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The Impact of Regulatory Complexity upon Self-regulation:
Evidence from the Adoption and Certification of Environmental Management Systems

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This article focuses on environmental management systems (EMS) and aims to enhance our understanding of the relationship between environmental state regulation and self-regulation. Unlike previous studies that treat state regulation as uni-dimensional and focus on externally certified forms of environmental self-regulation, this article takes a more nuanced approach. It looks at how direct and indirect state regulation and its stringency influence both non-certified in-house and externally certified adoption of EMS. Methodologically, the study differentiates from previous research by acknowledging the interconnected nature of in-house and external certification decisions, viewing these decisions as sequential. Based on a survey of 2,076 UK firms, findings show that effective environmental protection entails collaboration between environmental state regulation and in-house adoption of EMS. Results also reveal that externally certified EMS substitute for state environmental regulation, filling the void that results from weakening state regulation in the context of neoliberalism.

Keywords
Environmental regulation, self-regulation, environmental management systems (EMS), corporate environmental responsibility.

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1. Introduction

This article aims to unveil the relationship between environmental state regulation and self-regulation (both in-house and externally certified forms of self-regulation). This relationship is increasingly important for policymakers who are looking to improve environmental performance with limited public resources. Yet, the way state regulation interacts with self-regulation is not clear, impeding policymakers' ability to enhance corporate environmental performance through self-regulatory tools. On one hand, studies in line with Porter hypothesis (Porter and van der Linde, 1995), indicate that strict state regulation complements self-regulation by triggering the adoption of voluntary self-regulatory tools for environmental protection (Berrone, et al., 2013; Börzel, 2009; Short and Toffel, 2010; Testa et al., 2011). On the other hand, scholars view the rise in the adoption of environmental self-regulatory tools as a shift from *government* to *governance* where non-state actors, such as corporations, increase their participation in regulatory actions (Albareda, 2008; Balleisen and Eisner, 2009; Hysing, 2009). In this context, state environmental regulation and voluntary self-regulation are conceptualized as adversaries or substitutes (Berliner and Prakash, 2013; De La Cuesta Gonzalez and Martinez, 2004; Gupta and Innes, 2014; Potoski and Prakash, 2013).

Despite the significance of this debate, theoretical and empirical insights on *whether*, and *how*, state regulation affects firms' decisions to adopt self-regulatory environmental tools (e.g. in-house Environmental Management Systems (EMS), ISO14001, Eco-Management Audit Scheme (EMAS)) remain non-coherent. Two particular shortcomings in the literature lead to this confusion.

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First, with few exceptions (Potoski and Prakash, 2005; Prakash and Potoski, 2012), prior literature treats state environmental regulation as a key, yet one-dimensional, determinant of voluntary self-regulation. Hence, little attention is given to understanding which types of environmental regulation can stimulate voluntary environmental self-regulatory approaches. Nevertheless, in a globalized business environment, characterized by neoliberal deregulation attempts (Arsel and Büscher, 2012; Merino et al, 2010; Vogel, 2009), clarifying this relationship is crucial to ensure effective corporate environmental performance.

Second, previous research examining the relationship between state environmental regulation and voluntary self-regulation (e.g. González-Benito and González-Benito, 2008; Russo, 2009) rarely differentiates between in-house and externally certified forms of self-regulation. Although the former is not new (Bansal and Bogner, 2002; Jiang and Bansal, 2003), and features in previous studies (Aravind and Christmann, 2011; Boiral, 2011; Demirel and Kesidou, 2011; Wiengarten et al, 2013), with evidence suggesting that significant proportions of firms might opt for in-house self-regulation (Lannelongue and González-Benito, 2012; Johnstone and Labonne, 2009), most research focuses solely on externally certified forms of environmental self-regulation.

Both the in-house and externally certified environmental self-regulation entail the development of an EMS consisting of management procedures that aim to improve the environmental performance of an organization by changing the organizational structure, procedures, and routines (Netherwood, 1998). The difference between in-house and externally certified forms of self-regulation is that in the former, organizations develop their own EMS and do not seek external certification. In turn, externally certified forms of self-regulation entail audits from accredited third party auditors to ensure that their EMS is aligned with the requirements of the standard (usually ISO 14001 or EMAS).

The distinction between in-house adoption and certification of environmental self-regulation is vital because those firms that choose in-house adoption are primarily seeking to reduce their production costs and to improve efficiency (Darnall et al., 2008; King and Lenox, 2001), whilst firms that opt for certification are oftentimes strategically aiming to enhance their legitimacy by signaling improved environmental performance to stakeholders (Castka and Prajogo, 2013). Certification is not simply a marketing device, but it has become a prominent mode of social and environmental self-regulation (Schneiberg and Bartley, 2008). It is used by various stakeholders to tackle information asymmetries and collective action problems (Potoski and Prakash, 2009), regulate global supply chains and correct market failures (Guthman, 2007). Given the different positioning and objectives of in-house and certified environmental self-regulation, the literature needs to tackle these separately (Bartley, 2011).

This article makes a theoretical contribution to the corporate environmental responsibility literature by examining the role of different state environmental regulations in determining firms' choice of voluntary environmental self-regulatory tools. In doing so, the paper teases out how the diverse dimensions of the regulatory regime, consisting of multiple regulatory tools, can generate diverse environmental self-regulation responses among corporations. We focus on the three most important dimensions of an environmental regulatory regime according to literature (Frondel et al., 2007; Jiménez, 2005; OECD, 2010; Johnstone, 2007; Khanna et al., 2009) namely, (a) *direct instruments* (i.e. environmental regulations), (b) *indirect instruments* (i.e. environmental taxes), and (c) the *stringency of environmental policies*, and on *EMS* (both in-house and certified EMS), i.e. the most widely used self-regulatory tool for environmental protection (Figure 1).

-------------------------- FIGURE 1 ABOUT HERE --------------------------------

Drawing on the theoretical lenses of institutional economics (Bartley, 2011; Potoski and Prakash, 2009) and political theory (Abbott and Snidal, 2009; Eberlein et al., 2014), the article develops a conceptual framework where corporate voluntarily adoption and certification of environmental self-regulatory tools are influenced by public regulation in different ways. First, we argue that state regulation complements some forms of self-regulation, such as in-house EMS. Whilst state environmental regulation corrects failures in markets of responsible products and services (Akerlof, 1970), it might not be able to address market failures fully, as no single governance actor, either public or private, has all the competencies required to enact effective common-interest regulation (Eberlein et al., 2014). The results of this study show that effective environmental protection entails collaboration between state regulation and voluntary self-regulatory tools (i.e. the in-house EMS). Second, we posit that other forms of environmental self-regulation, such as certified EMS, substitute for state regulation. This might be due to the diminishing role of the state resulting from the prevalence of neoliberal policies (Bartley, 2011). As a consequence, the resulting regulatory void is often filled by some form of self-regulation (Potoski and Prakash, 2009).

