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Do Voluntary Programs Reduce Pollution? Examining ISO 14001's Effectiveness across Countries

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Voluntary environmental programs have emerged as important instruments of environmental policy. Despite considerable scholarly scrutiny, there remain debates about whether they reduce pollution among participants, and their overall impact at the country level. We present a cross-national analysis of the efficacy of ISO 14001, the most widely adopted voluntary environmental program in the world. While several single country studies have explored the effect of ISO 14001 participation on pollution reduction at the facility level, this is the first article to assess (i) national level pollution reduction effects of ISO 14001 participation levels, (ii) across a large number of countries, and (iii) across two pollutants. We examine whether all else equal, the national level uptakes of ISO 14001 are associated with reductions in air emissions (sulfur dioxide, SO_2) and water pollution (biochemical oxygen demand, BOD). Because firms, regulators, and environmental groups tend to focus more on visible types of pollution than less visible ones, we hypothesize that ISO 14001 uptake will be associated with more pronounced reductions in air pollution (visible) in relation to water pollution (less visible). Our analyses of pollution levels for a panel of 138 (72 for BOD) countries for the 1991–2005 period suggest that a 1 percent increase in aggregate levels of ISO 14001 adoption is associated with about a 0.064 percent reduction in SO_2 emissions, all else equal. In contrast, we do not find a statistically significant relationship between ISO 14001 adoption levels and changes in water pollution (BOD).

KEY WORDS: voluntary regulation, ISO 14001, environmental policy, effectiveness

Voluntary environmental programs have emerged as important instruments of environmental policy and management across the world (Coglianese & Nash, 2001; Darnall & Edwards, 2006; deLeon & Rivera, 2009; Harrison, 1998; King & Lenox, 2000; Rivera, 2010; Segerson & Miceli, 1998).[1] These programs seek to induce participating firms to adopt environmental stewardship practices that are over and above legal requirements. In return, program participants receive the ability to use the program brand name to signal their environmental stewardship to external stakeholders who cannot otherwise fully observe participants' environmental practices (Darnall & Carmin, 2005). This allows external stakeholders to differentiate between environmental stewards and non-stewards in order to focus their rewards and scorn.[2]

Despite their promise, a fair amount of academic research suggests that the effect of voluntary environmental programs on pollution reduction is uneven (Delmas &

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Keller, 2005; Khanna & Damon, 1999; Koehler, 2007; Morgenstern & Pizer, 2007; Rivera & deLeon, 2004; Rivera, deLeon, & Koerber, 2006; Toffel & Short, 2011). Most environmental groups tend to be skeptical, perhaps due to concerns that voluntary environmental programs are intended to preempt more stringent public regulations (Maxwell, Lyons, & Hackett, 2000). Critics see voluntary programs as cheap talk at best and green washing at worst (Steinzor, 1998). Yet others see these programs in a more promising light (Kettl, 2002). To assess the debate on program efficacy, we focus on ISO 14001, the most widely adopted voluntary environmental program in the world (Delmas & Montes-Sancho, 2011). ISO 14001 is sponsored by the Geneva-based International Organization for Standardization (ISO), the world leader in establishing product and process standards. As a management systems-based standard, the theory behind ISO 14001 is that firms violate environmental laws and pollute excessively because they do not have well-functioning environmental management systems (EMS). ISO 14001 requires participants to establish verifiable EMS that encourage the Plan-Do-Check-Act approach,[3] which helps in legal compliance as well as environmental stewardship. Coglianese and Nash (2001) have aptly termed these approaches "regulating from the inside." Since its launch in 1995, ISO 14001 has been widely adopted across the world. By 2005 there were 111,163 ISO 14001 certified facilities across 138 countries (ISO, 2009).

Our study assesses the extent to which ISO 14001 adoption levels are associated with reduction in regulated air and water pollution. We suggest that program participants will make strategic choices by focusing their stewardship efforts more at visible pollutants in relation to less visible pollutants. Our analyses of a panel of 138 countries (72 for water pollution) over the period 1991–2005 suggest that a 1 percent increase in ISO 14001 adoption is associated with 0.064 percent decreases in sulfur dioxide (SO_2) pollution, a visible pollutant. We do not find a statistically significant relationship between ISO adoption and water pollution, as reflected in biochemical oxygen demand (BOD), a less visible pollutant.

This article makes several contributions to the environmental policy literature. Previous studies have explored the effect of ISO 14001 participation in facilities located in a single country and for a single pollution measure, with changes in pollution levels observed across narrow time intervals (Arimura, Hibiki, & Katayama, 2008; Potoski & Prakash, 2005; Toffel, 2005; Turk, 2009). To the best of our knowledge, this is the first article to assess (i) the national level pollution reduction effects of ISO 14001 uptake, (ii) across a large number of countries as opposed to a country-level study, (iii) across a range of pollutants as opposed to focusing on a single pollution measure.

By examining the varying impact of ISO 14001 on different types of pollutants, we explore the link between problem visibility and policy responses in the study of environmental politics. Scholars note the influence of issue visibility on governmental priorities toward the supply of public goods (Mani & Mukand, 2007). We extend this argument to examine incentives private actors face in supplying different types of public goods, air and water pollution reductions in our case. The premise is that environmental stewardship has an opportunity cost for firms, not merely in relation to the pursuit of profits but also in relation to other types of corporate social responsibility policies they might pursue. Given the relatively high visibility of air pollution in relation to water pollution (Cao & Prakash, 2010; Dunlap, 1994; Gallup, 2005), we hypothesize that ISO 14001 certified firms will strategically invest more resources to reduce air pollution in relation to water pollution. An observable implication is that effect of national level ISO adoption on reductions of air pollution should be more pronounced in relation to reductions in water pollution. This is an important finding because it moves the voluntary program literature beyond the debates on *overall* efficacy, to the issue of *varying* efficacy across pollution types.[4] The asymmetry in participating firms' efforts in air versus water pollution opens up new sets of questions such as what policy interventions might be needed to correct a potential mismatch between problem visibility and problem severity.

