.03	-0.05		-0.06		-0.04	
	(0.40)	(0.20)		(0.14)		(0.26)	
GInspections	-0.003	-0.003		-0.003			
	(0.39)	(0.36)		(0.33)			
ISO 9001			1.11^{A}		1.19 ^{A}		1.27 ^{A}
			(0.00)		(0.00)		(0.00)
Exporter			0.15		0.15		0.18
			(0.15)		(0.19)		(0.20)
Revenue			0.02 ^{C}		0.02 ^{C}		0.02^{B}
			(0.06)		(0.07)		(0.02)
FJV			0.17	0.14	0.16	0.18	0.19
			(0.29)	(0.53)	(0.29)	(0.49)	(0.23)
EPD			0.95 ^{A}	0.03	0.97 ^{A}	0.05	1.02^{A}
			(0.00)	(0.11)	(0.00)	(0.84)	(0.00)
Customer			0.50 ^{B}	0.04	0.52 ^{B}		
			(0.05)	(0.88)	(0.03)		
Inspection			-0.15	0.09	-0.19		
			(0.41)	(0.72)	(0.27)		
C x I			1.31 ^{A}	0.88 ^{B}	1.06 ^{A}		
			(0.00)	(0.01)	(0.01)		
Constant	2.13 ^{A}	1.40 ^{C}	-2.58 ^{A}	1.46^{B}	-2.65 ^{A}	1.37 ^{C}	-3.30^{A}
	(0.00)	(0.08)	(0.00)	(0.05)	(0.00)	(0.09)	(0.00)
Observations	542	558		558		558	
Chi^2 (Fit) P-Val	0.05	0.00		0.00		0.00	
Anderson Stat. P-Val		0.00		0.00		0.00	
Hansen Stat. P-Val		0.40		0.76		0.86	
Wald P-Value (ρ =0)		0.04		0.34		0.26	

Notes:

1. Robust P-Values in parentheses. A: p<0.01, B: p<0.05, C: p<0.1
2. All specifications include city and industry fixed effects

Column (1) in each table shows the results for the naïve probit model of environmental performance. The coefficient estimates on *ISO 14001* indicate certification is correlated with superior environmental performance and are significant at the 5% level for *Violation* and at the 1% level for *Compliance*. These results are not sufficient to support causal inference, but are consistent with the hypothesis that ISO 14001 certification improves environmental performance. Estimated coefficients on *GInspections* and *Standards* were not significant in either model.

Column (2) in each table shows the results for the SURBP model using the full set of regressors from column (3) of Table 4 as instruments. The estimated coefficients on *ISO 14001* are the same sign as in the probit specification. The estimated coefficient is significant at the 10% level for *Violation* and at the 1% level for *Compliance*. Comparing columns (1) and (2) in both tables, the estimated coefficients on *ISO 14001* certification are larger in absolute value in the SURBP models. Once again, the additional controls in the environmental performance equations are not significant.

Column (3) in each table shows the results for each SURBP model after re-specifying the environmental performance equations to include predictors of *ISO 14001* that could plausibly be correlated with environmental performance. These include *EPD., Customer, Inspection, CxI* and *FJV*. The first four variables are all directly related to environmental protection effort and outcomes. *FJV* is also included to reflect the hypothesis in Christmann and Taylor (2001) that multinationals exert pressure on their partners to improve their environmental performance. The estimated coefficients on *ISO 14001* retain their sign and are significant at the 1% level for *Violation* and at the 10% level for *Compliance. FJV* and *EPD* are also significant in the *Violation* model, while (*CxI*) is significant in the *Compliance* model. *GInspections* and *Standards* were not significant in either model.

The Anderson and Hansen statistics in column (3) indicate the instruments perform well in 2SLS specifications of each model. However, including other potentially endogenous regressors in the environmental performance models may have induced bias in the estimation of the coefficients. Including additional endogenous variables would make it impossible to draw causal inference using the estimated coefficients on *ISO 14001* (Angrist and Pischke, 2008).