Methodologically, the article applies a novel technique in the environmental self-regulation literature by employing a two-stage nested econometric model, namely a bivariate probit with sample selection model, to estimate the determinants of firms' EMS in-house adoption and EMS certification. We follow innovation literature (Piga and Vivarelli, 2004) and model EMS in-house adoption and certification decisions in sequential order, using simultaneous econometric estimation methods (Berinsky, 2004). Consequently, determinants of these two interlinked decisions can be estimated more accurately compared to earlier literature that treats these decisions as exogenous in distinct probit models.[4] Our modeling

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[4] The assumption of these models is that adopting an EMS and certifying it are two independent decisions with no synergies.

strategy acknowledges the interconnected nature of the two decisions and views them as sequential; minimizing the risks of sample selection bias. Detailed econometric methodology is discussed in Section 3.

Empirically, we contribute to the literature by introducing new firm-level data from the UK. We utilize a dataset based on the UK's official Environmental Protection Expenditure survey. In doing so, this study becomes the first large-scale investigation of the in-house adoption and certification of self-regulatory tools for environmental responsibility in the UK and one of the few large-scale empirical studies related to EMS.

2. Theoretical Framework and Literature Review

2.1. Understanding the Relationship between State Environmental Regulation and Environmental Self-regulation

The literature highlights that globalization, the demise of the state, and societal demands for environmentally friendly practices are key socio-political developments in promoting voluntary environmental self-regulation (Vogel, 2005). These trends have created a complex regulatory environment in which the relationship between state environmental regulation and self-regulation is opaque. Previous studies have documented the political shift towards economic liberalism and the relevant support for the autonomy of the market in solving environmental problems. Main theoretical perspectives in this literature include the conceptualization of environmental self-regulation as decentralized institutions strategically used by firms for own benefit (King et al., 2005); institutional and resource-based views to analyze firms' motives for adopting self-regulation (Darnall et al., 2008; Heras-Saizarbitoria et al., 2011); institutional perspectives discussing firms' commitment (Boiral, 2007; Daddi et al., 2016; Delmas and Montes-Sancho, 2011; Phan and Baird 2015); and insights from club

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theory to discuss how governments can promote adoption of environmental self-regulation (Kolln and Prakash, 2002; Prakash and Potoski, 2007). Additionally, various studies have looked into the corporate and environmental benefits of environmental self-regulation (Ferrón-Vílchez, 2016; Nishitani et al., 2012) and the potential of self-regulation in absence of state regulation (King and Toffel, 2009; Shimshack and Ward, 2005).

Overall, there is skepticism in the literature about environmental self-regulation's potential to substitute state regulation, as meta-analyses suggest that adopters of self-regulation perform no better than non-adopters (Lyon and Maxwell, 2007; Darnall and Sides, 2008). It is argued that environmental self-regulatory initiatives are not merely for harmless window-dressing but they can significantly undermine the effectiveness of environmental state laws (Short and Toffel, 2010). In this context, the institutional economics literature has highlighted the importance of state regulation in the context of environmentally responsible businesses (Bartley, 2011). The main argument here is that since environmental self-regulation does not fully allow the market to control the negative externalities of economic activities, it fails to maximize society's welfare and corrective policy interventions may be deemed necessary (Bowen et al., 2012).

Yet, the political theory literature on transnational governance argues that state regulation alone is not effective in correcting market failures, because in a neoliberal and globalized economy, the state retreats from issues pertinent to corporate responsibility (Bauman, 2007). The argument is that globalization of the economy has downgraded the role of the state as political sovereignty. The state is expected to free capital and corporations from regulation and allow them to operate unfettered (Stiglitz, 2003). Some authors have gone as far as arguing that state no longer functions and that it is thoroughly appropriated by transnational corporations (Miyoshi, 1996). Others argue that the role of governments has been limited to establishing a minimum legal framework to ensure the operation of the market (De La Cuesta

Gonzalez and Martinez, 2004). Governments, including many European ones, have favored this position since it enabled them to minimize the financial and political risks state regulation entails (Vogel, 2005). In many cases, governments have declared their incapacity in dealing with social and environmental issues and have encouraged the adoption of self-regulatory approaches by providing regulatory relief such as granting permits, reductions in financial guarantees and tax reductions (Testa et al., 2016). According to Eberlein et al. (2014) such incapacity to fully regulate entails cooperation between public and private governance actors. Similarly, Abbott and Snidal (2009) emphasize the necessity of public and private governance actors to collaborate in order to pursue effective common-interest regulation, as governance actors need to have certain competencies (i.e. independence, representativeness, expertise and operational capacity) and no single governance actor, either private or public, has all the competencies.

These accounts provide a rich framework for analysis but reveal little about the relationship between state environmental regulation and self-regulation. Most studies treat state regulation as uni-dimensional and focus mostly on externally certified forms of self-regulation ignoring non-certified in-house tools of self-regulation. To move beyond these tensions in the literature, we take a more detailed approach into regulation and self-regulation. Specifically, we focus on the policy instruments governments use to regulate environmental issues and the stringency of these tools. We also take into account both types of adoption of self-regulation, namely in-house and externally certified. The discussion in the next section is organized to reflect the potentially different impact of state regulations upon self-regulatory tools of corporate environmental responsibility.

2.2. State Environmental regulation: Direct instruments, Indirect instruments and Regulatory Stringency

The literature divides state environmental regulation tools into two categories: *direct instruments* (i.e. environmental regulations) and *indirect instruments* (i.e. environmental taxes) (Jiménez, 2005; OECD, 2010). Direct regulation is also referred as command-and-control, where *command* denotes the specification of direct and mandatory performance standards or technologies to abide by, and *control* indicates that non-compliance is penalized (Baumol, 1988). Direct regulation policies utilize instruments such as ambient, technology-based and performance-based standards. Indirect instruments include Pigouvian taxes, subsidies, deposit/refund systems and tradable permits. They provide economic incentives to polluters in order to make the best private choice to coincide with the best social low-carbon choice (Milliman and Prince, 1989).

Here we also consider the regulatory stringency defined as "the explicit and implicit, policy-induced price of environmental externalities" (OECD, 2015: 22). Regulatory stringency might be more important than the choice of a single direct or indirect instrument in controlling environmental impact (Frondel et al., 2007; Johnstone, 2007; Khanna et al., 2009), as it can enable cleaner alternatives to become more attractive than incumbent technologies or methods (Grubb et al., 2014).

2.2.1 The Impact of Direct instruments upon In-house EMS and Externally Certified EMS

Previous studies analyzing the influence of direct instruments on firms' adoption of environmental self-regulatory tools point out that firms use these tools to avoid sanctions (Hackett, 2013). Most scholars see direct regulation as an enabler for the formation of corporate environmental governance regimes and, therefore, a driver for environmental self-regulation (Anton et al., 2004).