Our article proceeds as follows. In the next section, we describe the ISO 14001 program and its design. Following that we outline the theoretical approach, and then present our model, identifying and discussing the key variables. In the next section we present statistical methods and empirical results, followed by a concluding section discussing the implications of our empirical analyses and areas for future work.

ISO 14001

Founded in 1946, the ISO is a prominent global policy actor. It formulates technical and management standards, having developed over 18,000 to date. In terms of its organizational composition, the ISO is a nongovernmental organization whose members are the national bodies that are charged with setting national standards (Mattli & Büthe, 2003). As of a recent count, the ISO has 162 member bodies, each representing a country.[5]

Following the extensive discussions among governments, businesses, and international bodies at the 1992 United Nations Conference on Environment and Development (the Rio or the Earth Summit), the ISO introduced the ISO 14001 environmental standards in 1995. The idea was to employ ISO's expertise and credibility in standard setting in environmental policy. In part, ISO 14001 responded to concerns about the relationship between trade and environment, and the lack of oversight by global trading institutions over environmental issues. There was also recognition that traditional regulatory approaches were inadequately addressing environmental challenges, and the regulatory structure did not offer sufficient opportunities for businesses to invest in environmental stewardship. ISO 14001 offered a voluntary, nontraditional approach to environmental governance which complemented the extant regulatory structure.

ISO 14001 requires participants to establish a written environmental policy approved by senior management that lays out quantifiable environmental targets with plans for regularly reviewing them, and to designate a top manager to oversee implementation of the firms' EMS. In some respects, ISO 14001 is primarily a compliance tool because noncompliance with law is often rooted in ignorance of law (Brehm & Hamilton, 1996; Winter & May, 2001). Given the regulatory complexity, appropriate EMS are essential to ensure compliance with the law. Because ISO 14001 commits participating firms to adopt the best available environmental technologies, assess the environmental impact of their operations, and establish programs to train personnel in EMS, it is also used as a tool for crafting and monitoring beyond compliance environmental stewardship policies.[6] For ISO participants, these EMS are typically quite extensive, requiring substantial investments in personnel, training, and most critically, in establishing paper trails for their environmental operations.

Unlike some other voluntary environmental programs, ISO 14001 requires participants to receive an initial certification audit and subsequent annual recertification audits to verify that their EMS is of ISO 14001 caliber. Both types of audits are conducted by third-party auditors who themselves have been approved and accredited by their domestic national standards body. The audit and certification measures are designed to prevent participants from shirking their ISO 14001 program responsibilities. Establishing an EMS and having it audited by a third party can cost from $25,000 to over $100,000 per facility (Darnall & Edwards, 2006; Kolk, 2000). An ISO-certified EMS requires substantial investment beyond the cost of external auditors. These include the costs of maintaining paper trails, documenting processes, and even hiring additional personnel.

Several studies have explored whether ISO 14001 participation leads to pollution reduction, generally using samples of facilities located in a given country, focusing on a single pollutant or measure of pollution, and assessing pollution changes between two periods of time—before and after certification. In his analysis of 316 U.S. electronics facilities, Russo (2002) finds that ISO 14001 certification is associated with decreased air emissions. In their study of over 3,000 U.S. facilities regulated under the Clean Air Act, Potoski and Prakash (2005) find that ISO 14001 adoption is associated with air pollution reduction (but see Dahlström, Howes, Leinster, & Skea, 2003; Toffel, 2005). Outside the United States, Arimura et al. (2008) provide evidence suggesting that ISO 14001 participation is associated with pollution reduction in Japan. Turk (2009) reports similar findings from Turkey; Link and Naveh (2006) from Israel; Padma, Ganesh, and Rajendran (2008) from India; and Schylander and Martinuzzi (2007) from Austria.

We present an analysis of the effect of national level ISO 14001 adoption counts on national air and water pollution levels using a panel research design. We focus on firms' strategic calculations given the limited resources they can devote to environmental stewardship. Below we outline our theoretical approach to study these issues.

National Pollution Levels: Theoretical Background

A range of domestic and international factors influence national pollution levels. Among domestic economic factors, countries with larger economies typically have higher pollution levels. Countries with a higher salience of manufacturing sectors also tend to have higher pollution levels given the reliance on fossil fuels for manufacturing activities. Alongside economic activities, urbanization is often viewed as influencing pollution levels. Some believe that urbanization leads to more pollution while others suggest that urban areas can lead to lower pollution levels given the economies of scale in confronting environmental problems (Torras & Boyce, 1998). Perhaps the most well-established debate pertains to how a country's wealth influences its pollution levels. The Environmental Kuznets curve literature suggests a nonlinear relationship between pollution and wealth (Grossman & Krueger, 1995). As economies industrialize and become wealthy, their pollution levels increase. However, scholars have noted that after a certain wealth level (as reflected in per capita gross domestic product [GDP]) has been achieved, pollution levels begin to decline. The argument is that wealthy societies face demands from their citizens who, having satisfied their "lower order" material needs, want a cleaner environment; a "higher order" need. At the same time, wealthy societies have more resources to protect the environment.

Domestic political factors can also influence national pollution levels. A much debated factor is a country's level of democracy (Fredriksson, Neumayer, Damania, & Gates, 2005). On the one hand, democracy empowers citizens to demand environmental protection. Because governments tend to be more responsive to the demands of citizens in democracies in relation to nondemocracies, governments arguably have incentives to enact regulations that protect the environment. On the other hand, if pollution reduction is a public good while economic growth creates private benefits, citizens may favor economic growth over environmental protection. Thus, the relationship between democracy and environmental protection is complex. Scholars also note the role of ideology of the ruling party (partisanship in the American politics literature) might influence pollution levels. Some suggest that left-wing governments favor environmental protection (Neumayer, 2003). On the other hand, scholars point to the pollution record of the former Soviet Union and other socialist countries that had dismal records in environmental protection. Thus, it seems that the role of ideology in influencing pollution levels is complex and perhaps contingent.