Column (4) in each table shows the results for the SURBP estimator after excluding potentially endogenous variables from the environmental performance models. Variables relating to customer type (*Customer, Inspection, CxI*) were eliminated because firms may have attracted "green" customers by exhibiting superior environmental performance. *GInspections* was eliminated because EPBs may inspect a firm more or less frequently based on their environmental performance.

Estimated coefficients on *ISO 14001* retain their sign and significance in both models. None of the additional control variables were significant in the *Compliance* model, but *EPD* and *FJV* were both significant in the *Violation* model. The Hansen and Anderson statistics derived from the 2SLS specifications support the use of the remaining instruments (*Exporter, Revenue, ISO9001*) in both models. Chi-squared tests indicate the instruments were jointly significant in the first-stage of the SURBP models for *Compliance* (p-value=0.00) and *Violation* (p-value=0.00). Estimating just identified specifications of both SURBP models using only ISO 9001 as an instrument for ISO 14001 indicated *Exporter* and *Revenue* were not significant in the second stage of either the *Violation* (p-value = 0.66) or the *Compliance* (p-value = 0.96) models. These results strongly support their use as instruments for *ISO 14001*.

5: Discussion and Conclusions

The estimation results shed some light on the potential role of voluntary standards in managing China's environmental crisis. First, they reproduce some of the key findings from the existing literature on ISO 14001. Size, export status and the magnitude of sunk environmental protection costs were useful predictors of certification status. The positive relationship between certification and serving a "green" customer base supports the hypothesis that firms adopt ISO 14001 in response to market incentives. The positive relationship between ISO 9001 and ISO 14001 suggests previous experience with the ISO system may reduce the costs associated with seeking an additional certification.

The results also support the argument in Potoski and Prakash (2005) that programs like ISO 14001 are more effective when combined with ex-post monitoring. The estimated coefficient on the interaction term (CxI) was positive and significant in column (3) of Table 4. The interaction term also enters positively and significantly into the Compliance model in column (3) of Table 6. Customers with a preference for "green" production standards seem more willing to work with ISO 14001 certified firms if they can monitor their actual environmental performance. This type of monitoring is also associated with superior environmental performance. In the absence of ex-post monitoring, firms may be tempted to use ISO 14001 as a form of "green washing," presenting an environmentally-friendly face without changing their behavior.

The estimation results also provide evidence of strategic behavior on the part of regulators. Dean et al. (2009) found evidence that foreign investment is attracted to provinces in China with weaker enforcement of environmental regulation. They argue this is part of a "race to the bottom" wherein EPBs competitively weaken enforcement to promote local economic growth. Comparing columns (3) and (4) between Table 5 and Table 6, *FJV* was associated with a significantly lower likelihood of being cited for violating environmental regulations, but had no effect on firms' self-reported compliance. This could indicate foreign joint ventures are not more likely to obey environmental regulations, but are cited less often for violating them.

Finally, the environmental performance equations presented in Table 5 and Table 6 present robust evidence of a causal relationship between ISO 14001 certification and superior environmental performance. Certification increased the likelihood firms reported compliance with all relevant environmental regulations and decreased the likelihood firms reported being cited for violating environmental regulations. This effect is observed in naïve, single-stage probit models and persists when using a valid set of instruments to control for potential endogeneity between certification and environmental performance. This is the first firm-level evidence that the widespread adoption of ISO 14001 certification may help alleviate China's environmental crisis.

These results indicate that the adoption of ISO 14001 can improve environmental outcomes even where regulations are weakly enforced, but they should be evaluated in light of several methodological limitations. First, the measurements of environmental performance used in the analysis were all self-reported. While respondent anonymity was maintained to reduce strategic incentives for false reporting, these types of responses are not the most reliable indicators of actual performance. The analysis could be improved with the use of more objective measurements of firms' environmental performance. Second, the firms in the sample were observed only in cross-section. Although every specification included city and industry fixed effects, there may be important firm-level heterogeneity that can only be addressed using panel data. Employing firm fixed effects or a difference-in-difference estimator to control for unobserved firm-level heterogeneity would help support a causal interpretation of the observed relationship between ISO 14001 and environmental performance.

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