Institutional theory, the main theoretical framework adopted to investigate the role of environmental regulations in EMS diffusion, does not fully uncover regulatory complexity. Only a minority of studies recognizes the complex nature of environmental regulation and its multidimensional – and sometimes contradictory – effects on the uptake of environmental self-regulation (Lynch-Wood and Williamson, 2011). Furthermore, past research does not always pay attention to important differences between certified and in-house forms of environmental self-regulation; the two types are bundled under a single category to represent environmental self-regulation, overlooking the fact that motivations to adopt in-house and externally certified EMS can be inherently different.

The EMS literature argues that firms choosing to adopt any form of EMS are mainly interested in reducing their production costs and improving operational efficiency as an adoption motivation (Darnall et al., 2008; King and Lenox, 2001; Baek, 2017), whereas certifying these self-regulatory tools might be driven by the legitimacy[5] (Husted et al., 2017) and signaling benefits of certification (Kwon et al., 2002; Castka and Prajogo, 2013). Furthermore, treating the in-house and certified forms of environmental self-regulation under one category overlooks the sequential relationship that exists between the two. Particularly for EMS, the decision to adopt an in-house EMS precedes the certification decision (Jiang and Bansal, 2003).

Given that in-house adoption of EMS generates efficiency gains and delivers environmental benefits through waste reduction (Baek, 2017; Darnall et al., 2008), it can be particularly effective in creating corporate environmental improvements and meeting

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[5] Recent work by Husted et al., (2017) highlights that MNE subsidiaries and domestic firms are augmenting their local legitimacy by adopting different types of certifications; as the first are seeking to overcome the liability of foreignness whilst the latter the liability of localness.

regulatory demands (Anton et al., 2004; Khanna et al., 2009; Testa et al., 2016; Wätzold et al., 2001). Thus, in-house EMS adoption has the benefit of improving corporate performance and of signaling to the regulators that a firm is en route to better environmental performance. Hence, we would expect that regulatory compliance motivations arising from *direct instruments might drive in-house EMS adoption*.

In contrast, we would expect that *direct instruments would have a negative effect on externally certified EMS* as a number of recent studies (Berliner and Prakash, 2013; Prakash and Potoski, 2013) suggest that corporate voluntarism has evolved as a substitute for government intervention in the broader framework of neoliberal state policies. Accordingly, firms certify an in-house EMS externally in order to address the void created by the insufficiency of regulations and to signal their green credentials to stakeholders. Delmas and Montes-Sancho (2011) argue that the relationship between regulatory pressures and certification of environmental self-regulation is highly contextual and depends on how certification mechanisms interact with institutional regulations. If EMS certification has co-evolved with regulatory forces and firms receive significant regulatory relief for certifying their EMS, then such certification would offer additional benefits for firms that already have an in-house EMS. Only in such cases can direct regulations be expected to complement and boost certification decisions among firms that have adopted in-house EMS (Bansal and Bogner, 2002).

In heavily regulated environments, such as the UK, external certification of self-regulation brings little regulatory relief to certifying companies, and result in rather low marginal benefits from certification (Glachant et al., 2002; Wätzold et al., 2001). As certification costs are high (Curkovic and Sroufe, 2011; Darnall and Edwards, 2006) and the marginal legitimacy benefits might be negligible, one could expect the prevalence of regulations to deter certification, particularly when firms face significant and urgent

compliance pressures and certification has little added value to offer on top of in-house adoption of environmental self-regulation. In such cases firms may instead opt for alternative actions that more effectively serve their compliance needs.

2.2.2 The Impact of Indirect instruments upon In-house EMS and Externally Certified EMS

The environmental economics literature argues that indirect (i.e. market-based) instruments are more flexible than direct regulations (Baumol, 1988) by providing significant opportunities for environmental corporate actions with a wider range of choices for the firm (Andersen and Sprenger, 2000). However, the empirical literature presents mixed findings that do not always confirm these theoretical propositions (Arimura et al. 2011; Frondel et al. 2008). Reviewing the econometric and case-study-based literature, Kemp and Pontoglio (2011) conclude that the impact of indirect instruments on self-regulatory tools of corporate environmental responsibility is significantly weaker than is asserted by theoretical environmental economists. Other empirical studies support this conclusion (Demirel and Kesidou, 2011; Testa et al., 2012).

In sum, whilst the theoretical literature postulates that indirect instruments stimulate environmentally responsible practices, empirical research does not necessarily endorse that view. This inconsistency may be due to the fact that indirect instruments are applied more laxly than direct regulation instruments (Frondel et al., 2007). Based on these contrasting arguments, we tentatively expect that *indirect instruments, such as environmental taxes, could drive the adoption of in-house EMS provided that they are set at an adequate rate*. Setting taxes at an appropriate rate is critical, as the tax rate needs to reflect not only the externality costs imposed on the global climate, but also the environmental opportunities that taxes may engender (e.g. adoption of EMS or investment in clean technologies) (Grubb et al., 2014).

Yet, when it comes to certified forms of self-regulation, one would expect that *indirect instruments* would *have a negative effect on externally certified EMS* due to high certification costs and marginal legitimacy benefits as discussed in Section 2.2.1 (Curkovic and Sroufe, 2011).

2.2.3 The Impact of Regulatory Stringency upon In-house EMS and Externally Certified EMS

The motivation to adopt self-regulatory tools such as EMS in order to comply with environmental regulations is stronger in circumstances where firms are confronted with more stringent regulatory requirements and a higher threat of potential sanctions. Evidence from advanced and emerging economies (Angel and Rock, 2005; Darnall et al, 2008) shows that under more stringent policy schemes, self-regulation can offer higher value to a firm by controlling its environmental impact and reducing the sanction's risk associated with non-compliance. Thus, we would expect that *firms faced with regulatory stringency would be more likely to adopt in-house EMS*.

Earlier studies state that the same applies for external certification; as in stringently regulated and monitored environments certification sends a credible signal of *cleanness* to the government (Johnstone and Labonne, 2009). However, recent studies argue that there may be little need to signal cleanness through formal certification under heavily regulated industrial settings where pollution levels are already closely measured, monitored, and controlled by the authorities. Berliner and Prakash (2013) and Prakash and Potoski (2013) state that EMS certification is used to generate a distinction via *brand name recognition*, which assures stakeholders that the firm is *clean*. When regulatory regimes are lax, firms tend to certify their EMS in order to differentiate themselves in the marketplace. Yet, the potential marginal benefits of certification decline with increased regulatory pressures and more stringent

monitoring (Prakash and Potoski, 2012). Hence, we would expect that *regulatory stringency would have a negative effect on externally certified EMS.*

Overall, whilst the impact of direct and indirect instruments and regulatory stringency upon in-house EMS adoption is generally found to be positive; the literature is less clear about the effects of state environmental regulations upon external certification. The empirical section of this article aims to advance this literature and to deliver evidence of how regulations interact with self-regulatory tools by focusing on the case of EMS in the UK.