Scholars have noted the role of international factors such as exposure to the global economy on pollution levels. The much debated race to the bottom hypothesis suggests that trade dependence creates incentives for governments to tolerate high levels of pollution typically by relaxing the stringency of environmental regulation. Globalization optimists, on the other hand, suggest that exposure to the global economy leads to reduction in pollution because international competition forces firms to utilize resources more efficiently: given that pollution is a resource waste, this should lead to lower pollution levels. The trade–environment debate has been extended further by scholars examining how pollution levels are affected not by how much a country exports but to whom it exports. The argument is that countries protect their environment when they receive pressures for environmental protection from their importing partners via their trade linkages (Vogel, 1995). Indeed, the analogous argument has been made in the context of foreign direct investment (FDI), another important manifestation of economic globalization. Scholars suggest that because the countries where multinational corporations (MNC) are headquartered play an important role in shaping the policies of overseas subsidiaries, what matters for environmental policy is not how much FDI a country receives but from which countries it receives. The pollution impact of an American MNC on Malaysia, for example, will be different from that of a Chinese MNC operating in the same industrial sector.

While scholars have identified important factors influencing national pollution levels, the literature has not examined the role of voluntary environmental programs in this regard. Indeed, the voluntary program scholarship has focused on the pollution impact at the facility level and has not investigated how the sum of these micro-level impacts might be assessed at the macro level. We believe this is an important issue given the high levels of growth in the number of such programs as well as their memberships. Indeed, the emergence of voluntary environmental programs as instruments of environmental policy need to be understood in the context of the perceived shortcomings of traditional government regulations for solving environmental problems. These regulations tend to "command" firms to reduce pollution by "controlling" how they might do so, usually by prescribing pollution control technologies. Critics have faulted the command and control regulatory approach for high compliance and enforcement costs, and regulatory rigidity (Ayres & Braithwaite, 1992; Borck & Coglianese, 2009; Fiorino, 2006; Gunningham, Grabosky, & Sinclair, 1998). Enforcement shortfalls are noticeable across the world, especially in developing countries (Börzel & Risse, 2010). Voluntary environmental programs are among the new policy instruments aimed at correcting the weaknesses of traditional regulatory approaches.

This study examines ISO 14001's impact on air and water pollution reduction after controlling for the key pollution drivers that prior literature identifies. As discussed in the previous section, ISO 14001 obligates its participants to establish EMS and adopt quantifiable environmental targets. Consequent to such changes in internal management processes, there is an expectation of pollution reduction. Importantly, scholars suggest that the environmental impact of environmental programs may extend beyond their formal participants. Because there are firms that do not formally participate in the said ISO 14001 and yet adopt ISO-14001-like policies because of the influence of ISO 14001 participating firms, the overall impact of voluntary environmental programs may reflect pollution reductions achieved both by program participants *and* the nonparticipants reacting to spillover influence from the participants. Borck and Coglianese (2009) note that to "the extent that participants in these programs adopt innovative practices that later diffuse throughout an entire sector, the aggregate spillover effect from a VEP theoretically could be substantial" (p. 310). Lyons and Maxwell (2007) also note the potential impact of spillovers on program efficacy. Lange (2008) reports program spillovers from participants to nonparticipants in the case of the Coal Combustion Products Partnership and contends that spillovers should be included in assessing the efficacy of voluntary programs. In an important recent study, Arimura, Darnall, and Katayama (2011) find that ISO 14001 certified facilities require more progressive environmental practices from their suppliers, a diffusion dynamic other scholars have identified as well (Christini, Fetsko, & Hendrickson, 2004; Christmann & Taylor, 2001; Coglianese & Nash, 2001; Vandenbergh, 2007). Importantly, both ISO 14001 certified MNC (Albornoz, Cole, Elliott, & Ercolani, 2009) and domestic firms with ISO 14001 certification can be expected to contribute to these EMS spillover processes.

While our empirical work does not seek to apportion the contributions of participants and nonparticipants in ISO 14001's overall impact, we recognize that both

ISO participants and nonparticipants affected by spillovers must eventually face resource constraints in pursuing environmental stewardship. As strategic actors seeking maximum payoff for their environmental stewardship investments, these firms are likely to focus their efforts in areas where their efforts are visible. After all, the purpose of joining ISO 14001 is to receive recognition for environmental stewardship.

Social psychologists suggest that routine and daily visual experiences shape how individuals perceive the importance of an issue (Bickerstaff & Walker, 2001; Howell, Moffatt, Bush, Dunn, & Prince, 2003). Cao and Prakash (2010) suggest that compared with water pollution, air pollution tends to be more visible and consequently receives more policy attention.[7] The 1972 Clean Water Act receives less federal enforcement than the Clean Air Act.[8] Public opinion surveys show a higher attention to air pollution in relation to water pollution. Dunlap's (1994) study on environmental attitudes across 24 countries finds that air pollution is the most frequently mentioned problem in 23 countries while water quality in 4 only. A Gallup (2005) survey in China noted:

> More telling is the finding that half of those living in the country's 10 largest cities now say they view air pollution where they live as either very (17%) or somewhat (33%) serious. Chinese express slightly less concern about water quality than air pollution, perhaps because the effects of the latter are more directly evident. Only a fifth of all Chinese see water pollution in their locales as a very (8%) or somewhat (12%) serious problem; this group is outnumbered by those who believe the local water pollution problem is not a serious problem at all (28%). In contrast to the results on air pollution, urban residents are only slightly more likely than their rural counterparts to believe their own communities are facing a water pollution challenge.