3. Data and Methodology

3.1. Sample

The empirical research in this article is based on a dataset of companies that participated in the UK's *Environmental Protection Expenditure by Industry* for the manufacturing, mining and quarrying sectors (for information on the dataset see: Demirel and Kesidou, 2011; Kesidou and Demirel, 2012; Kneller and Manderson, 2012). It contains information about the financial and environmental protection activities of plants, including a question that asks companies which EMS they have implemented with possible responses of: (1) None, (2) In-house, (3) ISO14001, and (4) EMAS. The survey questions are reported in Appendix A. The survey is administered by the UK Department for Environment, Food and Rural Affairs (DEFRA) and uses a stratified random sample of companies with a minimum of ten employees (based on the Standard Industrial Classification and firm size) across industrial sectors with different levels of pollution potential (see industrial sector profile of participants in Appendix B). The data collected in this survey constitutes the basis for the UK's official environmental statistics and provides the broadest coverage and detail among environmental surveys conducted in the UK.

The article draws on data published in 2013 and includes firms with positive environmental spending.[6] Of the 7,827 facilities contacted, 2,352 returned validated responses, giving a response rate of 30%. This is in line with similar surveys in the field (see Darnall et al., 2010). Further cleaning of the data to eliminate responses with missing observations resulted in a total of 2,076 firms included in the current analysis.

3.2. Empirical Strategy and Dependent Variables

Previous studies model the adoption of in-house EMS and external certification of EMS, either separately treating these two decisions as independent with no synergies, or acknowledge the related nature of the two decisions but do not view them as sequential (e.g. Johnstone and Labonne, 2009; Ziegler and Nogareda, 2009). However, there are significant overlaps between the requirements of in-house EMS and externally certified EMS, invalidating the theoretical basis for the perception of two decisions as independent. In practice, the decision to certify EMS is an extra step after in-house EMS adoption (Jiang and Bansal, 2003).[7] In first instance, an in-house EMS is put in place. Subsequently, a pilot period follows during which gaps between the implemented EMS and the EMS's requirements are identified and addressed through appropriate improvements. Only, after this stage, a firm may opt for an external audit to acquire external certification or an internal audit to maintain the in-house EMS (Terlaak, 2007).

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[6] In the two years after that, DEFRA collected information only from heavily polluting firms. As a result, the sample was significantly smaller (227 companies in 2014 and 200 companies in 2015) and not adequate for statistical analysis as it is not representative of the population of companies in the UK. It should be noted that the analysis in this article reflects the EMS in-house adoption and certification among firms with positive environmental spending.

[7] Organizations seeking to adopt an in-house EMS often use external consultants who analyse the firm's operations and environmental impacts. An EMS is then designed and implemented in line with the requirements of the standard (usually ISO14001 or EMAS). This begins with documenting how the organization interfaces with the environment, followed by establishing environmental objectives, targets and a programme to accomplish them (Iatridis and Kesidou, 2016).

Figure 2 depicts the nested structure of in-house and external certification decisions. The first decision that a firm takes is whether to adopt an in-house EMS. Afterwards, following a piloting period, it has to decide whether to certify the EMS externally. In other words, firms that certify their EMS are often a subsample of those that adopted an in-house EMS. Unless this sequential structure is incorporated into the empirical estimation strategy, the estimates are biased and inconsistent due to sample selection problems (Heckman, 1977). Hence, the adoption and certification of an EMS need to be jointly modeled, as the two decisions cannot be treated as independently exogenous.

--------------------- FIGURE 2 ABOUT HERE ------------------------------------

To account for the aforementioned sample selection problem, we use a bivariate probit with sample selection model, where a selection equation is estimated using the full sample, followed by an outcome equation estimated for the *selected* observations. Differently from the Heckman selection model, the dependent variables in both the selection and outcome equations are binary variables (Greene, 2012).[8] We jointly model the two dichotomous dependent variables in-house EMS adoption (**EMS**) and external certification EMS (**CERT_EMS**) in a two-stage econometric model with a nested structure:

(Eq.1)

STAGE 1: ***SELECTION EQUATION*** with dependent variable EMS

$$y_{i2} = \beta_2 x_{i2} + \varepsilon_{i2}, y_{i2} = 1 \quad if \ y_{i2}^* > 0 , \qquad 0 \ otherwise$$

STAGE 2: ***OUTCOME EQUATION*** with dependent variable CERT_EMS

$$y_{i1} = \beta_1 x_{i1} + \varepsilon_{i1}, y_{i1} = 1 \quad if \ y_{i1}^* > 0 , \qquad 0 \ otherwise$$

$$\left(y_{i1}, x_{i,1}\right) is \ only \ observed \ when \ y_{i2} = 1$$

The dichotomous dependent variables of the selection and outcome equations are derived from the EMS-related questions in the survey. Firms were asked whether they had implemented an environmental management system (**EMS**) and whether this was certified (**CERT_EMS**) by ISO14001 or EMAS. Both are binary variables taking the value of 1 in the case of a positive response to the relevant question (see Appendix A). 35.2% of firms have an in-house EMS and of these 51% are externally certified.[9]

3.3. Independent Variables

To investigate the impact of *direct instruments*, we use the variable environmental regulations (**ENV_REG**), which takes the value 1 if a firm indicates that its decision to invest in environmental protection was affected by the presence of environmental regulations at national level. We examine the impact of *indirect instruments* with the use of the **ENV_TAX** variable that takes the value 1 if the firm reveals that environmental taxes have been a reason for its investments in environmental protection.

In order to examine the impact of the *stringency* of government's overall environmental policy interventions across direct and indirect instruments, we use the variable **STRING** which is constructed as the proportion of abatement costs incurred (i.e. the capital and operating costs of complying with all types of environmental regulations) relative to the firm's annual turnover. Pollution abatement costs are used as a measure of environmental stringency in the literature reflecting that firms in more energy intensive sectors/businesses face higher pollution

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[9] The majority of the firms with certification have opted for ISO14001 certification. In particular, 17% of all responding companies had an EMS certified to ISO14001, and 0.34% certified to EMAS.

abatement expenditures and are more likely to be affected by regulatory stringency (Brunnermeier and Cohen, 2003).[10]

We complement the DEFRA survey with data from external sources to account for energy use by industry, an alternative proxy for regulatory stringency. Prior research has shown that energy use intensity is closely correlated with pollution emissions (Cole et al., 2005) and regulatory stringency experienced at the industry level (Gary and Shimshack, 2011). Thus, we investigate the differences across industries facing different degrees of regulatory stringency. In order to capture the tendencies of in-house EMS adoption and certification in more/less polluting industries, we group the industries represented in our data under five quintiles (**ENERGY_Q1-Q5**) based on their annual energy use as detailed in Appendix B.