The influence of issue visibility on public policy has been noted in the literature. Mani and Mukand (2007) reveal how issue visibility distorts governmental priorities regarding the supply of different public goods by leading to an undersupply of essential but nonvisible public goods. Challenging the notion that democracy improves budgetary allocations for public goods, they show that democracy widens the gap between the supply of more visible public goods (e.g., famine prevention) at the cost of the supply of less visible public goods (e.g., preventing malnutrition). Because pollution reduction is a classic public good, we expect that firms invest in supplying more visible public goods (regulated air pollutants) in relation to less visible public goods (regulated water pollutants). These incentives should be more pronounced in the context of voluntary programs because firms employ their participation in such programs as a mechanism to achieve recognition for their environmental stewardship.[9] Therefore, we expect that firms' voluntary program participation efforts are likely to focus more on environmental outcomes that are likely to get noticed, such as air pollution reductions compared with water pollution reductions.[10]

We are not asserting that all types of air pollution are perfectly visible or all types of water pollution are invisible. Our more modest assertion is simply about the relative visibility of water and air pollution. Air pollution is visible, with smoke plumes jutting out of smokestacks, while water pollution tends to be partially hidden, with submerged water pipes surreptitiously discharging waste water into rivers and streams. Also, pollutant visibility may affect how many stakeholders influence firms; for example, visibility may condition how citizens directly interact with firms or how they influence government's regulatory enforcement. In this article, we are unable to distinguish empirically among different venues by which pollutant visibility may influence firms. We, therefore, propose to test the following hypothesis:

Hypothesis: Countries' ISO 14001 adoption levels are associated with more pronounced reductions in SO_2 emissions in relation to reductions in BOD discharges.

The next section outlines our model and the empirical strategy to test the above hypothesis.

Model and Methods

We employ a cross-sectional time series panel of 138 countries (72 in the BOD analyses) from 1991 through 2005.[11] Although our results hold even when we restrict our panel to the 1995–2005 period (Table 4), we examine the panel from 1991 to 2005. The reasons are twofold. First, while ISO 14001 was launched in 1995, discussions about this program began in earnest even prior to the 1992 Rio summit. Second, modeling periods when the program did not exist has considerable research design advantages because it reduces the chances that our analysis is spuriously capturing contemporaneous pollution and ISO 14001 trends. The empirical model evaluates countries' SO_2 and BOD pollution levels as a function of their ISO 14001 certifications (logged) plus controls for political, social, and economic conditions.

Some statistical issues complicate empirical estimations of the effects of ISO 14001 on countries' pollution levels. Some regressors may be endogenous and thus correlated with the error term. The variable of primary interest, ISO 14001 certifications count, may be endogenous if, for example, firms join ISO 14001 in anticipation of later pollution reductions that they would achieve without joining the program. A lagged dependent variable included in the model to address concerns about serial correlation could likewise be endogenous in that it is correlated with the error term. Further complicating matters is the fact that our data are wide with the number of countries exceeding the number of time periods ($J > T$). This means that some standard approaches to panel data analysis such as country fixed effects may be problematic, especially in the presence of a lagged dependent variable (Nickell, 1981).[12]

To address these issues, we use a linear generalized method of moments (GMM) difference estimator for panel data (Arellano & Bond, 1991; Roodman, 2006, 2009).[13] The models use a lagged dependent variable (Y_{it-1}) to address dynamics in pollution emissions and use first differencing to account for unobserved heterogeneity across countries, allowing us to drop country-level fixed effects. The approach can be expressed as:

$$\Delta Y_{it} = \beta_0 + \alpha\Delta Y_{it-1} + \beta_1\Delta ISO14001_{it-1} + \boldsymbol{\varphi}\Delta \mathbf{X}_{it-1} + \varphi\Delta \mathbf{Z}_{it} + T_t + \Delta\boldsymbol{\varepsilon}_{it} \quad (1)$$

In equation (1), the subscript i indicates country and t indicates year. Y_{it} is the pollution level for country i in year t; $ISO14001_{it-1}$ is the number of ISO 14001 certifications in country i at time t-1. Δ indicates first differences so that $\Delta Y_{it} = Y_{it} - Y_{it-1}$. **X** and **Z** are vectors of country-specific and time-varying control variables, listed below, with the variables in **X** lagged by 1 year to take into account delays in their effects on pollution and guard against reverse causality. Variables in **Z** are presumed to have contemporaneous effects on pollution. The coefficient β_0 is the intercept, β_1 is the coefficient of interest measuring the effects of ISO 14001 certifications, $\boldsymbol{\varphi}$ is a vector of coefficients for the variables in X, and ϕ is a vector of coefficients for **Z**. T_t are year fixed effects and ε is the error term.

In equation (1) ΔY_{it-1} and $\Delta ISO14001_{it-1}$ are potentially endogenous variables that may be correlated with $\Delta\varepsilon_{it}$. To address this, we employ lagged levels of ISO14001 as instruments for $\Delta ISO14001_{it-1}$ and past values of the lagged response variable (Y_{it-1}) as instruments for ΔY_{it-1}. A potential issue is that the instrumented variable's lagged levels may be poor instruments for changes in its current value. We report the Hansen tests of the instruments' validity; an insignificant Hansen test suggests valid instruments. Increasing the number of instruments improves estimation by more precisely estimating the instrumented variable. But adding too many instruments can likewise compromise inference by overfitting the instrumented variables and failing to expunge their endogeneity with the dependent variable. Some suggest as a rule of thumb that the number of instruments should be less than the number of units (countries in our case), although Roodman (2009) suggests this may be too high. Without hard rules, we adopt the convention of including fewer instruments than countries and look for Hansen tests with *p*-values that are "safely" above standard significance levels (e.g., $p > 0.20$) but not so high as to approach the implausible ($p >> 0.90$), which might suggest overfitting. We start with two periods of lag lengths and experiment with longer lags. Our aim is to have sufficient number of instruments for valid estimation of the endogenous variables but not so many instruments that risk over identification. Finally, we use the "two-step" standard error estimation to account for potential heteroscedasticity, as recommended by Roodman (2009), including the "robust" option (Windmeijer, 2005) to account for potential downward bias in two-step standard error estimates.

All in all, the model provides fairly exhaustive controls for confounding factors. First differences control for time invariant factors within each country while the independent variables control for a broad range of time-varying factors such as countries' economic and social conditions, trade, foreign investment, politics, and regulatory policies. The model controls for time series dynamics through a lagged dependent variable and other time effects through dummy variables for each year. The model addresses potential endogeneity issues with the ISO 14001 measure and lagged dependent variable by using their lagged values as instruments.

Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Logged	Data Source
Base models, Tables 3						
SO_2	4.637	2.181	–1.510	10.502	Yes	EDGAR
BOD	11.262	1.528	6.641	15.939	Yes	WDI
ISO14001	1.915	2.658	0	10.063	Yes	ISO
GDP	24.710	2.0338	20.088	30.209	Yes	WDI
GDP per capita	10181.19	11398.74	241.806	49070.02	No	WDI
GDP per capita2	2.34e+08	4.20e+08	58470.03	2.41e+09	No	WDI
Population	16.230	1.489	12.713	20.989	Yes	WDI
Industry	3.368	.350	2.104	4.558	Yes	WDI
Urban	3.867	.539	2.023	4.615	Yes	WDI
Regulatory stringency	3.851	.669	.693	5.451	Yes	IEA
Exports-treaty	2.723	.660	0.00	4.530	Yes	[a]
Exports	4.227	.519	2.523	6.051	Yes	WDI
FDI stocks	8.079	2.537	2.0757	15.096	Yes	UNCTAD
Expanded controls, Table 4						
ISO 9000	3.463	3.499	0.00	11.798	Yes	ISO
Democracy	3.701	6.433	–10	10	No	Polity IV
Ideology	.066	.415	–.893	1	No	WBDPI
ISO 14001-treaties	3.354	4.488	0.00	14.630	Yes	[a]

[a]Authors' calculations.

Table 2. Data Sources

Source	Name	Citation
EDGAR	Emissions Database for Global Atmospheric Research v4.0.	European Commission (2009)
WDI	World Development Indicators	The World Bank (2011).
ISO	ISO Survey of Certification	International Organization for Standardization (2006)
UNCTAD	UNCADStat	United Nations Conference on Trade and Development (2011).
WPDPI	Database of Political Institutions	Beck et al. (2001).
POLITYIV	Polity IV Project	Marshall, Jaggers, & Gurr (2004)
IEA	International Environmental Agreements Database Project	Mitchell (2002–2011)
YIO	Yearbook of International Organizations	Union of International Associations, various years

Variables

Table 1 presents the descriptive statistics of the independent and dependent variables in the analyses. Table 2 lists data sources. The two dependent variables (Y) are measures of countries' emissions of a regulated air pollutant, SO_2 and a common indicator of water pollution, BOD. Consistent with the literature, for SO_2, the variable is the log of SO_2 emissions is gigagrams. For BOD, the variable is the logged kilograms of BOD per day.[14] The primary explanatory variable of interest is the number of ISO 14001 certifications (logged) in the country in a given year, as reported on the ISO Web site (ISO, 2006). We expect that, all else equal, an increased count of ISO

14001 certifications will be associated with lower emissions of SO_2. For water pollution (BOD) we expect a less pronounced relationship between countries' ISO 14001 certifications and pollution levels.

To isolate the effect of ISO 14001 certifications on pollution reduction, our analyses include controls for domestic and international factors that can be expected to influence countries' pollution levels. Beginning with domestic factors, economic conditions in a country have major consequences for pollution levels. Our model controls for (logged) *GDP*. We control for wealth measured as *GDP per capita* (in constant 2005 dollars at purchasing power parity) along with its squared term to account for the nonlinear relationship between wealth and pollution, as suggested by the Environmental Kuznets curve hypothesis (Grossman & Krueger, 1995). The model controls for the share of industrial production in GDP (*Industrial*) since industrial production tends to have higher pollution levels relative to other economic sectors like agriculture and services. Since firms' pollution reduction may be due to the adoption of ISO 9001 quality standards, our model controls for (logged) *ISO 9001* certifications in a country. Political pressure can influence pollution levels as well. Some believe that left-wing parties favor environmental protection (Neumayer, 2003). Hence we control for the *Legislative ideology* of a country's legislature. The variable is an index that takes the proportion of legislative seats held by the three largest parties multiplied by –1 for parties of the right, 1 for parties of the left, and 0 for centrist and nonideological parties. The three variables are then summed into an index ranging from –1 (right) to 1 (left).[15] The relationship between the level of democracy and environmental protection has been debated in the literature (Buitenzorgy & Mol, 2011; Li & Reuveny, 2006). Hence, we control for levels of *democracy* as reported in the Polity IV database.

Domestic social and political factors can also influence countries' pollution levels, including population size (logged), which we measure with the variable *Population*. Since urban areas tend to generate more pollution, we include the variable *Urban population*, which measures the share of total population living in urban areas. Governmental regulations are an important determinant of both national pollution levels and facilities' propensities to join ISO 14001. While there are no measures of countries' environmental regulations with sufficiently broad and long coverage for our purposes, there are fortunately proven proxies based on countries' environmental treaty commitments (Neumayer, 2002).[16] *Regulatory stringency* is the log of the number of a country's environmental treaty commitments for each year, as reported in Mitchell (2002–2011).

International factors can influence domestic pollution levels. We include several controls for these influences. *FDI Stocks* (logged) measures the stock of the FDI in a country. *Exports* measures a country's exports as a proportion of GDP. Vogel (1995) suggests that a country that exports to destinations where citizens demand environmental protection may themselves experience pressure to reduce their own pollution. To measure these effects, we calculate the following spatial lag to capture the fact that stringency of environmental regulations (as proxied in treaty membership) of importing countries can influence pollution levels in the exporting country. *Export destination treaties* measures country I's exports as a proportion of its GDP, weighted

Table 3. National Pollution Levels and ISO 14001 Registrations, GMM Model Results

	SO_2		BOD	
Independent variables (differenced)	Coeff.	Std Error	Coeff.	Std. Error
Y_{it-1}	0.072	0.136	1.006**	0.0478
$ISO14001_{it-1}$	–0.064**	0.028	–0.014	0.011
GDP	0.186	0.195	0.009	0.025
GDP per capita	0.001	0.000	–1.11e–07	3.17e–06
GDP per capita2	–1.10e–09**	5.54e–10	–1.40e–11	4.67e–11
Population	1.211**	0.418	–0.012	0.041
Industry	0.086	0.110	–0.015	0.029
Urban	0.561	0.390	–0.019	0.029
Regulatory stringency	–0.138**	0.068	0.020	0.013
Exports-treaty	0.013	0.021	–0.005	0.007
Exports	–0.001	0.056	0.014	0.028
FDI stocks	–0.013	0.016	0.002	0.010
Year dummies	Yes		Yes	
N (countries)	138		72	
N (total)	1838		682	
Wald chi-squared (d.f.)	354.41 (33)		300,317.55 (32)	
Arellano–Bond Test for AR(1) in first differences (*p*-value)	–1.88	(0.06)	–4.03	(0.00)
Arellano–Bond Test for AR(2) in first differences (*p*-value)	–0.81	(0.42)	–0.44	(0.66)
Hansen test (chi-squared, d.f.) (*p*-value)	57.92 (54)	(0.33)	9.78 (8)	(0.28)

$^{**}p < 0.05$.
Note: All independent and dependent variables are differenced.

by the number of environmental treaties in the receiving country J. Finally, *ISO 14001 treaties* measures the ISO 14001 certification in country I's treaty partners, weighted by the proportion of I's environmental treaty memberships in common with J.