3.4. Control Variables

We control for a range of factors that are considered important EMS drivers. First, we control for the impact of customer pressures (Arimura et al., 2011) by using a dummy variable **CUST**; indicating whether the firm has invested in environmental protection due to customer demands. Second, we control for heterogeneity in the innovative capabilities of firms as a driver of EMS adoption and certification (Cañón-de-Francia et al., 2007). Accordingly, we use two firm-level indicators of technological innovation capabilities: **ECORD** and **EQUIP**. ECORD captures firms' innovation capabilities by taking the logarithm of R&D budget specifically allocated for environmental innovations. EQUIP is a dummy variable reflecting whether the company has invested in machine and equipment upgrades to offset its environmental impact. Third, we use the logarithm of cost savings (**CS**) to control for claims that cost cutting benefits' of

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[10] King and Lenox (2001) recommend adjusting similar measures of stringency geographically to account for the differences varied environmental regulation across different regions. It was not possible to make this adjustment in the dataset due to anonymity of the firms, and the relatively central nature of environmental regulations in the UK.

environmental corporate behavior is an important driver of EMS adoption (Porter and van der Linde, 1995). Fourth, we control for company effects (**PARENT**) to address the arguments that parent company pressures in the form of authoritative directives lead to EMS adoption (Annandale et al., 2004), whereas the decision to certify EMS is often left to local facilities (Jiang and Bansal, 2003). Finally, in all estimations, we control for firm size with the logarithm of the number of employees (**SIZE**) (Martin-Peña et al., 2014).

To identify the selection equation, we use two variables: **PROD**, the ratio of company turnover to employment, as a proxy for firm productivity, and **INH**, the ratio of in-house environmental protection expenditures to total environmental operating costs, as a proxy for in-house capabilities in environmental protection (Lannelongue and González-Benito, 2012). Firm productivity and in-house environmental capabilities are likely to drive the adoption of in-house EMS. For example, Darnall and Edwards (2006) find evidence that superior firm capabilities reduce the overall costs of EMS adoption and therefore, encourage adoption. Once EMS are implemented within a firm, we would expect that the decision to certify them not to be contingent upon in-house capabilities. This is mainly due to the fact that external stakeholders drive the certification decision, which is used to gain legitimacy (Jiang and Bansal, 2003; Neumayer and Perkins, 2004).

Table 1 provides summary statistics for the dependent and independent variables used and offers a summary profiling of the participants while full survey questions are reported in Appendix A. Additionally, we checked for Common Method Variance and reached the conclusion that this is not a major concern in the current work.[11]

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[11] To check for Common Method Variance (CMV), we took into account a number of ex ante approaches, implemented in the research design, as well as an ex post approach, implemented after the research was conducted. Four key sources of CMV are identified in the literature: (a) *common rater effect*, (b) *item characteristics effect*, (c) *item context effect*, and (d) *measurement context effect* (Podsakoff et al., 2003). In the current study, even though variables derive from simple and unambiguous constructs, it is still crucial to assess whether any sources of CMV are present in the data. (a) *Common rater effect* arises when respondents modify their answers due to

4. Results

Table 2 presents the estimation results. Firstly, we note that the empirical strategy employed in the article to control for sample selection is superior to a simple probit model as confirmed by the significant rho statistics for all models (M1-M3). The estimations presented in Table 2 are for a base (M1), a full (M2), and an alternative model (M3).

With regards to environmental regulation, the results show that the coefficients indicating the impact of ENV_REG on in-house EMS adoption are positive and statistically significant ($p < 0.001$) in M1-M3, while the coefficients indicating the impact of ENV_REG on EMS certification are negative in M1-M3 with significance levels ranging between statistically significant ($p < 0.05$) to marginally significant ($p < 0.10$).

With reference to environmental taxes, the findings in M1-M3 suggest that the variable ENV_TAX exerts a positive impact upon in-house EMS adoption and a negative impact upon EMS certification, even though none of these effects is statistically significant ($p > 0.10$).

As for regulatory stringency, the results indicate that the STRING variable in M1-M3 exerts a positive effect on the adoption of in-house EMS, while it affects the certification

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reasons of social desirability (Malhotra et al., 2006). To minimize social desirability bias, all questionnaires were anonymous. (b) *Item characteristics effect* occurs when the questions are obscurely phrased. Such bias was not a problem in the current study due to simple and concise definitions. (c) *Item context effect* is a problem when numerous questions lead to respondent fatigue, or when the placing of the questions linked to the dependent and independent variables may suggest a causal relationship. Questions associated to the dependent and independent variables were presented in a balanced manner in the questionnaire to avoid this. (d) *Measurement context effect* is a problem when a single respondent provides answers to the independent and dependent variables at the same time (Podsakoff et al., 2003; Malhotra et al., 2006). Measurement context effects may be present in the data as the independent and dependent variables were measured simultaneously from one source. As an ex-post approach, we used Harman's (1967) single-factor test with an unrotated factor analysis applied to all variables. If CMV is present in the data, a single factor accounts for the majority of the variance in the variables (Podsakoff et al., 2003). The unrotated factor analysis produced four factors accounting for 47% of the cumulative variance – so no single factor emerged suggesting that CMV does not significantly affect the results of the empirical analysis.

decision negatively even though the majority of these coefficients are marginally significant or insignificant. Further evidence on the positive effects of regulatory stringency on in-house EMS adoption and the negative effects for EMS certification is found in M3. The coefficients for industries associated with different energy-use-intensity (ENERGY_Q1-Q5) suggest that firms in the most polluting industries (ENERGY_Q5) are more likely to adopt an in-house EMS, whereas firms in less polluting industries have a higher tendency to certify (ENERGY_Q2). Industries with lower energy-use/environmental-impact are characterized by *environmental impact opacity*, referring to the obscurity of a firm's environmental impact and the difficulty for external stakeholders to assess it, as these industries feature laxer regulations and less clear emission criteria (Jiang and Bansal, 2003). In absence of clear regulatory criteria, externally certified forms of EMS can fill the void and help firms gain legitimacy and transmit information to external stakeholders. Closely monitored energy-intensive industries, on the other hand, present reduced environmental impact opacity. Hence, EMS certification presents a lower ability to function as a distinguishing branding strategy (Neumayer and Perkins, 2004).

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Regarding control variables, as represented in M2, the CUST variable has a positive but insignificant impact in the selection and outcome equations. Hence, customers' environmental concerns do not appear to influence the EMS in-house adoption and certification decisions. Prior studies report that customers' environmental concerns do not often translate into purchase actions (Lane and Potter, 2007; Young et al., 2010).

Proxies for firms' technological innovation capabilities, ECORD and EQUIP, suggest that innovation capabilities among firms are a significant driver of EMS in-house adoption but have no significant impact upon certification. The finding that EMS in-house adoption builds on the technological innovation capabilities of a firm is in line with studies pointing to

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complementarities between technological and organizational innovations (Battisti and Stoneman, 2010), and between technological and environmental innovations (Demirel and Kesidou, 2011; Ziegler and Nogareda, 2009). Yet, the lack of a significant relationship between innovation capabilities and EMS certification suggests that the latter has less to do with a firm's capabilities and is more a reflection of its strategic objectives.

The cost savings variable (CS) displays a significant impact in the case of in-house adoption, with no significant impact upon certification. While the former is in line with the EMS literature, which asserts that firms adopt EMS to reduce waste and save costs by improving environmental organizational capabilities (Darnall et al., 2008), the latter is not out of line with the mixed results on the relationship between cost savings and EMS certification (Arimura et al., 2011; Johnstone and Labonne, 2009). Critics of EMS certification argue that it is usually used as an image-building tool, which might not improve environmental performance or save costs for most cases (Aravind and Christmann, 2011; de Jong et al., 2014).

Our findings indicate that parental pressures (PARENT) have a positive impact on the adoption of EMS while negatively affecting certification. This could relate to the attempts firms make to centralize their EMS certification to headquarters/main-sites so that the costs of certification can be limited. Finally, in relation to firm size (SIZE), in line with the findings of the literature, larger firms are found more likely to adopt and certify EMS. This can be attributed to the bigger environmental budgets large firms have and the higher societal pressures they face due to their higher visibility (Hillary, 2004).

5. Discussion and Conclusions

Previous studies examining the relationship between self-regulatory tools and state environmental regulation treat the latter as an important, yet one-dimensional factor. However, state regulation encompasses diverse types of environmental policies, affecting self-regulation

and, in turn, environmental corporate responsibility in different ways. Furthermore, there is a paucity of studies that examine the in-house adoption and certification decisions of self-regulation simultaneously. Prior literature focuses on single self-regulatory tools while overlooking the interrelationship between in-house adoption and external certification of self-regulation (Heras-Saizarbitoria et al., 2011; Singh et al., 2015).

In this article, we address the aforementioned gaps by framing a firm's decision to certify its EMS as a subsequent decision to in-house EMS adoption. Conceptually, we clarify the decision-making sequence, whereby self-regulatory tools are first implemented and then certified. Empirically, we show that a firm's decision to seek certification is endogenously determined. Consequently, by accounting for the nested nature of the two decisions, we are able to provide less biased and more consistent insights into the determinants of self-regulation.

The findings of this research advance knowledge in the corporate environmental responsibility literature by focusing on different dimensions of a regulatory regime and analyzing how different types of regulatory instruments affect firms' decisions to adopt and certify environmental self-regulation. We shift the focus towards different types of regulation to uncover the true influence of state regulation on voluntary self-regulation. Furthermore, the focus of this research, on in-house adoption and external certification decisions, refines knowledge of the relationship between state environmental regulation and self-regulation. Previous studies (Potoski and Prakash, 2013) have conceptualized these two forms of regulation as adversaries by proposing that in heavily regulated environments there is no need for firms to adopt self-regulatory tools such as EMS. We contribute to this stream of literature by showing that in heavily regulated environments, regulation partly substitutes for the external certification element of such tools, but not their in-house adoption.

More precisely, the results of this study illustrate that the requirements to comply with direct environmental regulations encourage the adoption of EMS as a means to reduce firms' environmental impact, but detract from EMS certification. Hence, environmental regulation complements the in-house adoption of self-regulatory tools and substitutes for the certification element of these tools. Given that firms adopting in-house forms of EMS are mainly interested in improving their efficiency (Darnall et al, 2008), our findings support the view that collaboration between state regulation and self-regulation can ensure effective environmental protection (Eberlein et al., 2014; Abbott and Snidal, 2009). Also, our findings on certification align with the literature suggesting that certification is a solution to problems of information asymmetries, separating the good apples from the bad (Akerlof, 1970; Bartley, 2011; Potoski and Prakash, 2009). More research in this area is needed, as the recent trend of deregulation worldwide might be the reason for the rise of certifications issued. Yet, we argue, in order to ensure effective environmental regulation, we need collaboration between various governance actors, not the substitution of one governance actor for another.

Our results related to indirect regulatory instruments do not provide robust evidence for the influence of environmental taxes on the in-house or certified adoption of EMS. This is surprising in light of the environmental economics literature, which promotes environmental taxes over direct regulation as more flexible and effective option (Martin et al., 2014). Whilst environmental taxes are prominently promoted due to flexibility, their implications for self-regulation are rarely discussed in the literature. A plausible explanation for these findings might be that environmental taxes are applied more laxly compared to direct instruments as governments come under pressure by industry lobbies (Milne and Andersen, 2012). The findings of this work highlight the need for further research in this area.

With regards to the influence of regulatory stringency on the in-house adoption and certification of EMS, the results broadly support the Porter Hypothesis (Porter and van der

Linde, 1995), suggesting that strict environmental regulation induces corporate environmentalism. In particular, industry-based regulatory stringency appears to play an important role in the adoption of in-house EMS. Thus, despite global economic trends of shifting regulatory control from public to the private domain, public regulation seems crucial for engaging firms in environmental actions. Remarkably, our findings indicate that the opposite happens with certification; the intensity of regulatory pressure reduces the likelihood of certification. This result seems paradoxical in the context of rising certification trends in the UK over the past few years (ISO, 2014). Yet, under widespread EU and UK neoliberal economic policies that diminish the power of public regulation, this trend illustrates that, under weaker regulatory pressures, certification grows in response to state's retreat.

In addition to theoretical contributions, the results of this research have implications for policymakers and practitioners. It is demonstrated that environmental regulation has a significant role to play in promoting corporate responsibility through self-regulation. Collaboration between policymakers and managers could potentially generate high returns for both actors, in that it could result in effective environmental regulations that correct market failures, thus reducing pollution and safeguarding firms' legitimacy. Policymakers should not be reluctant to regulate – and, when doing so, they should promote the adoption of self-regulatory tools like ISO14001 by providing regulatory relief for certified firms.

The article has a number of limitations. First, whilst this work disentangles the implications of regulatory dimensions to a significant extent, regulations consist of highly complex policy mixes operating with different instruments at national, regional, and local levels. The data used in this study focuses on the presence of different types of environmental policy instruments (i.e. direct and indirect) and their overall stringency, but it does not cover all dimensions or specific instruments (e.g. technology and performance standards, emission

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or product taxes). Future research that focuses on the implications of specific instruments for voluntary environmental programmes could provide important extensions to this work.