All in all, the model provides fairly exhaustive controls for confounding factors. First differences control for time-invariant factors within each country while the independent variables control for a broad range of time-varying factors such as countries' economic and social conditions, trade, foreign investment, politics, and regulatory policies. The model controls for time series dynamics through a lagged dependent variable and other time effects through dummy variables for each year. The model addresses potential endogeneity issues with the ISO 14001 measure and lagged dependent variable by using their lagged values as instruments.

Results

Table 3 presents results of the primary analyses for the years 1992–2005. Since the dependent variables are logged, the coefficients of the key independent variable (ISO 14001 adoptions, also logged) can be conveniently interpreted as elasticities, that is, the percentage change in the dependent variable in response to percentage change in the independent variable.

The results in Table 3 indicate that increasing levels of ISO 14001 certifications are associated with significant reductions of SO_2 emissions. A 1 percent increase in

ISO 14001 certifications is associated with a 0.064 percent reduction in SO_2 pollution, all else constant. Note that this 0.064 percent reduction occurs in the context of ISO 14001's exponential growth since its launch. The average change in (logged) ISO 14001 certifications in our sample was 0.28 for all countries and 0.70 for countries with at least one certification. About 10 percent of the sample had logged increases in ISO 14001 certifications above one. The upshot of this is that once countries start accumulating ISO 14001 certifications, small percentage changes in certifications are quite rare and changes of more than 20 percent and even more than 100 percent are not uncommon.

For a sense of scale, the average (unlogged) number of ISO 14001 certifications in our sample is about 265, which corresponds to the number of ISO 14001 certifications in Belgium in 2002. In that year, Belgium's SO_2 emissions were 205 gigagrams. Holding constant other variables in our model, increasing in 2002 Belgian ISO 14001 certifications by 10 percent (26.5) would reduce that country's pollution emissions by about 1.25 SO_2 gigagrams, holding constant the effects of other variables in the model.[17]

In the BOD analysis, the ISO 14001 coefficient –0.014 does not achieve statistical significance with *p*-value of 0.19, indicating that ISO 14001 certifications are not significantly associated with lower levels of water pollution, all else equal. This provides some support for the argument that ISO 14001 certifications focus firms' stewardship efforts more toward reducing visible air pollution (SO_2) in relation to less visible water pollution (BOD). The ISO 14001 coefficient in the BOD analysis is also much smaller than the ISO 14001 coefficient in the SO_2 analysis, indicating that ISO 14001 certifications reduce pollution more for the more visible pollutant. In fact, the difference between the ISO 14001 coefficient in the BOD analysis and the SO_2 is more than three times the standard error of the BOD ISO 14001 coefficient. It is also possible that the smaller sample size for water pollution (682 versus 1,838 for SO_2) may be inflating the standard errors, leading to somewhat low significance level.

The control variables generally behave as expected, though we note that the lack of significance among some variables is likely due to the extensive controls for country and year fixed effects, time series dynamics, and time-varying parameters. The results show that SO_2 levels are significantly higher among countries with larger economies and populations and are lower in countries with more stringent environmental regulations. Fewer controls achieve statistical significance in the BOD analyses. Both the SO_2 and BOD analyses follow the Kuznets curve relationship between wealth and pollution levels, with pollution increasing with wealth at lower levels of wealth and then decreasing with wealth at higher levels of wealth.

Finally, the diagnostic statistics suggest the models perform well. In both models presented in Table 3, the Arellano–Bond test shows no significant serial correlation for AR(2), (–0.81, $p = 0.42$) in the SO_2 model or the BOD model (0.44, $p = 0.66$). Likewise, the Hansen test suggests the instruments are valid in both the SO_2 (chi-squared (54) = 57.9, $p = 0.33$) and BOD (chi-squared (8) = 9.8, $p = 0.28$) models. Analyses with longer (collapsed) lags did not change the results in meaningful ways. In the SO_2 analysis, increasing the lag to 4 years, for example, increased the Hansen statistic *p*-value from 0.32 to 0.41, suggesting the instruments improved. The ISO 14001 coefficient becomes –0.052 with a p-value of 0.05. In the BOD analyses, the instrumental variables were estimated with 4-year lags using the "collapse" Stata option. Analyses with longer (collapsed) lags did not change the results in meaningful ways. With a 6-year lag, for example, the Hansen statistic p-value increased from 0.28 to 0.45, suggesting the instruments improved, while the coefficient of 0.018 and a p-value of 0.10. In other words, in all these specifications, the ISO 14001 coefficient in the BOD analysis is still much smaller than the ISO 14001 coefficient in the SO2 analysis.

Alternative Specifications

We explored several alternative specifications to assess the robustness of our results, reported in Table 4. Table 4 replicates the analyses presented in Table 3 while restricting the sample of countries as follows: years after 1995 (when ISO 14001 was launched), and excluding regions of the world where environmental institutions may be particularly weak (Africa) or particularly strong (the European Union). To save space, Table 4 reports the coefficient for ISO 14001 and the model diagnostic statistics but not the results for the other independent variables that are remarkable only for their consistency with those reported on Table 3.

The results for the effect of ISO 14001 on countries' pollution levels generally persist across these alternative specifications. In all SO_2 analysis specifications reported in Table 4, the coefficient for ISO 14001 is statistically significant, negative, and roughly comparable in magnitude to the base analyses presented in Table 3. The coefficient for ISO 14001 certifications is slightly smaller in the SO_2 analyses when excluding EU countries (–0.042) and African countries (–0.054), suggesting that the program's efficacy may vary across institutional context. The effect of ISO 14001 is slightly stronger (–0.071) when the analysis is restricted to the post-1995 period. In none of the alternative BOD specifications does the ISO 14001 coefficient achieve statistical significance; consistent with the base model, in these analyses the ISO 14001 coefficient remains at about –0.015 with p-values between 0.10 and 0.20. These results suggest that the effect of ISO 14001 on countries' SO_2 and BOD pollution levels is not an artifact of including the EU or African countries.

Conclusions and Future Research

This article assesses whether national level ISO 14001 counts are associated with reductions in aggregate pollution, and whether such reductions are comparable across air pollution (SO_2) and water pollution (BOD). Our cross-sectional time series research design covering of 138 countries (72 for BOD) for the period 1991–2005 employs extensive controls for time-varying variables along with country and year fixed effects. Our analysis suggests that a 1 percent increase in ISO 14001 certifications is associated with about a 0.064 percent reduction in SO_2 but not in water (BOD) pollution. In sum, the efficacy of ISO 14001 is uneven across pollutants. In the context

Table 4. National Pollution Levels and ISO 14001 Registrations, Reduced Sample GMM Results

Model	Δ ISO 14001_{it-1}	N (Countries)	N (Total)	Wald Chi-Squared (d.f.)	Arellano–Bond Test for AR(1) in First Differences	Arellano–Bond Test for AR(2) in First Differences	Hansen Test (Chi-Squared, d.f.)
Year > = 1995, SO_2	–0.065**	1517	138	463.00 (30)	–2.45	–0.78	47.95 (49)
Excluding EU, SO_2	–0.042**	1572	127	120.06 (33)	–2.38	–0.66	58.93 (54)
Excluding Africa, SO_2	–0.056**	1300	96	620.62 (33)	–2.94	–0.46	53.57
Year > = 1995, BOD	–0.016	622	72	230297.83 (28)	–4.01	0.54	8.17 (8)
Excluding EU, BOD	–0.021	496	61	285808.88 (32)	–3.22	0.62	12.33 (8)
Excluding Africa, BOD	–0.017	614	63	419507.18 (32)	–3.98	0.32	9.80 (8)

**$p < 0.05$.

Note: Specification replicates Table 3 models with reduced samples. All independent and dependent variables are differenced.

of ISO 14001's exponential growth over the time period studies, we can conclude that the program had important and substantive impact on pollution in many countries around the world.

Our article engages several important environmental literatures. For both air and water pollution we find support for the Environmental Kuznets curve hypothesis (Grossman & Krueger, 1995): economic growth has non-monotonic effects on pollution levels and after a certain wealth level is reached, pollution levels tend to decrease. We also engage with the policy research examining the influence of international trade and FDI on ISO 14001's adoption across countries (Delmas & Montes-Sancho, 2011; Prakash & Potoski, 2006). In doing so, this article offers an important corrective to the regulatory race to the bottom hypothesis. We provide some evidence that ISO 14001 adoption leads to reduction in SO_2 pollution. While we do not find statistically significant results for water pollution, we find no evidence that ISO 14001 increases pollution. Recognizing that voluntary environmental programs are not a panacea for global environmental problems, our article cautions scholars who view international economic linkages or voluntary policy instruments as necessarily encouraging regulatory races to the bottom. While certainly not definitive, we hope this article will move these environmental policy debates forward, especially in the realm of empirically testing opposing viewpoints, given the important role of voluntary programs in the interconnected contemporary world economy.

This article outlines new ideas for future research in environmental policy, particularly research on voluntary programs. Much of this literature, including the work on ISO 14001's efficacy at the facility level, has produced mixed findings. This is perhaps because scholars have studied these programs in different contexts and for different pollutants. Although we do not find evidence that ISO 14001 reduces water pollution, our findings on SO_2 counter claims that ISO 14001 is a greenwash that allows all ISO-certified firms to pollute while donning the mantle of environmental stewardship. Future work should combine macro-level analyses along with facility-level analyses. This will allow policy scholars to explore ISO 14001's effect across pollution types at the facility level and interpret them in relation to ISO 14001's macro-level effects.

Voluntary programs reflect the policy approaches embodied in new public management reforms. We believe our article moves this literature forward by showing choices by the regulated entities can influence program efficacy. The findings in this article should motivate policy scholars to examine firms' strategic considerations when both joining a program and implementing its stipulations. With ISO 14001 being more effective for visible pollutants like SO_2 than less visible water pollution (BOD), our evidence suggests that a program's efficacy may be contingent on the political salience of the targeted pollutant. Future research should also consider the extent to which findings from ISO 14001, a program that requires third-party auditing, generalize across voluntary programs. In particular, scholars debate whether shirking behavior that undermines program efficacy can be curbed by monitoring and sanctioning. King and Lenox (2000) find that the Responsible Care program was not effective in reducing pollution and suggest that the lack of third-party monitoring allowed shirking to take place. Other scholars question, however, the role of auditing and monitoring mechanisms toward efficacy of voluntary programs (Locke & Brause, 2007).

Policy scholars have emphasized how program design can influence program efficacy. Engaging with this literature, our work suggests that program design also bears upon on the number and quality of participants a program can attract. There may be a trade-off between increasing pollution reduction per participant (a function of stringency of program obligations and anti-shirking mechanisms) and the number of participants, as Borck and Coglianese (2009) suggest. Highly stringent programs are also high-cost programs, which may deter programs from joining them. The nature of this trade-off in the context of aggregate pollution reduction impact merits future research. Potoski and Prakash (2005) recognize that by itself ISO 14001's third-party certification is a moderately stringent mechanism to prevent shirking. Arguably, this is an important reason for its widespread popularity across and within countries, which is reflected in its effect on overall pollution reduction. The link between program design, program popularity, and pollution reduction needs to be explored further.