Second, the measurements used to capture the quality of EMS in this study rely on binary responses, whereas more detailed information on the *maturity* and *completeness* of in-house EMS applications (Darnall and Kim, 2012; Inoue et al., 2013) would allow further research to reveal the relationship between state regulation and self-regulation more precisely. Additionally, confirming the presence of in-house EMS on company websites and through brief consultations with participants, as well as crosschecking external EMS certifications using registers of certification bodies, could improve the validity of the data.

Third, as our analysis is based on a cross-sectional dataset, endogeneity problems are difficult to detect and control for. For example, ECORD could be potentially endogenous (i.e. firm specific unobservables that are correlated with ECORD might also determine EMS adoption and certification). As constructing a panel is not currently an option with this dataset, we are limited to dealing with this issue in a cross-sectional space. In doing so, we have re-run our regressions in absence of such control variables that could be endogenous. The results reveal that the impact of the main policy instrument variables remain unchanged, instilling confidence that any potential endogeneity issues are minor. Although we correct for endogeneity arising from selection bias and control for a large number of factors that affect EMS-related decisions in an attempt to minimize omitted variable bias, future work that uses panel data could offer a platform more conducive to tackling these econometric issues. The same applies to the fourth limitation of this article. The dataset used did not allow us to capture the tendency of firms that have adopted EMS and are preparing to get certified. Here too, the use of panel data will allow future studies to overcome such issues.

Finally, we acknowledge the limitations of the model resulting from the limited coverage of the dataset. Broader samples that cover the services sector can provide a more comprehensive understanding of EMS adoption and certification as an increasing number of service firms engage with EMS (Molina-Azorin et al., 2015). Additionally, as close links are present between environmental management and firms' innovative capabilities; indicators of innovation can help to improve the predicting capacity of the models (Martín-Peña et al., 2014).

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Appendix A. Summary of Survey Questions of All Variables.

Symbol	Variables	Survey questions
Dependent variables		
EMS	=1 if the firm has internally implemented environmental management systems (In-House).	*(1) Which of the following Environmental Management Systems have you implemented?(a) ISO14001; (b) EMAS; (c) In-House; (d) None; (e) Don't know*
CERT_EMS	=1 if the firm has externally certified environmental management system (ISO14001 and/or EMAS).	
Independent variables		
ENV_REG	=1 if the firm invested in environmental protection due to environmental regulation compliance.	*(2) Please give one reason for your environmental capital expenditure: (a) Environmental regulation compliance; (b) Equipment upgrade; (c) Environmental taxes e.g. climate change levy; (d) Customer environmental requirement; (e) Parent company or owner policy/corporate social responsibility policy; (f) Other.*
ENV_TAX	=1 if the firm invested in environmental protection because of environmental taxes.	
STRING	Stringency of environmental regulations = Abatement costs (i.e. capital and operating environmental protection expenditure) (£) /Annual turnover (£).	*(3) What was your company's total capital expenditure on 'end-of-pipe' pollution control equipment and 'integrated' processes that became operational in 2010? (4) What were your company's total environmental operating costs in 2010? (5) Turnover in 2010 for the unit reported on in this questionnaire. Note: Abatement costs is calculated as (3)+(4)*
Control variables		
CUST	=1 if the firm invested in environmental protection because of customer environmental requirements.	*Survey question 2d as above.*
ECORD	Logarithm of Environmental Research and Development expenditure	*How much was spent during 2010 on Research and Development to reduce the environmental impacts of your company's activities?*
EQUIP	=1 if the firm invested in environmental protection because of equipment upgrade.	*Survey question 2b as above.*
CS	Logarithm of Total cost savings resulting from environmental improvements (£).	*(6) Total annual savings against business as usual, resulting from: (a) improved use of or substitution of war materials; (b) more efficient water use or reductions in effluent; (c) more efficient energy use; (d) savings in waste disposal costs; (e) other.*
PARENT	=1 if the firm invested in environmental protection because of parent company.	*Survey question 2e as above.*
SIZE	Logarithm of number of employees.	*(7) Number of persons employed (at 31/12/2010) for the unit reported on in this questionnaire.*
PROD	Productivity = Annual turnover (£) / Number of employees.	*Survey questions (5) and (7) as above.*
INH	In-house capabilities in environmental protection = In-house environmental protection expenditures (£) / Total Environmental Operating Expenditures	*(8) What were your company's total in-house environmental operating costs in 2010 for all environmental protection facilities and environmental management (including labour, leasing payments for equipment, chemicals etc.)? (9) What were your company's total environmental operating costs in 2010?*

Note. DEFRA Government Survey of Environmental Protection Expenditure by Industry
(https://www.gov.uk/government/publications/environmental-protection-expenditure-survey).

Appendix B. Classification of Industries into Energy Quintiles.

ENERGY QUINTILES	SIC Code (2007) (and % of firms in the sample)	
ENERGY_Q1 (Lowest Polluting)	5 (0.17%)	Mining of coal and lignite
	9 (1.02%)	Mining support service activities
	14 (1.28%)	Manufacture of wearing apparel
	15 (1.79%)	Manufacture of leather and related products
	26 (11.31%)	Manufacture of computer, electronic and optical products
	32 (2.59%)	Other manufacturing
	33 (2.85%)	Repair and installation of machinery and equipment
ENERGY_Q2	8 (2.21%)	Other mining and quarrying
	16 (3.40%)	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	18 (5.40%)	Printing and reproduction of recorded media
	27 (3.15%)	Manufacture of electrical equipment
	30 (1.40%)	Manufacture of other transport equipment
	31 (3.27%)	Manufacture of furniture
	36 (0.43%)	Water collection, treatment and disposal activities, materials recovery
ENERGY_Q3	11 (0.64%)	Manufacture of beverages
	13 (2.00%)	Manufacture of textiles
	21 (1.66%)	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	25 (13.78%)	Manufacture of fabricated metal products, except machinery and equipment
	28 (6.42%)	Manufacture of machinery and equipment
	29 (2.30%)	Manufacture of motor vehicles, trailers and semi-trailers
ENERGY_Q4	10 (5.70%)	Manufacture of food products
	17 (1.57%)	Manufacture of paper and paper products
	22 (6.29%)	Manufacture of rubber and plastic products
	23 (2.42%)	Manufacture of non-metallic mineral products
ENERGY_Q5 (Highest Polluting)	6 (0.38%)	Extraction of crude petroleum and natural gas
	19 (0.81%)	Manufacture of coke and refined petroleum products
	20 (12.80%)	Manufacture of chemicals and chemical products
	24 (1.62%)	Manufacture of basic metals
	35 (1.36%)	Electricity, gas, steam and airconditioning supply

Table 1. Summary Statistics.

Variable	Observations	Mean	Std. Dev	Min	Max
Dependent Variables					
EMS	2076	0.352	0.478	0	1
CERT_EMS	2076	0.178	0.383	0	1
Independent Variables					
ENV_REG	2076	0.163	0.369	0	1
ENV_TAX	2076	0.013	0.113	0	1
STRING	2076	0.024	0.398	9.89×10^{-09}	14.355
Control Variables					
SIZE	2076	3.704	1.171	0	9.393
CUST	2076	0.017	0.131	0	1
PARENT	2076	0.045	0.208	0	1
EQUIP	2076	0.072	0.259	0	1
ECORD	2076	1.047	2.822	0	15.939
CS	2076	1.582	3.452	0	16.030
PROD	2076	144076.900	236897.800	22.143	4967625.000
INH	2076	0.188	0.268	0	1

Note: Full variable descriptions are available in Appendix A.

Table 2: Probit with Sample Selection Estimation Results.

	M1		M2		M3	
	Adoption	**Certification**	**Adoption**	**Certification**	**Adoption**	**Certification**
	(Selection Eq.)	(Outcome Eq.)	(Selection Eq.)	(Outcome Eq.)	(Selection Eq.)	(Outcome Eq.)
	Policy Instruments					
ENV_REG	0.158***	-0.072*	0.154***	-0.087**	0.154***	-0.069*
	(0.031)	(0.044)	(0.032)	(0.039)	(0.032)	(0.038)
ENV_TAX	0.083	-0.098	0.016	-0.090	0.017	-0.094
	(0.100)	(0.140)	(0.100)	(0.129)	(0.099)	(0.128)
STRING	0.031	-0.379	0.034*	-0.529	0.023	-0.814*
	(0.023)	(0.505)	(0.020)	(0.467)	(0.017)	(0.493)
ENERGY_Q2					-0.019	0.096**
					(0.034)	(0.042)
ENERGY_Q3					-0.007	-0.013
					(0.031)	(0.042)
ENERGY_Q4					-0.054	-0.052
					(0.035)	(0.057)
ENERGY_Q5					0.066*	0.048
					(0.037)	(0.044)
	Control Variables					
SIZE	0.098***	0.117***	0.075***	0.096***	0.068***	0.083***
	(0.011)	(0.038)	(0.011)	(0.034)	(0.011)	(0.027)
CUST			0.050	0.088	0.048	0.093
			(0.094)	(0.095)	(0.092)	(0.093)
ECORD			0.016***	0.001	0.016***	-0.000
			(0.004)	(0.005)	(0.004)	(0.005)
EQUIP			0.183***	-0.073	0.186***	-0.058
			(0.049)	(0.053)	(0.048)	(0.050)
CS			0.013***	-0.004	0.012***	-0.003
			(0.004)	(0.004)	(0.004)	(0.004)
PARENT			0.171***	-0.160***	0.146**	-0.180***
			(0.062)	(0.065)	(0.062)	(0.064)
INH	0.393***		0.281***		0.281***	
	(0.043)		(0.044)		(0.046)	
PROD	2.03×10^{-7}***		2.12×10^{-7}***		2×10^{-7}***	
	(0.000)		(0.000)		(0.000)	
INDUSTRY DUMMIES	YES	YES	YES	YES	NO	NO
Number of Observations	2076		2076		2076	
Censored Observations	1346		1346		1346	
Log Pseudolikelihood	-1553.294		-1511.510		-1572.544	
Wald Chi2	62.99***		77.2***		47.33***	
Athrho	-0.786***		-1.055***		-0.942***	
Rho	-0.656		-0.784		-0.736	
Wald Test of Independent Equations (rho=0):	8.42**		10.17***		12.82***	

Notes. *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
-The dependent variable in adoption equations is EMS while the dependent variable in the certification equations is CERT_EMS.

-The reported coefficients are the marginal effects and the robust standard errors. Note that average discrete probability effects are reported for dummy variables.

-Industry dummies at two-digit level are included.

-The seemingly unrelated estimation tests: Model (1) chi2(32) =   87.14 p=0.00, Model (2) chi2(37) = 138.35, p=0.00, Model (3) chi2(9) = 115.56, p =0.00.

-Likelihood ratio test for identification variables being equal to zero: Model (1) LR chi2(2)= 105.90, p=0.00 Model (2) LR chi2(2) = 60.86, p= 0.00 Model (3) LR chi2(2)=64.29, p=0.00.

Figure 1. Conceptual Model

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┌─────────────────────────────────┐        ┌─────────────────────────────────┐
│ State Environmental Regulation: │        │ Environmental Self-Regulation:  │
│                                 │        │                                 │
├─────────────────────────────────┤        ├─────────────────────────────────┤
│                                 │        │                                 │
│  Direct Instruments             │        │  In-house        Externally Certified │
│  Indirect Instruments           │        │  EMS             EMS            │
│  Regulatory Stringency          │        │                                 │
│                                 │        │                                 │
└─────────────────────────────────┘        └─────────────────────────────────┘
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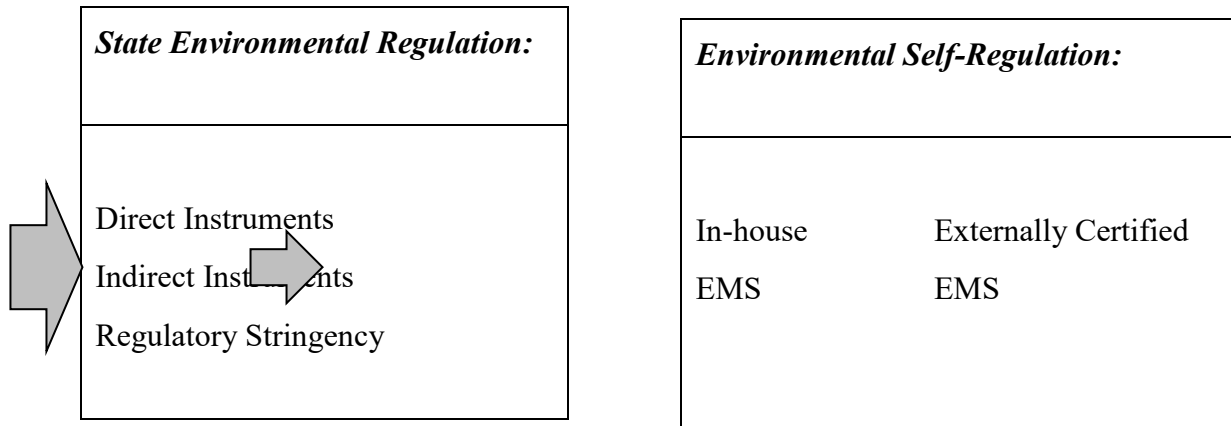
Figure 2. Nested Structure of In-house EMS Adoption and External Certification Decisions.

DECISION 1
(Selection Equation)
Adoption of In-house EMS

DECISION 2
(Outcome Equation)
External Certification of EMS

CERTIFIED EMS

(= 370 firms)

EMS

(=730 firms)

NOT CERTIFIED EMS

(=360 firms)

FULL SAMPLE

(=2076 firms)

NO EMS

(=1346 firms)