This article has not sought to apportion aggregate levels of pollution reductions between program participants and nonparticipants. We believe more research in this direction is warranted. For one, the policy literature lacks a clear theory as to why some programs have high levels of spillovers while others have modest levels of spillovers. There is virtually no careful empirical work assessing the contribution of program participants and nonparticipants in aggregate pollution reduction. We believe this is a cutting-edge issue for scholars seeking to theorize as well as undertake empirical work on the efficacy of voluntary programs.

Given that we outline a strategic model of environmental stewardship, future environmental policy research should look at both benefits and costs for firms for undertaking different types of stewardship activities (Chatterji & Toffel, 2010). Our argument pertains primarily to the benefit side of the question: firms receive greater benefits when they focus their efforts on reducing visible sources of pollution. What if it is also less expensive for firms to reduce pollution of visible sources? If so, firms' stewardship choices would reflect both pollution visibility and pollution cost issues. While cross-national longitudinal data on air and water pollution reduction costs are not available, we hope future work would be able to create such data sets and exploit them to test models of strategic environmental stewardship.

Finally, we recognize that the issue visibility is a complex concept, and physical dimension is only one of its many dimensions. A vast literature examines how issue visibility and public opinion affect policy (Page & Shapiro, 1983). The policy salience of an issue is a function not only of issues' attributes but also factors such as the political context (Stimson, 1991), and the attributes of the actors championing the cause. Because issues have life cycles, the public's interest may not remain constant over time. Exogenous shocks can increase the salience of certain issues (Kingdon, 2002). Finally, the media has a crucial role in influencing the visibility of certain issues (Iyengar, 1991). Thus, future work should look at both the physical as well as the political dimensions of issue visibility to explore how firms strategically respond to them.

Notes

1. Voluntary environmental programs include unilateral stewardship commitment that firms sometimes make (as in Walmart's Sustainability Focus), bilateral agreements negotiated between governments and firms (for example, Project XL), and public voluntary programs (such as ISO 14001). For a survey of this literature and discussions on various typologies, see Börkey, Glachant, and Lévêque (1998); Khanna (2001); Morgenstern and Pizer (2007); Lyons and Maxwell (2007); King and Toffel (2009); Borck and Coglianese (2009); and deLeon and Rivera (2009).
2. As Alberini and Segerson (2002, p. 17) note: "[U]nder a voluntary approach, a polluter will not participate unless his payoff (broadly defined) is at least as high as it would be without participation."
3. http://www.iso.org/iso/theiso14000family_2009.pdf
4. On trade-offs in sustainability ratings, see Delmas and Doctori-Blass (2010).
5. http://www.iso.org/iso/about/iso_members.htm; accessed August 8, 2011.
6. EMS have many dimensions and can vary across firms (Anton, Deltas & Khanna, 2004; Arimura et al., 2011; Coglianese & Nash, 2001; Darnall & Kim, 2012; Khanna, 2001). Third-party auditing becomes a way to ensure that the facility's EMS meet the objectives set out in ISO 14001.
7. In some cases air pollution might be a more serious problem than water pollution. What is crucial are the perceptions about pollution. If firms are likely to think air pollution is more visible than water pollution, we expect them to invest in environmental stewardship accordingly.
8. http://projects.nytimes.com/toxic-waters; Accessed August 8, 2011.
9. On how firms respond to being rated on their sustainability performance, see Chatterji and Toffel (2010).
10. Arguably, firms may focus on air pollution reductions because reductions in air pollution are less expensive than water pollution. Unfortunately, cross-national longitudinal data on the relative costs of air pollution reduction versus water pollution reductions are not available. We have found some industry-specific studies that seem to suggest that compliance costs (a proxy for pollution reduction costs) tend to be lower for water pollution in relation to air pollution, which lends more support to our theoretical argument. See for example, the report on California Orange industry (http://cab.cati.csufresno.edu/PDF/Regulatory%20Study%20Oranges.pdf) or the U.S. electricity generation industry (http://www.raponline.org/document/download/id/4670). If the ratio of air to water pollution reduction costs is stable during the time period of our study, the inclusion of country fixed effects should be able to account for differences in pollution reduction costs in the two media.
11. Pollution data on SO_2 beyond 2005 are not available.
12. A short-term exogenous shock specific to a country would be captured via the country's fixed effect at the time it occurred and thus produce inconsistent estimates for the other regressors (with more time periods the effects of cross-sectional exogenous shocks would be dissipated over time).
13. The term "Arellano and Bond estimator" has come to represent a class of models with different features, some later developed by Arellano and Bover (1995) and Blundell and Bond (1998). Some analysts call the whole class "Arellano and Bond GMM" estimators (perhaps because they can all be estimated in Stata using the xtabond and xtabond2 commands), while others distinguish between "difference GMM" (Arellano & Bond, 1991) and "system GMM" (Arellano & Bover, 1995; Blundell & Bond, 1998). System GMM has the advantage of incorporating additional and potentially more valid instruments, but at the expense of additional assumptions. Difference GMM has its advantages if valid instruments are available. Since our instruments appear valid with difference GMM, we do not use system GMM.
14. Since we are using a panel design, we focus on SO_2 and BOD for which data are available for a relatively long time series for a large number of countries. Consequently, we do not test the impact of ISO 14001 adoption on other pollutants.
15. We also experimented with analyses including measures of executive branch ideology and indexes including executive and legislative ideology. Executive Ideology is a measure of the ideological disposition of a country's chief executive, scored 1 if the chief executive is from a liberal party, –1 if from a conservative party, and 0 if from a centrist party or if there is no information or no executive in the country. The results were essentially identical to those presented below.

16. Cao and Prakash (2010) found that the number of treaty commitments is highly correlated ($r = 0.88$) with the stringency of environmental regulations in 24 countries in 1970, 1980, 1990, and 2000, providing further confidence that that treaty commitments are a strong proxy for the stringency of domestic environmental regulations.
17. The effect of a 10 percent increase in ISO 14001 certifications is $1.10^{-0.064} = 0.994$. For an SO_2 pollution level at 205, the reduction is thus $205 - (0.993 * 205) = 1.24$.

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